NTID 73.4

IMPACT CHARACTERIZATION OF NOISE INCLUDING IMPLICATIONS OF IDENTIFYING AND ACHIEVING LEVELS OF CUMULATIVE NOISE EXPOSURE

ENVIRONMENTAL PROTECTION AGENCY
AIRCRAFT/AIRPORT NOISE STUDY REPORT

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HENNING VON GIERKE, TASK GROUP CHAIRMAN

PREFACE

The Noise Control Act of 1972 (Public Law 92-574) directs the Environmental Protection Agency (EPA) to study the adequacy of current and planned regulatory action taken by the Federal Aviation Administration (FAA) in the exercise of FAA authority to abate and control aircraft/airport noise. The study is to be conducted in consultation with appropriate Federal, state and local agencies and interested persons. Further, this study is to include consideration of additional Federal and state authorities and measures available to airports and local governments in controlling aircraft noise. The resulting report is to be submitted to Congress on or before July 27, 1973.

The governing provision of the 1972 Act states:

> "Sec. 7(a). The Administrator, after consultation with appropriate Federal, state, and local agencies and interested persons, shall conduct a study of the (1) adequacy of Federal Aviation Administration flight and operational noise controls; (2) adequacy of noise emission standards on new and existing aircraft, together with recommendations on the retrofitting and phaseout of existing aircraft; (3) implications of identifying and achieving levels of cumulative noise exposure around airports; and (4) additional measures available to airport operators and local governments to control aircraft noise. He shall report on such study to the Committee on Interstate and Foreign Commerce of the House of Representatives and the Committees on Commerce and Public Works of the Senate within nine months after the date of the enactment of this act."

Under Section 7(b) of the Act, not earlier than the date of submission of the report to Congress, the Environmental Protection Agency is to:

> "Submit to the Federal Aviation Administration proposed regulations to provide such control and abatement of aircraft noise and sonic boom (including control and abatement through the exercise of any of the FAA's regulatory authority over air commerce or transportation or over aircraft or airport operations) as EPA determines is necessary to protect the public health and welfare."

The study to develop the Section 7(a) report was carried out through a participatory and consultive process involving a task force. That task force was made up of six task groups. The functions of these six task groups were to:

1. Consider legal and institutional aspects of aircraft and airport noise and the apportionment of authority between Federal, state, and local governments.

2. Consider aircraft and airport operations including monitoring, enforcement, safety, and costs.

3. Consider the characterization of the impact of airport community noise and to develop a cumulative noise exposure measure.

4. Identify noise source abatement technology, including retrofit, and to conduct cost analyses.

5. Review and analyze present and planned FAA noise regulatory actions and their consequences regarding aircraft and airport operations.

6. Consider military aircraft and airport noise and opportunities for reduction of such noise without inhibition of military missions.

The membership of the task force was enlisted by sending letters of invitation to a sampling of organizations intended to constitute a representation of the various sectors of interest. These organizations included other Federal agencies; organizations representing state and local governments, environmental and consumer action groups, professional societies, pilots, air traffic controllers, airport proprietors, airlines, users of general aviation aircraft, and aircraft manufacturers. In addition to the invitation letters, a press release was distributed concerning the study, and additional persons or organizations expressing interest were included into the task force. Written inputs from others, including all citizen noise complaint letters received over the period of the study, were called to the attention of appropriate task group leaders and placed in the public master file for reference.

OBJECTIVE

As part of the aircraft/airport noise study required by Section 7 of the Noise Control Act of 1972, the Environmental Protection Agency must study the "implications of identifying and achieving levels of cumulative noise exposure around airports." In support of this requirement, TaskGroup 3 was asked to:

1. Determine the merits and shortcomings of methods to characterize the impact of noise of present or proposed airport/aircraft operations on the public health and welfare.
2. Determine which of such methods is most suitable for adoption by the Federal Government, keeping in mind (1) the role of airport operators and

owners and the rights of the public; (2) the costs of noise monitoring, (3) the implications for enforcement of regulations; and (4) the relationships to other measures for environmental source description and control.

3. Determine the implications of issuing Federal regulations establishing a standard method for characterizing the noise from aircraft/airport operations and of specifying maximum permissible levels for the protection of the public health and welfare.

APPROACH

The Task Group met five times at intervals of two or three weeks (see Appendix F for minutes of meetings and list of organizations and individuals participating) to collect the necessary background information (see Appendix G) and to arrive at the conclusions and recommendations presented in this report. The difficult and controversial subjects of the Task Group assignment made a complete agreement and a consensus of all members on all subjects impossible. Exceptions and objections to the report by individual members or organizations are listed in Appendix H. In spite of these it is hoped that the report contains the reasonable and balanced majority view as integrated by the chairman.

The fundamental bases for the Task Group's approach were:

1. A scientifically, economically, and socially sound and defensible noise control program requires that any measure or method used to characterize the impact of aircraft/airport operations noise on the public health and welfare must in principle also be able to characterize the impact of all other types of noise regardless of their origin. Aircraft noise exposure mus be measured by the same yardstick as other noises. Neglect of this requirement is to a large extent responsible for some of the controversies in this area and the absence of clearly identified national noise goals.
2. Only if this first condition is fulfilled can aircraft noise exposure be added to other noise exposures to which people are subjected, so that the total noise exposure of individuals or the public can be measured or calculated. Discussion of noise effects with respect to health and welfare make sense only in terms of total noise exposure. Permissible or maximum desirable levels of noise for <u>each</u> source, and the duration of people's exposure to these levels must therefore be derived from the permissible or maximum desirable noise from <u>any</u> source to which the public may be exposed without

an undue effect on health or welfare. (Choosing the same measure for people's exposure to aircraft noise as is used to measure noise exposure from other sources does not necessarily imply that the same criteria of acceptability must be chosen for all sources.)

3. If permissible noise levels are determined on the basis of the total noise exposure of individual people, any system used to characterize noise impact with respect tc public health and welfare must be able to measure and/or calculate the noise exposure of individuals moving through different noise environments during their daily living routine. For example, occupational noise exposure during working hours, traffic noise during transportation to and from work, and the noise of the environment at home during evening and night all must be added to give the average noise level to which an individual is exposed during a day. All regulations and standards with respect both to environmental noise levels and to individual source emissions must ultimately be based on and justified by desirable or permissible values for total individual noise exposures, even though such regulations may be stated in terms of the average daily exposure level, at a specified location, due to an individual source (such as aircraft), or in terms of exposure of individuals to this source only.

4. The requirement to agree on such a universal measure to characterize cumulative human noise exposure is very urgent. Without such a measure no long-term, meaningful goals and standards can be set. This urgency clearly justifies selection of the best characterization method presently available without waiting for further research data and refinements. The urgency to develop a common measure for all types of noise exposure justifies whatever simplifications are required now to make it a practical tool for environmental noise control requirements and standards.

5. A practical simple measure of environmental noise cannot and need not take into account secondary effects. Neglecting secondary details in the measurement and control of environmental noise does not mean that these details are not important or that attention should not be paid to them through other control measures. For example, one-time noise events, high instantaneous peak values or objectionable discrete tones of individual sources must be separately controlled by emission noise standards. Standards for cumulative

environmental noise exposure and emission/certifications standards must complement each other. The emission or source standard can consider the details of the source characteristics and can employ methods of measurement, data analysis and interpretation appropriate for the characteristics of the particular noise or for effective noise control engineering on this noise source. However, it is mandatory that all detailed source standards can be translatable into one common noise measure. Exposures to all kinds of noise can then be added in this common measure of exposure to give a measure of total accumulated noise exposure.

Section 1 of this report gives the selected common measure of average noise level recommended by the Task Group for general use by the Federal Government for characterizing all types of environmental noise exposures. Appendix A gives the justification for the recommended procedure and its relation to other existing methods.

Section 2 gives details about the application of the noise exposure measure to the aircraft/airport noise situation, and about predicting, measuring and monitoring environmental noise. Most task group members agreed with the approach of Sections 1 and 2.

Section 3 discusses the basis for selecting maximum permissible noise exposure with respect to public health and welfare and recommends specific maximum cumulative exposure for the average person, to be adopted by the Federal Government.

Detailed justification for the health and welfare criteria selected, and for the maximum permissible noise exposures recommended is presented in Appendix B (with respect to hearing loss), Appendix C (with respect to interference with speech communication) and Appendix D (with respect to annoyance).

The economic impact of these recommendations is discussed semi-quantatively in Section 3 and in more detail in the reports of task groups 1, 2, 4 and 5. An analysis of the overall economic impact of achieving these permissible levels, and an analysis of a recommended time schedule was beyond the task group's scope. These recommendations should, therefore, be considered by the Administrator in the overall context of the requirements of the Noise Control Act. The agreement among members of the task group with respect to the maximum permissible noise exposure was not as good as for Sections 1 and 2. However, it was felt by the majority of the task group that the adoption of a goal for maximum permissible exposure in clearly defined and measurable units would be an important and significant step forward. Progress on specific tasks, such as the aircraft/airport study directed by the Noise Control Act of 1972, can then be evaluated in terms of progress toward this goal.

Section 4 presents the conclusions and recommendations of the task group.

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SECTION 1

THE MEASURE OF ENVIRONMENTAL NOISE EXPOSURE

Section 7 of the Noise Control Act of 1972 directs the Environmental Protection Agency to study the "--implications of identifying and achieving levels of cumulative noise exposure around airports." A primary consideration in this study is the specification of a measure for the noise produced at different locations in communities near an airport. A suitable choice for the measure should include the effects of average noise level and of exposure time.

A physical measure of cumulative noise exposure applicable to evaluation of airport noise should be based on consideration of the following requirements:

1. The measure should correlate well with the human responses regarding hearing loss, sleep and speech interference, and annoyance due to noise exposure.
2. The measure should be capable of assessing the accumulated effect of all noises during a long time.
3. The measure should be simple enough that it can be obtained by direct measurement without extensive instrumentation or elaborate analysis equipment.
4. The required measurement equipment, with standardized characteristics, should be commercially available.
5. The measure for airport noise should be closely related to measures currently used for noise from other sources.
6. The single measure of noise at a given location should be predictable, within an acceptable tolerance, from knowledge of the physical events producing the noise.

The remainder of this section discusses how these requirements were considered in the selection of the measure to be used for evaluating environmental noise around an airport.

PHYSICAL ATTRIBUTES OF SOUND AFFECTING HUMAN RESPONSE

The accumulated evidence of research on human response to sound indicates clearly that the magnitude of sound as a function of frequency and time are basic indicators of human response to sound. These facts are reviewed here.

MAGNITUDE

Sound is a pressure fluctuation in the air; the magnitude of the sound describes the physical sound, in the air; (loudness on the other hand, refers to how people judge the sound when they hear it). Magnitude is stated in terms of the amplitude of the pressure fluctuation. The range of magnitude between the faintest audible sound and the loudest sound the ear can withstand is so enormous (a ratio of about 1,000,000,000,000 to 1) that it would be very awkward to express sound pressure fluctuations directly in pressure units. Instead, this range is "compressed" by expressing the sound pressure on a logarithmic scale. Thus sound is described in terms of the sound pressure level (SPL), which is ten times the common logarithm of the ratio of the sound pressure in question to a (stated or understood) reference sound pressure, usually 20 micro-newtons per square meter.

FREQUENCY DISTRIBUTION

The response of human beings to sound depends strongly on the frequency of the sound. In general, people are less sensitive to sounds of low frequency, such as 100 hertz (Hz),* than to sounds at 1000 Hz; also at high frequency, such as 8000 Hz, sensitivity decreases. Two basic approaches to account for this difference in response to different frequencies are (1) to segment the sound pressure spectrum into a series of contiguous frequency bands by electrical filters, so as to display the distribution of sound energy over the frequency range or (2) to apply a weighting to the overall

Hertz is the international standard unit of frequency, until recently called "cycles per second"; it refers to the number of pressure fluctuations per second in the sound wave.

spectrum in such a way that the sounds at various frequencies are weighted in much the same way as the human ear hears them.

In the first approach a sound is segmented into sound pressure levels in 24 different frequency bands, which may be used to calculate an estimate of the "loudness" or "noisiness" sensation which the sound may be expected to cause. This form of analysis into bands is usually employed when detailed engineering studies of noise sources are required. It is much too complicated (i.e., expensive) for monitoring noise exposure.

To perform such analysis, especially for time varying sounds, requires a very complex set of equipment. A frequency-weighted sound pressure level, on the other hand, is a one-number measure of noise that can be obtained with simple equipment. Such a sound level with a designated frequency weighting is called simply sound level. Although this approach is not satisfactory for detailed analysis for engineering noise control, it provides a satisfactory description of noise from a response viewpoint, within the accuracy reasonable for community noise-evaluations.

With respect to both simplicity and adequacy for characterizing human response, a frequency-weighted sound level should be used by the Environmental Protection Agency for the evaluation of community noise. Several frequency weightings have been proposed for general use in the assessment of response to noise, differing primarily in the way sounds at frequencies between 1000 and 4000 Hz are evaluated.

The A-weighting, standardized in current sound level meter specifications, has been widely used for transportation and community noise description (Ref. 1). For many noises the A-weighted sound level has been found to correlate as well with human response as more complex measures, such as the calculated perceived noise level or the loudness level derived from spectral analysis (Ref. 2). However, psychoacoustic research indicates that, at least for some noise signals, a different frequency weighting which increases the sensitivity to the 1000-4000 Hz region is more reliable (Ref. 3). Various forms of this alternative weighting function have been proposed; they will be referred to here as "D-weighting." None of these alternative weightings has progressed in acceptance to the point where a standard has been approved for commercially available instrumentation.

One difficulty in the use of the A- or D-weighted sound level is that psychoacoustic judgment data indicate that effects of tonal components are sometimes not adequately accounted for by a simple sound level.

Some current ratings attempt to correct for tonal components. For example, in the present aircraft noise certification procedures, "Noise Standards: Aircraft Type Certification," FAR Part 36, the presence of tones is identified by a complex frequency analysis procedure. If the tones protrude above the adjacent random noise spectrum, a penalty is applied beyond the direct calculation of perceived noise level alone.

After consideration of this problem, the Task Group concluded that the presence of a tone penalty in certification procedures effectively encourages a manufacturer to minimize tones in the sound of aircraft. Thus, certification requirements will minimize the need to consider tones in an environmental noise measure, so long as tonal effects are properly considered under source certification.

TIME DISTRIBUTION

Most noise sources generate sound levels with recognizable temporal patterns. The level may be constant, as for a steady source, or it may vary with time, as with the noise produced at a given point on the ground during the passage of an aircraft in flight. Since response to noise is a function of the duration of the noise, it is necessary to have some description of its time pattern.

The most basic description of the time-varying nature of a noise signal observed at any point is a record of sound level as a function of time. The symbolic expression for a time varying sound level is $L_{(t)}$. Such a function might describe the pressure history at a fixed location for any one of a number of similar noise events. Alternately, $L_{(t)}$ might describe the fluctuating sound pressure level encountered by a single observer moving through various noise environments. Where a number of successive or overlapping noisy events occur, it is useful to have a continuous record of sound level as a function of time. From such a record, a statistical distribution of sound level versus percent of the total observation period can be derived. When such a distribution is obtained, it is common practice to identify by subscripts the respective sound levels exceeded during specified percentages of the observation time. Thus L_{90} is the sound level exceeded 90 percent of the time; L_{50} is the median value; L_{10} is the sound level exceeded 10 percent of the time.

DEVELOPMENT OF THE MEASURE OF COMMUNITY NOISE

The first step toward specifying a measure for cumulative exposure to environmental/community noise is to choose a measure that accounts for the varying sensitivity of the ear with frequency. Other factors that affect human response must be examined also. The factors considered most relevant to the selection of a suitable noise measure are discussed in this section.

FREQUENCY WEIGHTING

A conclusion of the previous section is that a frequency weighted sound pressure level is the most reasonable choice for describing the magnitude of environmental noise. In order to use available instrumentation for direct measurement, the A frequency weighting is the only suitable choice.*

The indications that a "D-weighting" might ultimately be more suitable for evaluating the integrated effects of noise on man, than the A-weighting, however, suggests that at such time as a "D-weighting" becomes standardized and available in commercial instrumentation, its value as the weighting for environmental noise should be considered, to determine if a change from the A-weighting is warranted.

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*All sound levels in this report are A-weighted sound pressure levels in decibels with reference to 20 micro-newtons per square meter.

AVERAGE SOUND LEVEL

As noted above, the measure of magnitude of noise in the community, at a given instant and place, is the fluctuating A-weighted sound level, often called simply sound level or noise level. The durations of the various sounds must be taken into account in an appraisal of "levels of cumulative noise exposure around airports." This is done by giving the average sound level during a stated time period. (Justification for the use of the average sound level is given in Appendix A).

This average sound level is sometimes called equivalent sound level. The symbol for both of them is L_{eq}. The average (equivalent) sound level is the constant sound level which, in a given situation and time period, would convey the same sound energy as does an actual time-varying sound. Two sounds, one of which contains twice as much energy but lasts only half as long as the other, would be characterized by the same average sound level; so would a sound with four times the energy lasting 1/4 as long, etc. This relation is often called the equal-energy rule. The average (equivalent) level for a number of events is somewhat greater than the sum of the sound levels for the various events divided by the number of them, by an amount that depends upon the range of variation of the sound level.

Some specifically named average sound levels are:

1. Hourly (average) sound level, L_h,
2. Daytime (average) sound level, L_d,
3. Nighttime (average) sound level, L_n.

For the present purpose, day extends from 7 a.m. up to 10 p.m. (0700-2200); night from 10 p.m. up to 7 a.m. (2200-0700) the next day.

DAYTIME/NIGHTTIME AVERAGE SOUND LEVEL

The repetitive cycle of events in most environments leads to the natural choice of a 24-hour day as the base period for evaluation of environmental noise. Most airport operations are quite stable in their day-to-day schedules. However, at many airports seasonal variations in schedules will change the frequency of aircraft operations during various months over the year. Thus, in assessing the environmental effect of an airport, the daily average noise level, averaged over an annual period, should be considered. This would be expressed as a yearly average of daytime/nighttime average sound level.

It is important to account for the difference in response of people in residential areas to noises that occur during sleeping hours as compared to waking hours. During nighttime, exterior background noises generally drop in level from their daytime values (see Appendix A). Further, the activity of most households decreases at night, lowering the internally generated noise levels. Thus, intrusive noise events often become more noticeable at night, since the increase in noise level of the event over background noise is greater than for daytime conditions.

Methods for accounting for these daytime/nighttime conditions have been developed in a number of different noise assessment methods employed around the world (Ref. 6). In general, the method used is to apply a penalty to noise events occurring during nighttime hours, that is, to treat night-time noises as though they were several decibels noisier than they actually are. Two approaches to identifying time periods have been employed: one divides the 24-hour day into two periods, the waking and sleeping hours, while the other divides the 24-hours into three periods—day, evening and night.

The penalties applied to the non-daytime periods differ slightly among the different countries (Ref. 4), but most of them penalize night activities by (nominally) 10 dB; the evening penalty, if used, is (nominally) 5 dB.

An examination of the numerical effects of using two periods versus three periods per day shows that for any reasonable distribution of aircraft flight operations, the two-period day and the three-period day are essentially identical (e.g. that is, the 24-hour equivalent sound levels are equal within a few tenths of a decibel. See Appendix A). It is recommended that the simpler two-period day be used.

Next we must select the actual times defining the day and night period. A suggestion that this choice be made optional within certain limits was considered but rejected, since a fixed schedule across the country was strongly preferred.

It was further considered whether the sudden imposition of a penalty at a specific time is reasonable, e.g., no penalty before a specific clock time, then imposition of the penalty a minute later. However, we concluded that the complexity of a variable time transition outweighed the possible benefits of its effect on final numerical values of average sound level and was not considered further.

These considerations lead to the recommendations of an average sound level during a 24-hour day, with a 10 dB penalty for the nighttime period from 2200 to 0700.

SEASONAL FACTORS

Consideration was given to the effects of seasonal variation of temperature on annoyance. Most studies indicate that, at least in colder climates, more complaints about noise occur during the summer months; presumably, this is because more people have windows open, and thus less noise reduction is provided by residential structures than in winter when windows are closed. On the other hand, home air-conditioning tends to keep windows closed during summer, and this factor may tend to equalize the winter and summer month complaints.

It was concluded that it is not reasonable to try to generalize any corrections for seasonal effects. Any such considerations should be applied on a local basis through planning ordinances or building code specifications where the local authorities have jurisdiction.

INDOOR-OUTDOOR FACTORS

The eventual purpose for establishing environmental noise level measures is to relate noise exposure to human response. Therefore, the noise levels to which people are actually exposed is of primary interest. While it may be more expedient to measure or predict outdoor noise levels, the fact that people spend most of their time indoors is significant. Two points then need to be considered. First, the proportion of time different segments of the population are indoors compared to outdoors, and second, the amount of noise reduction provided by various building structures.

The percentages of time different people spend indoors and outdoors depends on their age and occupation, and on geographical and climatological factors. These considerations properly come into play in the selection of specific criterion values for various situations, but not directly in the description of the physical noise exposure levels.

The effective noise reduction of buildings is also situation-dependent. If one restricts attention to residential structures, guidelines for noise reduction can be provided so that the indoor noise level may be estimated from the outdoor noise level from the same exterior noise source.

Data on the reduction of aircraft noise afforded by a range of residential structures are available (Ref. 5). These data indicate that houses can be approximately categorized into "warm climate" and "cold climate" types. Further, data are available for typical open-window and closed-window conditions. These data indicate a wide range of noise reduction provided by buildings within a given community due to differences in the use of materials, building techniques, and individual building plans. Nevertheless, for planning purposes, typical reduction in sound level from outside to inside a house is as follows:

A-Weighted Sound Level Reduction Due to Houses in Warm and Cold Climates, With Windows Open and Closed.

	Windows Open	Windows Closed
Warm climate	12 dB	24 dB
Cold Climate	17	27
Approx. national average* (extracted from Ref. 5)	15	25

*Valid for total window opening per room of 2 sq. ft. or less.

PSYCHOLOGICAL/SOCIOLOGICAL FACTORS

We do not propose to include in the measure of environmental noise any "non-acoustical" weighting functions to account for differences in people's response to noise, such as different acceptability of different noise sources, different attitudes of different populations toward noise, differing familiarity with the noise or socio-economic differences, etc. Such factors were included in previous ratings, such as Composite Noise Rating (CNR). The reason for not including these factors in the present measure are twofold:

1. Their inclusion would make it impossible to verify predicted values with actual measured sound levels;

2. Such factors cannot be justified if the basic purpose of the measure is not to predict the present-day response/complaint behavior of specific communities, but rather to establish average noise level goals with public health and welfare as the criterion.

It is recommended that such factors be considered when decisions about land use planning and maximum permissible noise exposure are being made. (See items 7 and 8 of conclusions, Section 4.)

DEFINITION OF DAY-NIGHT AVERAGE SOUND LEVEL AS THE MEASURE FOR COMMUNITY CUMULATIVE NOISE EXPOSURE

The previous sections support a basic measure for quantifying average noise around airports, namely the average A-weighted sound level, during a 24-hour time period, with a 10 decibel penalty applied to nighttime sound levels. In this formulation, "daytime" is the period between 0700 in the morning and 2200 (10 o'clock) at night; "nighttime" is the period from 2200 to 0700 hours the next day. A mathematical description for this formulation is provided in Appendix A.

The basic quantity described above is termed the "Day-Night Average Sound Level," or more briefly, "Day-Night Level." The unit for this quantity is the decibel, and the letter symbol for it is L_{dn}. Figure 1 shows typical values of L_{dn} for various types of environment, with corresponding subjective evaluations.

SOUND EXPOSURE LEVEL - A MEASURE OF NOISE FROM ONE EVENT

It is convenient to define a measure that accounts for the total accumulation of sound during an observation period or for a single noisy event; one such measure is called the Sound Exposure Level. In contrast to an average sound level, sound exposure level represents the summation, without averaging, of all sound energy during an entire event or observation period. Thus, even though the noise level may fluctuate up and down, the sound exposure level is always increasing. In principle, one could measure the sound exposure level as the sum of sound energy received during a very long period, like the lifetime of a man. Many important sounds, however, are of significant magnitude only during a much shorter time, like a few seconds. Hence, the sound exposure level of an aircraft flyover may practically be measured during the 10 or 20 seconds for which the sound level is within 10 (or 20) decibels of the maximum level.

Sound exposure level is the level of the time integral of A-weighted squared sound pressure for a specified time interval or event, with reference to a duration of one second. The unit of sound exposure level is the decibel, and the letter symbol for it is L_e.

The sound exposure level in decibels will exceed the equivalent sound level during some selected time interval by ten times the logarithm of the duration of the time interval in seconds. For example, the equivalent level (the average sound level) for a constant sound of 60 decibels observed for 1, 10, or 100 seconds will be 60 decibels in all three cases; the sound exposure levels for the same three conditions will be, respectively, 60, 70, and 80 decibels.

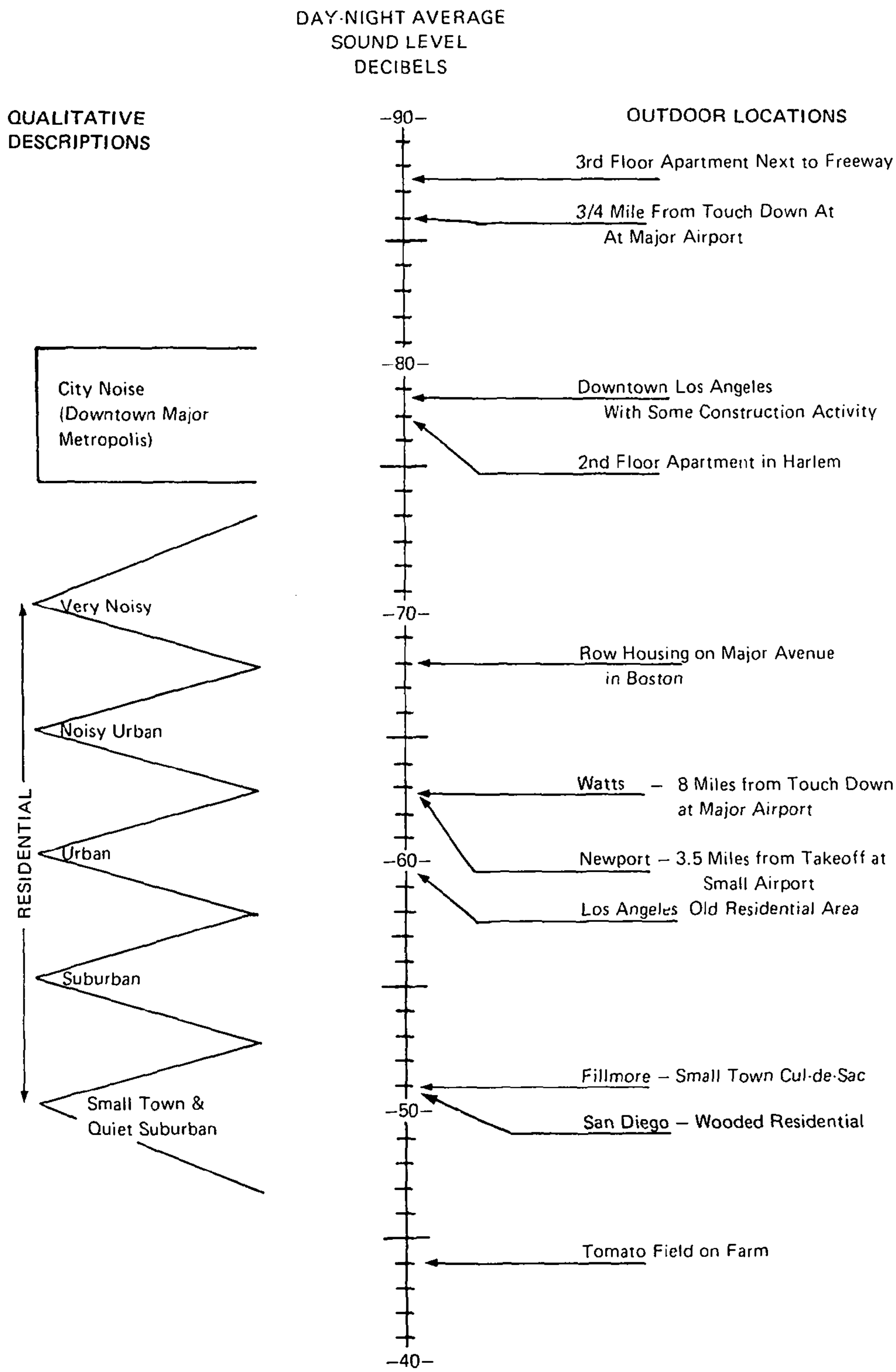

Figure 1. Outdoor Day-Night Average Sound Level in dB (re 20 Micronewtons/ Sq. Meter) at Various Locations

SECTION 2

APPLICATION OF DAY-NIGHT SOUND LEVEL TO AIRPORT NOISE

Among the requirements for a suitable measure of cumulative noise exposure around an airport are the ability to measure it with available instrumentation and the ability to predict expected values from a knowledge of physical characteristics of the noise sources. These matters are discussed in this section.

MEASUREMENT OF DAY-NIGHT AVERAGE SOUND LEVEL

The primary requirement in measuring average level is the ability to obtain an "energy average" of A-weighted sound level over the separate daytime and nighttime periods. These measurements may be performed with a variety of existing instrumentation, ranging from a standard sound level meter, used in conjunction with some sound level-history recorder such as a graphic level recorder, through meters that provide averaged noise levels periodically on an hourly basis, up to the more elaborate computerized monitoring systems now coming into use at some major airports.

The least sophisticated form of instrumentation, the combination of a sound level meter and a graphic level recorder, requires that the graphic recording of sound level as a function of time be segmented into the various intervals in which the sound level lies. That is, using a series of discrete "windows," say 1 to 5 dB in width, the percentage of time that the sound level lies within each window is determined. This sound level/time distribution can be determined either manually or with so-called "statistical distribution analyzers" produced by various equipment manufacturers. The energy average of the sound level pattern during the observation period can then be computed from this level distribution.

The recently available exposure meters, or integrating sound level meters, perform this same function without the use of a level recorder. Most of these instruments provide hourly average sound levels which may then be appropriately combined to obtain the day-night average level, L_{dn}. Several manufacturers also offer instruments in such a form that the 24-hour value of L_{dn} may be obtained directly from the instrument, including the provision of the nighttime weighting function.

The advantage of the above devices is their portability. They are suited to surveys of relatively short duration, e.g. days to weeks. Where continuous monitoring is desired, e.g. on an annual basis, it is more convenient to utilize a permanent monitoring system with a number of fixed microphones, and to feed the sound signals through telephone lines to a central recording station. A small digital computer may be incorporated with the central system so that a variety of analyses can be made. Such quantities as maximum sound level per event, sound exposure level, as well as hourlv and daily average sound levels may be easily obtained from such systems.

Clearly, the choice of measurement capability depends on the time span of interest, the funds available, the regulatory requirements, and other matters unique to each situation. It should be observed, however, that the intent of day-night sound level is to obtain a measure of the average sound level integrated over a long enough period of time to insure that variability in measurements due to weather, operational factors, traffic densities or seasonal effects are properly accounted for in the measurements.

PREDICTION OF DAY-NIGHT LEVEL FOR AIRPORT NOISE

In considering environmental noise in the vicinity of airports, it is important to be able to predict the noise environment for planning purposes. The measure chosen to describe environmental noise should also be readily adaptable to the various predictive methodologies that have been developed (Ref. 6, 7, 8).

In the case of airports, the methods for predicting noise exposure combine the noise generating properties of various aircraft types with aircraft performance and operational procedures to yield contours of equal average sound level during a specified time period. Since the basic component of average sound level is an energy summation of sound exposure levels, the noise source descriptions for different aircraft can conveniently be presented in terms of the sound exposure level as a function of distance of closest approach of the aircraft during an event for different engine power settings, e.g. takeoff, approach, ground runup.

The sound exposure level at any point on the ground, for a single aircraft operation, can be obtained by first determining the distance of closest approach from the point of observation to the aircraft flight path, and then obtaining the sound exposure level from data for the individual aircraft type relating sound level and distance. The average noise level at each point of interest is obtained by adding logarithmically the sound exposure level contributions from all aircraft operations during the time interval of interest. (See Appendix A).

Various Government agencies use slightly different methodologies and computer programs for predicting aircraft noise. Although the effective differences in the results of these predictions are small, they lead to unnecessary uncertainties, misinterpretations and discussions. The detailed prediction procedures for the day-night average sound level should be agreed upon and formalized as soon as possible between all Government Agencies and other interested organizations. For aircraft noise predictions the specific recommendations given in Appendix F list some of the items to be considered for incorporation into these procedures.

The prediction accuracy of any sound level model is no better than the accuracy of the operational input data. In planning efforts the operational projections are not necessarily an accurate reflection of the eventual operations. Differences in flight paths for different aircraft, in climb performance as a function of weight, and in atmospheric conditions all contribute to differences between predicted and measured values of noise exposure level. These problems are common to all prediction methodologies, however, and are not functions of the noise level measure employed. The accuracy of average sound level predictions over a projected 24-hour operation, is within ± 5 dB of the measured values, irrespective of the noise level measure; the reason for the wide scatter range is that actual operations deviate from the projected operations. However, the accuracy of estimated 24-hour equivalent noise levels for a set of known operational conditions compares within ± 1 dB of the measured values obtained for those operations. (Ref. 4.)

The choice of the day-night average sound level, L_{dn}, as a measure of environmental noise was partly based on its relative ease of measurement. In the last analysis, measured values of day-night average sound level taken over a long enough period of time that a stable representation of annual daily average levels can be obtained, are preferable to predicted values. The simplicity of the measurement of day-night average sound level recommends it highly in this application.

COMPARISON OF DAY-NIGHT AVERAGE SOUND LEVEL WITH OTHER AIRPORT NOISE DESCRIPTORS

A number of rating scales have been developed for airport noise analyses over the past 20 years (Ref. 10). Those most prominent in the United States have been the Composite Noise Rating (CNR) and the Noise Exposure Forecast (NEF). The CNR has been used by FAA and the military services, while NEF has been used to some extent by FAA and DOT. More recently the Community Noise Equivalent Level CNEL) has been developed for use in the California airport noise law (Ref. 11). A discussion of the comparisons between these ratings and L_{dn} is provided in Appendix A and it is explained why an exact relationship between the ratings cannot be stated.

For comparison, however, the following relationships can be assumed, together with the estimated range of scatter:

$$L_{dn} \simeq \text{CNEL}$$

$$L_{dn} \simeq \text{NEF} + 35 \ (\pm 3)$$

$$L_{dn} \simeq \text{CNR} - 35 \ (\pm 3)$$

A number of other ratings that have been developed internationally include the British Noise and Number Index (NNI), German Stoerindex ($\bar{Q}$), French Isopsophic Index (N), South African Noise Index (NI), International Civil Aviation Organization Weighted Equivalent Continuous Perceived Noise Level, WECPNL (Ref. 10). Each of these ratings accounts for the cumulative noise exposure in a very similar way, differing primarily in the technical details by which the noise exposure produced by individual aircraft flyovers is described. These measures are highly intercorrelated with NEF, CNR, CNEL, and thus with L_{dn}. (Ref. 10). Approximate conversions for these measures to L_{dn} can easily be derived, as they have been above for NEF and CNR (Ref. 10).

FAA is considering the use of a rating method for airport noise termed the Aircraft Sound Description System (ASDS). This method does not provide a measure of cumulative noise exposure and is thus not directly comparable to the other rating methods cited above.

THE EFFECTS OF OTHER NOISE SOURCES ON DAY-NIGHT AVERAGE LEVEL FROM AIRPORT OPERATIONS

The definition of average A-weighted sound level given in Section 1 is independent of the source of the noise. The average sound level in the vicinity of an airport will represent a combination of the noise produced by aircraft and the noise produced by other noise sources, e.g. motor vehicle traffic.

The contribution of aircraft noise, relative to that from other noise sources, will depend on the magnitude of the aircraft exposure levels, the total number of flyovers in any time period, and the exposure levels of the other sources. Various design charts for assessing the relative magnitudes of the contributions from these sources are provided in Appendix A.

In most airport noise situations of interest, the contribution of aircraft noise to the average sound level at locations near an airport will be dominant. For planning purposes, the average sound levels due to aircraft operations should first be predicted without regard to other noise sources. Then measured or predicted average sound levels at locations of interest in the community where other sources of noise are expected to be predominant should be obtained. Finally, the impact of the different noise sources can be evaluated both individually and together.

SECTION 3

BASIS FOR SELECTING MAXIMUM PERMISSIBLE AVERAGE NOISE LEVELS

The Noise Control Act of 1972 directs EPA to develop and publish noise criteria that "reflect the scientific knowledge most useful in indicating the kind and extent of all identifiable effects on the public health or welfare which may be expected from differing quantities and qualities of noise." This section of the report is based on recent surveys of the scientific data that will support EPA's criteria document and on preparatory work for the criteria document (Ref. 53). It is not the purpose of this section to recapitulate these data or past efforts, which are extensively documented in the literature (Ref. 54, 55, 21, 19), but rather to analyze how such data can be interpreted to arrive at maximum permissible average levels with respect to the cumulative environmental noise exposure defined in Section 1. The analysis tries to give quantitative relationships between the average sound level to which the average individual in a population is exposed and the resulting effects.

Although recommended values are presented here, the final choice of maximum permissible levels is not a technical/scientific one and cannot be made by this Task Group. Such a decision involves value judgments in the political, social, ethical and economic domain, beyond the responsibility of the Task Group, and must be resolved in the administrative or ultimately in the political-legal-legislative domain. However, the following analysis indicates that the options available for setting the maximum permissible average sound level are restricted to a range of not more than 20 dB, no matter how the challenge "to protect the public health and welfare with an adequate margin of safety" is interpreted.

The approach of this section will be first to present the quantitative relationship between cumulative exposure and the risk of health effects, primarily noise induced permanent hearing loss. Similar relationships are derived between average sound levels and the percentage of individuals annoyed by aircraft noise, and between average sound levels and the percentage of time that speech communication will be interrupted. Annoyance due to noise and interference with speech communication cannot be identified at this time with direct disease producing health effects, but must be interpreted as interference of the noise environment with public health and welfare according to the intent of the Noise Control Act; certainly, according to the definition of health of the World Health Organization, these noise effects on human activities and well being would be included under health effects.

It must be kept in mind that the relationships between noise exposure and public health and welfare analyzed in the following are based on statistical probabilities rather than on individual cause-effect relationships. Therefore, the generalized relationships and the recommendation of limit values are no evidence of whether any particular individual's health is affected by the noise.

With the cause and effect relationships between human health and welfare and cumulative noise exposure in hand, the question still remains as to what constitute, for the purpose of this report, "significant" effects on public health and welfare. It is reasonable, however, to require that an environment for all Americans "free from noise that jeopardizes their health or welfare" (Noise Control Act of 1972) should have no practically significant health effects for the most sensitive segment of the population. This means that in terms of annoyance, speech interference, hearing considerations, or other health effects, any noise level recommended should have no significant effect on the majority of the people. Based on these assumptions, maximum permissible average sound levels, L_{dn}, are recommended, one for immediate implementation and one as long-term goal. These criterion levels are:

1. Realistic with respect to the naturally occurring background levels produced by normal human activities, such as talking; and
2. Economically feasible, provided that an appropriate time schedule for compliance is developed. These levels can be enforced by relatively simple environmental noise monitoring systems.

Whether or not the numerical values recommended here are finally adopted, the analysis framework and the quantitative relationships for the various noise effects criteria, as presented here, should be used for discussing and characterizing the effects of the ultimate choice of maximum permissible average sound level and to analyze the implications of achieving such levels. Setting limits for average environmental noise, as proposed in this report, would not eliminate the need to protect people from occasional individual very noisy events and to restrict, by source emission standards, the contributions of individual noise sources to the public noise environment. Such efforts must be pursued concurrently to the extent technologically possible and economically feasible. Similarly the detailed characteristics of individual noise sources, such as their pure tone contributions, must be controlled by emission/certification standards.

Once maximum permissible average sound levels are accepted, the Federal or local authorities must still decide how the total permissible noise dose should be allocated between the major individual noise contributors; i.e., for example, what percentage of the total dose should be used for aircraft noise and what percentage for traffic noise.

Recommending upper limits of permissibility to protect the public against noise jeopardizing their health or welfare should not be interpreted as recommending insensitivity to the degradation with respect to noise of existing environments having lower noise levels (e.g., National Parks or wilderness areas). In other words, increasing noise levels to the levels of permissibility in presently quiet areas should only be allowed if justified in the national or public interest or welfare.

HEARING LOSS

There are two important considerations in evaluating environmental noise with respect to potential permanent hearing loss: the direct effect of environmental noise that is loud enough to cause hearing damage, and the indirect effect of environmental noise which, though not loud enough itself to cause damage, can still prevent recovery of the hearing mechanism from an occupational, recreational or environmental noise overdose. The implications of these two considerations are examined in detail in Appendix B and are summarized in the following paragraphs.

DIRECT EFFECT

The hearing threshold for an individual at a specific frequency is determined by measuring the level of the quietest sound that can be heard by the individual. The amount of hearing loss at any frequency is measured by the amount by which the hearing threshold has shifted upward from a previous value, or from the population norm.

Table 1 summarizes the relationship between daily noise exposure level and maximum noise induced permanent threshold shift for the most sensitive 10 percent of the population. The data assume 8 hours occupational noise exposure per day, repeated over a 40 year working lifetime. Usually, the threshold shift increases gradually over the 40 years of exposure; the term "maximum" refers to the greatest threshold shift occurring in this period, generally at the end.

The average of the permanent threshold shifts at frequencies of 500, 1000 and 2000 Hz, is used to define a "hearing handicap," a person is considered to suffer a hearing handicap when his average puretone threshold for these three frequencies exceeds by 25 dB or more the International Standards Organization (ISO) audiometric zero (Ref. 12). The average threshold shift for these three frequencies is usually less than that at a frequency of 4000 Hz, where the greatest change in hearing threshold generally occurs for most types of noise. The data at 4000 Hz therefore provide a more sensitive indicator of the noise induced permanent threshold shift than data at lower frequencies.

Individual changes in hearing less than 5 dB are not generally considered noticeable or significant. For instance, repeated audiograms on the same individual will often show a 5 dB variability. Thus, the threshold of hearing damage should be defined at the environmental noise level expected to cause a permanent threshold shift of 5 dB at 4000 Hz in the most sensitive 10 percent of the population. From Table 1, this threshold level is seen to be an average A-weighted sound level slightly less than 75 dB for an 8 hour exposure to broadband noise. For intermittent noises, such as that produced by aircraft or other moving vehicles, this threshold level may be increased by 5 dB to 80 dB, because of the opportunity for the ear to recover between noisy events.

INDIRECT EFFECTS

Complete recovery from high levels of daily occupational or environmental noise requires a substantial period of "quiet" with the A-weighted sound level less than 65 dB (See Appendix B). Assuming a house noise level reduction of 15 dB, with windows partially open, the outdoor average sound level thus should not exceed 80 dB in order to assure that the indoor level does not exceed 65 dB.

Table 1

Maximum noise induced permanent threshold shift in decibels, at various audiometric frequencies, for the most sensitive 10 percent of the population, assuming a 40-year exposure for 8 hours per day, as a function of the A-weighted average sound level of broad-band noise. (See Appendix B for additional detail.)

	A-Weighted Average Sound Level in dB**			
Audiometric Frequencies (Hz)	75	80	85	90
Average shift at 500, 1,000 and 2,000 Hz	1	1	4	7
Average shift at 500, 1,000, 2,000 and 4,000 Hz	2	4	7	12
Shift at 4,000 Hz	6	11	19	28

*Example: of a large number of people exposed for 8 hours per day over a 40 year working lifetime to broad band noise with A-weighted average sound level of 85 dB, the most sensitive 10 percent of these people will exhibit, on the average, permanent threshold shifts as follows: at a frequency of 4000 Hz, the shift will be 19 dB; the average of the shifts at the frequencies 500, 1000, 2000 and 4000 Hz will be 7 dB; the average of the shifts at 500, 1000 and 2000 Hz will be 4 dB.

**Add 5 dB to the average sound level for intermittent noise such as that produced by aircraft operations.

DAY-NIGHT AVERAGE NOISE LEVELS LOW ENOUGH TO PREVENT HEARING LOSS

Values of day-night average sound levels consistent with the above two considerations are summarized in Table 2. Based on the direct effect, the recommended upper limit of average sound level (80 dB for 8 hours outdoor exposure to intermittent noise) translates to outdoor maximum permissible values of L_{dn} between 80 and 86 dB, depending on the difference between the daytime and nighttime values of average sound level. The most probable maximum permissible value for L_{dn} in an actual environment would be 83 dB (See Appendix A, Fig. A-7).

Therefore, considering the direct effect only, an outdoor noise exposure of L_{dn} = 83 dB or less will produce no noticeable hearing change in 90 percent of the population who are outdoors on the average as much as 8 hours per day. This group is envisioned to include mostly young children and retired persons in warm climates, or certain occupational situations. Since the relationship between noise exposure and hearing in children has not been experimentally established, the criterion established for working adults must be used. The possibility that children might be more sensitive than adults to noise must be assessed when establishing what constitutes an adequate margin of safety. The general public who are not outdoors as much as 8 hours will of course be better protected from aircraft noise. Hearing loss from noise produced by occupational or recreational activities is not considered here, except to note that a noise dose of 75 dB for 8 hours would be insignificant (less than a 1 dB change in average sound level) when added to the current 90 dB (or proposed 85 dB) average sound level that is the limit for occupational exposure 8 hours per day (Ref. 13).

The day-night average sound level determined by the "indirect effect" requirement for an 8 hour period of "quiet" is the same (L_{dn} = 83 dB) as found for the direct effect, provided the 8 hours occur during daytime. However, if, as usual, the quiet period occurs at night, the values of L_{dn} are greater, ranging between 86 and 90 dB.

Table 2

Summary of permissible values of the outdoor day-night average sound level in decibels for intermittent aircraft noise, under two alternative constraints and for three values of the difference between day and night values of the average sound level.

Constraint		Difference in Day and Night Values of Outdoor Average Sound Level		
		0	4*	10
Direct Effect Requirement	8 hours outdoors in daytime with L_{eq} = 80 dB	86**	83**	80**
Indirect Effect Requirement	8 hours indoors at night with L_{eq} - 65 dB indoors or 80 dB outdoors	86	87	90

*Most likely value in this range of L_{dn} (See Appendix A).

**If outside noise is steady, e.g., not composed of a series of intermittent single event noises, such as produced by aircraft, these values should be reduced by 5 dB.

Thus, the maximum permissible limits resulting from the direct effects of environmental noise are controlling, if the "quiet" period occurs at night.

In summary, the hearing damage criteria indicate that a day-night average sound level less than 83 dBA is required, to assure that at least 90 percent of the general population have no measurable loss of hearing ability over the 500 to 4,000 Hz range of frequency. Such cumulative effects of environmental noise would show up only after exposures exceeding 10 years. This means that hearing damage data on which to base criteria of acceptable noise exposure, or to modify the initial choice of criteria, accrue very slowly. Prudence demands a conservative approach to setting criteria in such a situation. Moreover, the 83 dB limit was derived under certain assumptions regarding life style and exposure that might lead to over- or underestimation of individual exposures. Therefore, in view of the latter uncertainty, it is judged reasonable to recommend an L_{dn} of 80 dB as the maximum permissible yearly outdoor average sound level, to prevent adverse health effects on people's hearing.

SPEECH COMMUNICATION

Speech communication is essential to man, both outdoors and indoors.

Outdoors

Out-of-doors, the distance between the talker and listener over which effective speech communication can be carried on depends on both the voice level of the talker and the level of the environmental noise that surrounds the conversants. The relationships among the different parameters are summarized below and are given in greater detail in Appendix C.

Table 3 compares, for different degrees of vocal effort, the distance between a talker and listener out-of-doors with the steady environmental noise level that just permits reliable speech communication (defined as 95 percent sentence intelligibility, i.e., 95% of the key words in spoken sentences are correctly understood by the listener). (Ref. 49.)

Table 3

STEADY A-WEIGHTED NOISE LEVELS THAT ALLOW COMMUNICATION WITH 95% SENTENCE INTELLIGIBILITY OVER VARIOUS DISTANCES OUTDOORS FOR DIFFERENT VOICE LEVELS

VOICE LEVEL	COMMUNICATING DISTANCE (meters)					
	0.5	1	2	3	4	5
Normal voice	72	66	60	56	54	52 dB
Raised voice	78	72	66	62	60	58 dB

In choosing suitable limits on environmental noise to permit comfortable speech, it appears reasonable to limit outdoor noise levels so as to permit reliable speech communication with normal voice up to two meters separation between talker and listener. The choice of two meters for the communicating distance is considered reasonable for typical outside communication requirements in urban areas. To achieve this goal the average sound level should be no greater than 60 dB, according to Table 3.

Indoors

To assess the intrusion of outdoor levels into dwellings, the criterion of distance between talker and listener is not valid, because of the reverberant build-up of sound by reflections from the walls of the room. For years, however, there have been widely accepted criteria of recommended indoor noise levels appropriate to various activities. (Ref. 57.) A reasonable criterion value, from the upper half of the range of A-weighted sound levels recommended for living rooms (for radio and TV listening, as well as domestic activities), hotels, motels, small offices and similar spaces where speech communication is important, is 45 dB. A steady noise which does not exceed this level will assure 100% sentence intelligibility for relaxed conversation. Assuming 15 dB noise reduction through an open window, the steady outdoor noise level could reach 60 dB without exceeding this recommended indoor noise criterion for residences.

On the basis of Table 3, the same value of 60 dB is recommended as the maximum permissible value for intruding steady noise for speech communications, both outdoors and indoors. It is shown in Appendix C that things are changed only slightly if these criteria are interpreted as average noise levels for fluctuating noises, such as aircraft or traffic noise. In fact, the average noise level is a conservative measure of noise for protection of speech communications; the maximum permissible average sound level chosen to protect speech communication offers somewhat less speech interference when the noise fluctuates than when it is relatively steady.

These criteria for average sound level should apply at all times of the day when people wish to pursue their habitual waking activities, both indoors and outdoors; that is, they will govern the average daytime sound level (0700 - 2200). For the range of sound level around 60 dB, the most probable value of day-night average sound level is about 3 dB higher than the daytime average sound level. Therefore, it is concluded that the day-night average sound level should not exceed 63 dB if people are to enjoy their normal domestic activities indoors or to converse without difficulty outdoors at a two meter distance.

A curve showing the complete relationship between the outdoor and indoor day-night average sound level and percentage sentence interference is shown in Figure 2.

ANNOYANCE

The word annoyance is used in this report as a general term for reported adverse responses of people to environmental noise. In this context not the laboratory noisiness/ annoyance studies but the studies of annoyance which are largely based on the results of sociological surveys have been considered. Such surveys have been conducted among residents in the vicinity of airports of a number of countries including the United States (Ref. 14, 15, 16, 17, 56).

The results of these surveys are generally related to the percentage of respondents expressing differing degrees of disturbance or dissatisfaction due to the noisiness of their environments. Some of the surveys go into a complex procedure to construct a scale of annoyance; some report responses to the direct question of "how annoying is

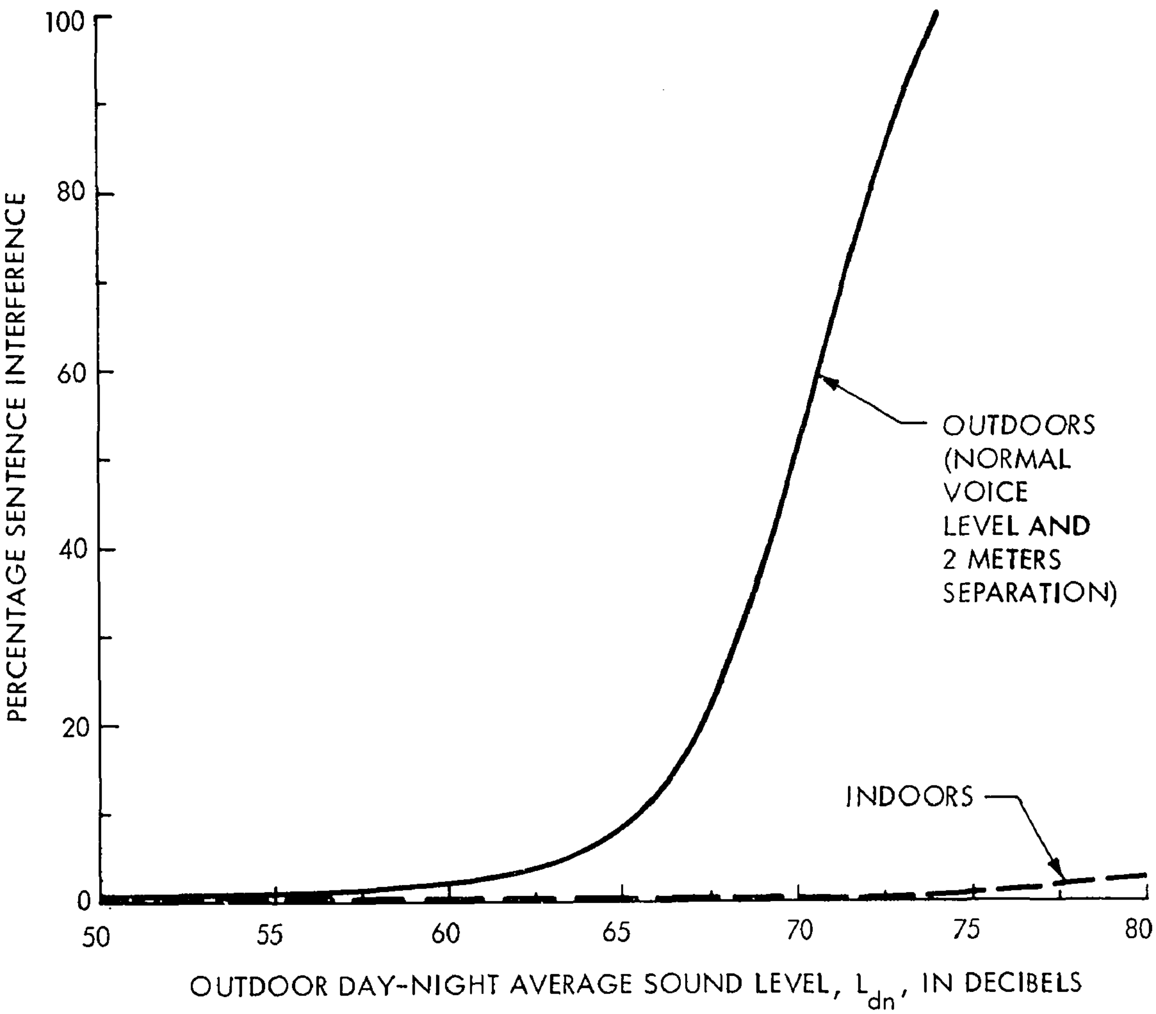

Figure 2. Maximum Percentage Interference with Sentences as a Function of the Day-Night Average Noise Level. (Percentage Interference Equals 100 Minus Percentage Intelligibility, and L_{dn} is Based on L_d + 3)

the noise." Each social survey is related to some kind of measurement of the noise levels (mostly from aircraft operations) to which the survey respondents are exposed. Correlation between annoyance and noise level can then be obtained.

The results of the social surveys show that individual responses vary widely for the same noise level. Borsky, (Ref. 18), has shown that these variances are reduced substantially when groups of individuals having similar attitudes about "fear" of aircraft crashes and "misfeasance" of authorities are considered. Moreover, by averaging responses over entire surveys, almost identical functional relationships between human response and noise levels are obtained for the whole surveyed population as for the groups of individuals having neutral attitudinal responses.

In deriving a generalized relationship between reported annoyance and day-night average sound level it seems reasonable to use the average overall group responses, recognizing that individuals may vary considerably, both positively and negatively compared to the average, depending upon their particular attitudinal biases.

An intercomparison of various survey results is presented in Appendix D, where three of the most prominent social surveys around airports are examined. These are the first and second surveys around London's Heathrow Airport, and the Tracor study around eight major airports in the United States (Ref. 14, 15, 16). The noise level data in each survey were converted to outdoor L_{dn} for the purpose of this analysis. An additional analysis was made of the overt community response for the 55 community noise situations reported in the EPA report to Congress (Ref. 19).

The relationship between the percentage of respondents who were "highly annoyed" and the day-night average sound level is shown in Figure 3, for the combined results of the first London survey, the Tracor study and the second Heathrow survey. These results, based on nearly 2,000 respondents in the first London survey, and more than 7,500 respondents in the combined surveys show an essentially identical relationship* between the percent of people highly annoyed and the average sound

*Meaning that the regression equations are practically indistinguishable.

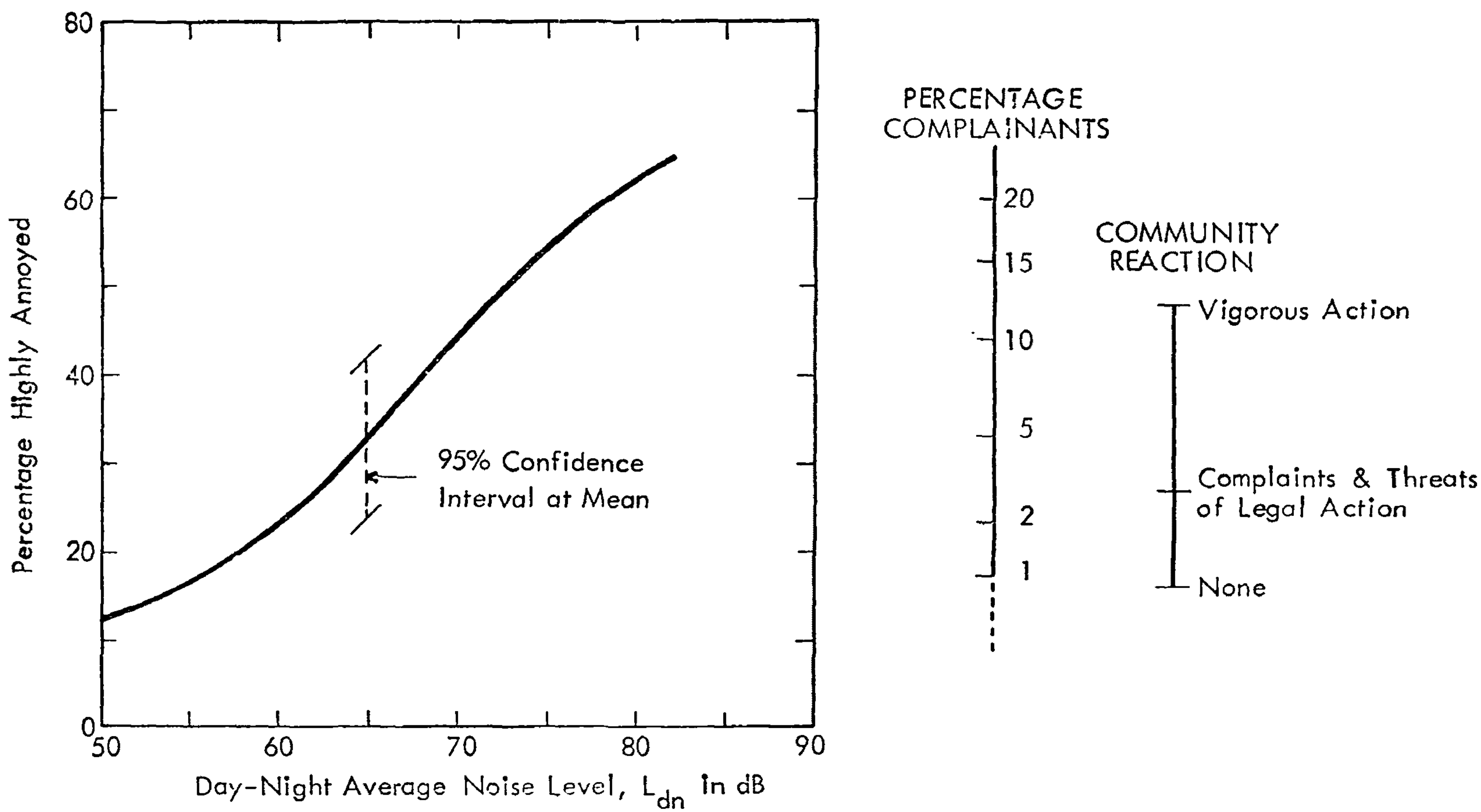

Figure 3. Intercomparison of Various Measures of Individual Annoyance and Community Reaction as A Function of the Day-Night Average Noise Level, L_{dn} in Decibels.

level. The results are in complete agreement with the conclusions of a recent analysis of British, French and Dutch survey results, conducted by the Organization for Economic Co-Operation and Development (OECD) (Ref. 20).

As part of the Tracor analyses, a relationship was derived between the number of people highly annoyed and the number of people who actually lodged complaints about the noise. A scale based on this relation is also shown on Figure 3.

As a final comparison, a scale showing differing degrees of overt community response is shown at the far right on Figure 3. This scale represents responses to a variety of noises, not only aircraft, based on the 55-case study described in Appendix D. On the average, adverse community reaction to noise becomes of serious concern at values of L_{dn} over 60 dB.

Individual annoyance and complaint data are summarized in Table 4. The percentage of complaints varies from 2 to 22% over the L_{dn} range of 60-80 dB, an average rate of increase of 1% per dB. In this same range of noise levels, the rate of increase in the percentage of people who are highly annoyed increases from 23 to 62%, an average rate of 2% per dB. However, for values of L_{dn} less than 60 dB the rate of increase in the percentage of people highly annoyed increases at a lower rate, an average of 1% per dB.

One may conclude that, at values of the day-night average sound level greater than 60 dB, the rate of increase of annoyance with an increase in noise is substantially greater than at lower levels, a conclusion that is also evident from the change of slope of the curve in Figure 3.

In summary, to achieve an environment in which no more than 20% of the population are expected to be highly annoyed and no more than 2% actually to complain of noise, the outdoor day-night average sound level should be less than 60 decibels. Higher noise levels must be considered to be annoying to an appreciable part of the population, and consequently to interfere directly with their health and welfare.

Table 4

Percentages of the population near airports who are highly annoyed and who lodge complaints about noise, for various values of the day-night average sound level of aircraft noise (from Figure 3)

Outdoor Day-Night Average Noise Level in dB	Percentage Highly Annoyed	Percentage Complainants
50	13	less than 1
55	17	1
60	23	2
65	33	5
70	44	10
75	54	15
80	62	over 20

GENERAL HEALTH EFFECTS OF NOISE

Although there is the possibility that noise of high level or extreme fluctuations may contribute indirectly to the incidence of non-auditory diseases, no conclusive evidence to support this possibility has been documented. Most experts agree that there is no well-established effect of noise on health (in the more restricted sense, i. e., the absence of disease) besides noise-induced hearing loss. A recent critical review of this subject (Ref. 21) came to the conclusion "if noise control sufficient to protect persons from ear damage and hearing loss were instituted, then it is highly unlikely that the noises of lower level and duration resulting from this effort could directly induce non-auditory disease."

The maximum permissible noise levels with respect to health effects on the hearing organ, proposed in the section on hearing loss above, are 5 to 10 dB more protective than the hearing conservation criteria and standards presently used by the Federal Government and Industry (Occupational Safety and Health Act of 1970). Therefore, according to present day knowledge, exposures to levels below the 80 dB limit recommended here should be considered acceptable as far as their direct contribution to non-auditory diseases is concerned.

This is not to say that there are no indications to arouse concern in this area; but a substantial amount of research on non-auditory effects of noise on health would be required to alter the above statements. Such research should be fostered and the results should be carefully monitored for any evidence indicating that the maximum permissible average sound levels recommended herein are excessive.

Sleep disturbance due to noises is a potential indirect health effect of considerable concern, for it can certainly affect psychological well being, irritability and mood (Ref 21). The awakening effect of noise depends on the characteristics of the individual person and the noise (such as time of night, age of individual, etc.). Noise limits for sleep interference cannot yet be so clearly established as for the risk of hearing loss or for speech interference. However, in quiet bedrooms, sound levels below 30 dB have ordinarily no arousal effects, while steady noise above 50 dB resulted in numerous complaints.

The maximum permissible outdoor level of L_{dn} = 60 dB, proposed above in order to limit people's annoyance due to noise, would provide average sound levels from exterior noise sources below 35 dB at night in an average bedroom with closed windows. The levels in a bedroom with open windows could, of course, be higher but it is reasonable to expect people who open their windows at night to be able to accommodate to slightly higher levels. While individual noise events might still be audible even in the presence of heating and air conditioning equipment, and might sometimes result in changes of sleep pattern, they would be considered for the most part as normal and acceptable by the large percentage of the US population living in an airport environment today. It does not appear that much would be gained by setting the goal for day-night average sound level lower than 60 dB, for this would not necessarily protect against occasional individual noise events of short duration but of high arousal/annoyance value. The permissible day-night average sound level should not be set unrealistically low in an attempt to account for the effects of individual events of low probability which are not "cumulative" effects. It is recommended instead, that maximum sound levels during the night should be controlled through separate local noise ordinances, if desirable and necessary.

Experience has shown (Appendix A) that, for typical traffic, airport and city noises, when the day/night difference in the equivalent noise level is 10 dB or more, the daytime exposure is the main concern with respect to potential speech interference and annoyance. In these situations, a maximum permissible outdoor L_{dn} of 60 dB, will generally cause negligible speech interference or annoyance during daytime, and will most likely cause no adverse effects on night-time sleep in normal people accustomed to the environment, even with windows partially open.

NATURAL INDOOR NOISE "FLOOR"

An important consideration in choosing criteria of acceptable environmental noise is the indoor noise level to be expected in residential areas irrespective of the outdoor noise environment. It clearly makes little sense to establish criteria for external noise sources that would lead to indoor levels lower than the "self-noise" of residential living.

While few reported data are available on the variation of noise levels within homes housing a variety of different life styles, some limited information can be provided. The following measured values are considered representative of indoor average sound levels where external noise intrusion is not significant, as seen in Table 5.

Table 5

Condition	L_{eq} - dB
Typical people movement, no TV or radio	40 - 45
Speech at 10 feet, normal voice	55
TV listening level at 10 feet, no other activity	55 - 60
Stereo music	50 - 70

It should be noted that these values are average sound levels, not the maximum sound levels, which for speech, music, and appliances can range up to 75 to 80 dB for short durations. During sleeping hours when no appliances, TV or radio are in operation, internally generated noise levels will be lower.

It is reasonable to conclude that in a typical quiet residential environment, values of L_{eq} between 40 and 45 due to domestic activities alone, are as low as can be expected during waking hours. There is no reason, therefore, to reduce daytime outdoor noise levels below the point where the corresponding indoor intrusion is less than about 40 to 45 dB.

The day-night average sound level outdoors is greater than the daytime average sound level (L_d) by 0-3 dB, for differences of L_d and L_n between 10 and 4 dB, respectively. For a typical house with open windows, the noise reduction between indoors and outdoors is 15 dB. Therefore, the values of an outdoor L_{dn} expected to produce a daytime average sound level of 40 dB indoors are 55 to 58 dB, and those expected to produce an indoor daytime level of 45 dB are 60 to 63 dB. These values of outdoor L_{dn} can be increased by 10 dB if the windows are closed.

It is concluded that values of outdoor day-night average sound level ranging between 55 and 63 dB produce indoor daytime noise levels with open windows equal to the natural indoor noise floor inside houses. Lowering the outdoor noise level below these values would be of little value inside houses, since the natural indoor noise floor will control the indoor noise levels.

NUMBER OF PEOPLE IMPACTED VERSUS VARIOUS GOALS FOR THE DAY-NIGHT AVERAGE SOUND LEVEL

The most direct method of assessing the impact of environmental noise and the implications of selecting specific levels of permissible cumulative exposure is to count the number of people affected as a function of the value of the day-night average noise level to which they are exposed. Table 6 summarizes the results of a preliminary estimate of the number of people exposed to various levels of noise from each of the three major sources of high level environmental noise: freeways, airports and urban traffic in densely populated cities.

Table 6

Estimated Number of People Exposed to Noise From Aircraft Operations, Freeway Traffic and Urban Road and Street Traffic at Various Values of Outdoor Day-Night Average Sound Level

Number of People in Millions				
L_{dn} exceeds	Freeway Traffic	Aircraft Operations	Urban* Traffic	Total**
60 dB	3.1	16	18.0	37.1
65 dB	2.5	7.5	7.5	17.5
70 dB	1.9	3.4	3.2	8.5
75 dB	0.9	1.5	0.6	2.4
80 dB	0.3	0.2	0.1	0.6

*Based only on cities having populations greater than 25,000, comprising a total population base of only 92 million.

**There may be some duplication of people in these totals.

The freeway neighborhood population estimates are based on data provided in the EPA report to Congress (Ref. 1) and on noise level data for typical urban freeways. The airport neighborhood population estimates are based on data in the report of the Aviation Advisory Commission (Ref. 22) and in the EPA report to Congress (Ref 23). The urban population estimates are based on data contained in Ref. 24 for the 92 million people living in cities having populations greater than 25,000.

The total number of persons exposed to noise from all three sources is at least 18% of the total population at an L_{dn} level of 60 dB and over 8% of the population at an L_{dn} level of 65 dB. For these levels of L_{dn}, the number of people affected by urban traffic noise is equal to or greater than the number affected by aircraft operations in the vicinity of airports. This result is not surprising, because an L_{dn} of 60 dB is typical throughout urban neighborhoods with detached housing in major cities, and an L_{dn} of 65 is typical for noisy urban neighborhoods.

The total number of persons estimated to be affected at a L_{dn} of 80 dB or more is about 0.3% of the total population, one-third of whom are affected by aircraft noise. These persons may be subject to risk of hearing damage if they reside for many years in such an environment.

There are three possible approaches to reducing the number of people affected by noise. They are:

1. Reduce the noise at its source and/or restrict the number of noisy operations.
2. Increase the noise reduction in the sound paths between the source and the people.
3. Move the people away from the noise.

Various methods for reducing aircraft noise at its source or for controlling the number of operations and the associated economic impacts are the subject of other task force reports in this series. Similar assessments for reducing surface vehicle noise at its source will be contained in future EPA documents.

With respect to the second possible approach, the noise reduction of a dwelling may be increased by 10 to 20 decibels at a cost of approximately \$3,000 - \$5,000 respectively for a 1500 square foot detached house. (Ref. 25.) If the noise levels within dwelling units currently exposed to outdoor levels of L_{dn} of 60 dB were to be reduced to values comparable with an outside L_{dn} of 60 dB or less by use of noise control treatment, it is estimated that the cost for these 37 million people would be 30 to 40 billion dollars. If 5 dB greater noise were allowed indoors, equivalent to an outdoor L_{dn} of 65 dB, the estimated noise control cost would be 12 to 17 billion dollars for the 17.5 million people affected. Naturally this solution would be effective only indoors with windows closed; the outdoor environment would be unchanged. This situation could be improved with respect to traffic noise by the use of suitable barriers and acoustical absorption to supplement the exterior house wall treatment. However, such supplementary efforts are impractical for the noise from aircraft flight operations, and consequently, the second possibility of increased noise reduction may never yield acceptable protection against aircraft noise heard outdoors.

The third alternative of moving people away from the noise does not appear to be practicable on a large scale. The direct costs for implementation greatly exceed those estimated for noise control treatment, except where they can be offset by conversion of land from residential to commercial or industrial uses. Such conversion may be practical and economically feasible in the immediate vicinity of some airports. The applicability and economic feasibility of this approach must be determined for each local situation.

SUMMARY OF EFFECTS OF NOISE ON PEOPLE AT VARIOUS VALUES OF DAY-NIGHT AVERAGE SOUND LEVEL

In the preceding sections the effects of noise on various human activities and responses have been reviewed. In order to assess the implications of specifying different values as limits for maximum permissible day-night average sound level, the available data are summarized in Table 7.

TABLE 7. HEALTH EFFECTS OF NOISE AT DIFFERENT VALUES OF OUTDOOR DAY-NIGHT AVERAGE SOUND LEVEL, L_{dn}, IN DECIBELS

	HEARING		SPEECH		ANNOYANCE	
Outdoor Day-Night Average Sound Level in Decibels re-20 micronewtons per square meter	Hearing Risk for Speech in % of Exposed People	Percent of Exposed People With Permanent Threshold Shift (5 Decibels at 4000 Hertz)	Maximum Speech Interference* in Percent OUTDOORS**	INDOORS***	Highly Annoyed in % of Exposed People	Complainants in % of Exposed People
50	0	0	0.8	0.1	13	1
60	0	0	2.5	0.1	23	2
70	0	0	53	0.1	44	10
80	0	4	100	1.5	62	20
90	8	66	100	3.2	– UNKNOWN	–

* Percentage of key words misunderstood in spoken sentences.

** Normal voice effort and 2 meter separation between talker and listener. When speech interference is excessive the average communication can be improved by reducing separation distance and/or raising voice level. For example, with an L_{dn} of 80 dB the average interference will not exceed 5% for a separation of 0.5 meter and raised voice level.

*** 15 decibels noise reduction through partially opened windows, and relaxed conversational effort.

Example: When the day-night average sound level is 90 decibels outdoors:

HEARING RISK:
The percentage of people suffering a hearing handicap in a group exposed to this level of noise is expected to be 8 percentage points higher than the percentage of people with hearing handicaps in a group, otherwise similar, who are *not* exposed to noise levels of this magnitude. (This column refers only to hearing impairment in the frequency range most important to understanding speech frequencies of the 500, 1000 and 2000 Hertz (cycles per second) bands.)

66% of the entire population is expected to have a noise induced permanent threshold shift greater than 5 decibels at a frequency of 4000 Hertz (cycles per second).

SPEECH INTERFERENCE:
For conversation outdoors, the percentage of key words misunderstood in spoken sentences will be 100%, and for conversation indoors, 3.2%."Maximum Speech Interference" here refers to conditions of continuous steady noise; the speech interference would be less for *intermittent* noise and substantially less for *infrequent* intermittent intrusions corresponding to the same value of Day-Night Average Sound Level.

ANNOYANCE:
The number of noise exposed people who are highly annoyed and the number who are expected to complain about the noise are unknown for this level of exposure, but they are greater than 62% and 20%, respectively, which are the values appropriate to an outdoor L_{dn} of 80 decibels.

SECTION 4

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

The Task Group arrived at the following conclusions:

1. For the characterization of the cumulative impact of noise environments on human health and welfare a single noise measure is required for use by the Federal Government. This measure must be the same for all types of noises so that the contributions of various types of noise source to the total environmental exposure can be identified.

2. Evaluation of existing and proposed methods available for the description of environmental noise leads to recommendation of the day-night A-weighted average sound level as the method of choice. The method is described in detail in Section 1; it can be related to other more complicated methods in use for special applications as discussed in Appendix A. The method has the following advantages:

   - It is relatively simple.
   - It can be used for the prediction of noise environments in land use planning studies as well as for the measurement and economical monitoring of existing noise environments.
   - A-weighted sound level has been shown to correlate well with the various effects of noise on people.

   The method has the following shortcomings:

   - To evaluate the effect of noise on human annoyance, better weighting functions than A-weighting may be possible (for example, a D-type weighting). However, the evidence is not conclusive and no network for such weighting has yet been standardized.

- The method does not account for pure tone components or for impulsive character in the noise. These noise characteristics have a definite influence on the annoyance value of some aircraft noise (for example, compressor noise and helicopter noise). Neglecting these characteristics in the proposed measure makes their control by other means necessary (emission/certification standards). None of these shortcomings is considered serious enough to justify delay in adopting a common measure. It is emphasized that this measure of day-night average sound level is not intended for use in determining compliance of product noise with specifications or individual source noise certification.

3. To specify maximum permissible noise exposure with respect to human health and welfare, the selected measure must be used not only to describe the noise environment of a given location; but must be extended to describe the noise environment to which individuals and populations are exposed during their 24-hour living routines. This leads to the concept of the average sound level to which individuals and populations are exposed as the only reasonable and defensible primary measure for limiting human exposure to noise. The average sound level depends on the noise to which individuals are exposed, indoors and outdoors, at home, at work, in school, etc. Human exposure, as assessed by this primary measure, can therefore be controlled not only by controlling the average sound level of the outdoor environment but also by modifying the noise reduction effected by buildings. The measure gives a clear and objective basis for land use planning and for zoning and can take into account changes in climate, life style, etc.

4. The measure of day-night average sound level (L_{dn}) can be used to predict the effects on a population of the average long term exposure to environment noise. These relationships, as outlined in Section 3 for noise induced permanent hearing loss, interruption of speech communication, and individual annoyance, should be used for choosing maximum permissible average sound

levels. Compliance with the maximum permissible average sound level can be monitored by relatively simple and available instrumentation.

5. To avoid significant long-term effects of environmental noise on human hearing (i.e., to avoid any effect after 10 years in at least ninety percent of the population) requires an average outdoor $L_{dn} \leq 83$ dB* according to strict application of current scientific test data. A reasonably conservative choice of a criterion of acceptable exposure would be $L_{dn} \leq 80$ dB. Other permanent or disease producing health effects cannot yet be quantitatively correlated with cumulative exposure.

6. An outdoor L_{dn} of approximately 60 dB or less is required in order that no more than 23% of the population exposed to noise would be individually highly annoyed. (The same average sound level would guarantee that, on the average, 95% effective speech conversation at two meters distance outdoors would be possible at all times, and normal domestic speech activities are possible indoors, with open windows.) It therefore appears reasonable to propose an L_{dn} of 55 to 60 dB as the long range goal for maximum permissible average sound level with respect to health and welfare. (Note that this level is not considered optimum, merely the upper limit of permissibility. No endorsement is intended of degradation of existing areas having a lower noise level.) Adoption of such a goal must be examined in terms of the overall context of the Noise Control Act of 1972, including the effects of such a choice on the total public welfare of the nation.

7. According to the estimates in the Table 5, a goal of $L_{dn} \leqslant 60$ dB has the implications that the noise exposure environment from all noise sources must be changed for approximately 15% of the US population. To consider a general nation-wide goal of $L_{dn} \leq 55$ dB appears unrealistic at this point for two reasons: (a) It means changing the noise environment of almost 40% of the US population at a tremendous economic penalty. (b) There is no clear evidence that lowering

*The symbol $\leqslant$ means "less than or equal to" the average noise level to this limit would reduce the percentage of people annoyed by occasional noise events or at occasional times during their life (Section 3). An environment in which not even a small percentage of the population will be annoyed by some noise events a small percentage of the time appears to be a utopian and unrealistic goal. The disturbance by individual noise events and occasional high noise levels should be controlled by maximum permissible noise levels for individual events established by local authorities. Control over such events should not be attempted by lowering the average sound level.

8. The absence of a pure-tone penalty in the basic measure for average sound level (See 2 above and Section 1) is based on the assumption that pure tone components are primarily to be controlled by emission control standards. As long as such standards are not effective or in cases where, for technological or other reasons, significant pure tone components remain, it is advisable to consider them in the detailed prediction/land use planning procedure. The effective perceived noise level methodology (CNR and NEF) is adequate for this. However, to arrive at the day-night average sound level, which can be validated by measurements and compared to other noise exposures, such data must be approximated by the average sound level as described in Section 2. For environments where pure tones are known to be present, local authorities should lower the recommended maximum permissible day-night average sound level by 2 to 5 dB. Monitoring of average sound level is then possible with the same simple instrumentation. (Situations where this procedure might be advantageously applied are the approach area of military jets having no pure-tone intake noise control, or helicopter noise exposures, and others.)

9. In summary, it is a realistic goal to keep the day/night average sound level below 60 dB in residential areas, where the average includes a 10 decibel penalty on nighttime noise levels. In conjunction with noise emission standards and local control of individual noise events, such a limit is expected to insure, according to present knowledge, a noise environment without significant effect on public health and welfare.

RECOMMENDATIONS

The task group recommends the following actions:

1. The Environmental Protection Agency and other Federal Agencies should adopt as soon as possible, the day-night A-weighted average sound level as the measure for environmental noise. At such time as a suitable "D-type weighting" becomes standardized and available in commercial instruments, its value as a weighting for environmental noise should be considered, to determine whether or not it should replace the A-weighting recommended here.

2. For the aircraft noise study and aircraft noise standards required by the Noise Control Act of 1972, the recommended measure should be used to identify levels of cumulative noise exposure and to study the implications of achieving specific levels of permissible cumulative noise exposure. It should be used for cost benefit studies, planning, monitoring and enforcement.

3. The prediction procedures for day-night average sound level from aircraft operations, ground traffic and other major noise sources should be standardized in all details for uniform use by all Government Agencies. Although the differences in procedures used by DOT, DOD, HUD, and in the California airport noise law are small, and the effects of these differences on the final exposure prediction are minor, these differences will continue to be used as excuses against the practical implementation and enforcement of the day-night average noise level. There is no good technical or other reas to have a detailed standardized method. (See Section 2.)

4. Predictions for land-use planning purposes of day-night aver level from aircraft operations should not consider the noise fror sources in the initial analysis. On the other hand, development egulatory actions based on day-night average sound level must conside the contributions, if any, of other noise sources to the values of L_{dn} at any point in the community.

5. To protect the public health and welfare against the risk of any measurable permanent noise induced hearing loss, with adequate margin of safety, and

to protect the public against completely unacceptable amounts of annoyance and speech interference, a yearly outdoor day-night average sound level of 80 decibels in residential areas should, as soon as possible, be promulgated as the permissible limit. Exceptions to this maximum permissible noise level must be based on zoning regulations and/or building codes that will assure a maximum average sound level (not day-night average!) of the occupants (allowing for a reasonable combination of indoor and outdoor exposures, based on the expected living styles of the community) not exceeding 75 dB.

6. A yearly day-night average sound level of 60 dB or below should be the long range limit of the EPA for environmental noise quality in residential areas with respect to health and welfare. For specific situations local authorities may prescribe lower noise levels, particularly for areas that have a quieter environment now, and for which there is no planned requirement in the public interest to allow noise levels to increase to the maximum permissible level. Exceptions to the outdoor $L_{dn} \leq 60$ dB may be based on zoning regulations, building codes and/or expected lifestyles, provided the indoor L_{dn} predicted to reach the individual ear from environmental (not produced by the individual) noise is less than 45 dB.

7. The time schedule for implementation of the $L_{dn} \leq 60$ dB goal with respect to aircraft noise should be based on detailed economic and technological feasibility studies, and should agree with a similar schedule to reach this goal with respect to other noise sources, such as traffic noise. To achieve this goal, public understanding must be raised of the noise exposure problem, the proposed measure of noise exposure, the noise exposed zones and the permissible noise levels with respect to health and welfare.

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APPENDIX A

JUSTIFICATION OF THE USE OF THE AVERAGE SOUND LEVEL AS A MEASURE OF COMMUNITY NOISE

PROBLEMS TO BE RESOLVED IN CHOOSING A NOISE MEASURE

NEED FOR A SIMPLE AND PRACTICAL RATING SCHEME

All efforts to alleviate noise pollution must finally rest on the means for describing the magnitude of the noise problem as it affects human beings. To assess the present noise exposure, to establish criteria for an acceptable noise environment, to limit the noise output of especially prominent sources of disturbance -- all these goals demand the adoption of a rating scheme, such that a numerical evaluation of the noise (preferably in terms of a single number) will bear a meaningful relation to the amount of public disturbance caused by the noise. Thus, we look for ways to measure the physical properties of the community noise exposure that are closely connected with people's subjective judgment. We measure, with acoustical test equipment, certain aspects of the noise that, either alone or in combination, can be used to predict accurately how people will respond to the noise.

The question of what and how much to measure is important in choosing a measure to characterize community noise, largely because of the economic implications of the cost of making measurements. It is more expensive to make "complicated" measurements than "simple" ones. Thus, for a given measurement budget, one can, for example, mount a more extensive survey, covering a greater area of the community, if the data to be taken are relatively simple. Of course, recent technological advances in logic circuitry have made it possible to make certain relatively complex measurements routinely and simply. It is a question of choosing between the ultimate refinement in measurement techniques and a practical measurement approach that is no more complicated than is needed to predict the impact of noise on the people, and that can be extensively applied at a reasonable cost.

FREQUENCY ANALYSIS OF THE NOISE AND THE A-WEIGHTED SOUND LEVEL

One of the most useful ways to characterize a noise is by a frequency analysis, because people not only distinguish the high-frequency components from the low-frequency components in a composite noise, but they find high frequency noises much more annoying than low-frequency noises of the same level. Therefore, to evaluate how disturbing each noise will be, we should know how much of the sound energy in that noise is contained in each band of frequency. This means keeping track of an entire set of frequency-band sound levels for each noise: as many as nine different numbers for octave-band data, or twenty-five different numbers for 1/3 octave band data, to cover the important frequency range from 31 to 8000 Hz.

Fortunately, much of this complication can be avoided by the use of a special electrical weighting network in the measurement system, that simulates the response of the average human ear to sounds of different frequency: each frequency of the noise then contributes to the total reading an amount approximately proportional to the subjective response associated with that frequency. Measurement of the overall noise with a sound level meter incorporating such a weighting network yields a single number such as the A-weighted Sound Level, or simply sound-level, in decibels.

For zoning and monitoring purposes this choice marks an enormous simplification and a significant economy. For this reason, A-weighted Sound Level has been adopted without exception in large-scale surveys of city noise coming from a variety of sources. It is universally accepted as an adequate way to deal with the ear's differing sensitivity to sounds of different frequency. The magnitude aspect of a noise can then be handled in terms of greater or smaller sound-levels.

NOISE ABATEMENT AND SIMPLE RATINGS

The dominant characteristic of environmental noise is that it is not steady -- at any particular location the noise usually fluctuates considerably, from quiet at one instant to loud the next. Thus, we cannot simply say that the noise level at that location is "so-many decibels." To describe the noise exposure completely requires a statistical approach. Consequently, we should speak of the "noise exposure" at a location, meaning the whole time-varying pattern of sound levels. Such a noise exposure can be described by giving the complete curve depicting the cumulative distribution of sound levels, showing exactly what percent of the whole observation period each level was exceeded.

A complete description of the noise exposure would distinguish between daytime, evening and night time, and between week-day and week-end noise level distributions; it would also give distributions to show the difference between winter and summer, fair weather and foul.

The practical difficulty with the statistical methodology is that it yields a large number of statistical parameters for each measuring location; and even if these were averaged over more or less homogeneous neighborhoods it still would require several numbers to characterize the noise exposure in that neighborhood. It is literally impossible for any such array of numbers to be effectively used either in an enforcement context, for the purpose of noise abatement or to map out existing noise exposure base lines.

It is essential therefore, to look further for a suitable single-number evaluation of community neighborhood noise exposure. Note that the ultimate goal in noise abatement is to characterize with reasonable accuracy the noise exposure of whole neighborhoods (within which there may actually exist a fairly wide range of noise levels) so as to prevent extremes of noise exposure at any given time, and to detect unfavorable trends in the future noise climate. For these purposes, pinpoint accuracy and masses of data for each location are not required, and may even be a hindrance, since one could fail to see the forest for the trees.

A noise measure must be found that collapses the array of statistical parameters described above into a single usable figure for describing the noise exposure of a neighborhood, even if that simplification entails some compromise with the current standard of highest attainable accuracy.

AVERAGE SOUND LEVEL

The average sound level, sometimes called the equivalent continuous noise level (both having the symbol L_{eq}) is the continuous sound-level that is equivalent, in terms of noise energy content, to the actual fluctuating noise existing at the location over the observation period.* The Equivalent Continuous Noise Level was developed in Germany over a period of years and was introduced in 1965 as a rating specifically to evaluate the impact of aircraft noise upon the neighbors of airports[26]. It was almost immediately recognized in Austria as appropriate for evaluating the impact of street traffic noise in dwellings[27], and in schoolrooms[28]. It has been embodied in the National Test Standards of both East Germany[29] and West Germany[30] for rating the subjective effects of fluctuating noises of all kinds, such as from street and road traffic, rail traffic, canal and river ship traffic, aircraft, industrial operations (including the noise from individual machines), sports stadiums, playgrounds, etc. It is the rating used in both the East German[31] and West German[32] standard guidelines for city planning. It was the rating that turned out to correlate best with subjective response in the large Swedish traffic noise survey of 1966-67. It has come into such general use in Sweden for rating noise exposure that commercial instrumentation is currently available for measuring L_{eq} directly; the lightweight unit is small enough to be held in one hand and can be operated either from batteries or an electrical outlet[33].

During the period when the L_{eq} rating was coming into wide acceptance in Europe, there was little familiarity with it in this country, because the relevant literature was not available in English. One exception was the use of the concept of equivalent level in the 1957 original Air Force Planning Guide for noise from aircraft operations[34]. A more recent application is the development of the CNEL (Community Noise Equivalent Level) measure for describing the noise environment of airports. This measure, contained in the Noise Standards, Title 4, Subchapter 6, of the California Administrative Code (1970) is based upon a summation of L_{eq} over a 24 hour period with weightings for exposure during evening and night periods.

*L_{eq} is read "L-equivalent".

RELATED APPLICATIONS OF THE ENERGY EQUIVALENCE CONCEPT

The concept of representing a fluctuating noise level in terms of a steady noise having the same energy content is widespread in recent research. There is solid experimental evidence that it accurately describes the onset and progress of permanent noise-induced hearing loss[35], and considerable evidence to show that something very much like it applies to annoyance in various circumstances[36]. The concept is approximately borne out by Pearson's experiments[37] on the trade-off of level and duration of a noisy event, and by numerous investigations of the trade-off between number of events and noise level in aircraft flyovers[38]. Indeed, the Composite Noise Rating currently in use by the FAA[38] is a formulation of L_{eq}, modified by corrections for day vs. night operations, etc. The concept is embodied in several recommendations of the International Standards Organization, for assessing the noise from aircraft[39], industrial noise as it affects residences[40], and hearing conservation in factories.[41]

AVERAGE SOUND LEVEL AND ITS RELATIONSHIP TO OTHER NOISE MEASURES

EXPRESSIONS FOR AVERAGE SOUND LEVEL

The basic definition of L_{dn}, apart from the nighttime penalty, is formulated in terms of the equivalent steady noise level, L_{eq}, that in a stated period of time would contain the same noise energy as the time-varying noise during the same time period. That is,

$$10^{\frac{L_{eq}}{10}} = \frac{1}{t_2 - t_1} \int_{t_1}^{t_2} \frac{p^2}{p_o^2} \, dt$$

In many applications it is useful to have analytic expressions for the average sound level L_{eq} in terms of simple parameters of the time-varying noise signal, so that the integral does not have to be computed. It is often sufficiently accurate to approximate a complicated time-varying noise level with simple time patterns. For example, industrial noise can often be considered simply in terms of a specified noise level that is either on or off as a function of time. Similarly, individual aircraft or motor vehicle noise events can be considered to exhibit triangular time patterns that occur intermittently during a period of observation. (Assuming an aircraft flyover time pattern to be triangular in shape instead of shaped like a "normal distribution function" introduces an error of, at worst, 0.7 dB). Other noise histories can often be approximated with trapezoidal time pattern shapes.

The following sections provide explicit analytic expressions for estimating the average sound level in terms of such time patterns, and graphic design charts are presented for easy application to practical problems. Most of the design charts are expressed in terms of how much (ΔL) the level of the new noise source exceeds an existing background noise level, L_b. This background noise may be considered as the existing (that is, before the introduction of the new noise) average sound level, provided that its fluctuation is small relative to the maximum value of the new noise level.

CONSTANT LEVEL NOISE -- STEADY OR INTERMITTENT

The L_{eq} for a continuous noise having a constant value of L_{max} is

$$L_{eq} = 10\log_{10} \frac{1}{T} \int_0^T 10^{\frac{L_{max}}{10}} dt = L_{max} \qquad \text{(dB)} \quad \text{(A-1)}$$

When L_{max} is intermittently on during the time period T, for a fraction, x, of the total time, with a background noise level L_b present for the time (1-x), L_{eq} is given by:

$$L_{eq} = L_b + 10\log_{10} \left[(1-x) + x \cdot 10^{\frac{\Delta L}{10}} \right] \qquad \text{(dB)} \quad \text{(A-2)}$$

where $\Delta L = L_{max} - L_b$. This expression is plotted in Figure A-1 for various values of ΔL and x. It can be seen from the figure that, for values of L_{max} that are 10 dB or more higher than L_b, L_{eq} is approximated quite accurately by:

$$L_{eq} = L_{max} + 10 \log x \qquad \text{(dB)} \quad \text{(A-3)}$$

Triangular Time Patterns

The average sound level for a single triangular time pattern having a maximum value of L_{max} and rising from a background level of L_b is given by:

$$L_{eq} = L_b + 10\log_{10} \frac{10}{2.3\Delta L} \left(10^{\frac{\Delta L}{10}} - 1\right) \qquad \text{(dB)} \quad \text{(A-4)}$$

where again $\Delta L = L_{max} - L_b$. When ΔL is greater than 10 dB, the following approximation for L_{eq} is quite accurate:

$$L_{eq} = L_{max} - 10\log_{10} \frac{2.3\Delta L}{10} \qquad \text{(dB)} \quad \text{(A-5)}$$

The value of L_{eq} for a series of n identical triangular time patterns having maximum levels of L_{max}, and durations measured between (L_{max} - 10 dB) points of τ seconds, and a background level of L_b, occurring during a total time period T, is given by:

$$L_{eq} = L_b + 10\log_{10} \left[1 + \frac{n\tau}{T} \left\{ \frac{10^{\frac{\Delta L}{10}} - 1}{2.3} - \frac{\Delta L}{10} \right\} \right] \qquad \text{(dB)} \quad \text{(A-6)}$$

A design chart for determining L_{eq} for different values of ΔL as a function of $n\tau$ per hour is provided in Figure A-2.

An approximation to equation (I-6) for cases where ΔL is greater than 10 dB is given by:

$$L_{eq} = L_{max} + 10\log \frac{n\tau}{2.3T} \qquad \text{(dB)} \quad \text{(A-7)}$$

Trapezoidal Time Patterns

The average sound level, L_{eq}, for a trapezoidal time pattern having maximum level of L_{max}, background level of L_b, duration between (L_{max} - 10 dB) points of τ, and duration at L_{max} of ξ is given by

$$L_{eq} = 10\log_{10} \frac{1}{\frac{(\tau-\xi)\,\Delta L}{10} + \frac{\xi}{2}} \left[10^{\frac{L_B}{10}} \cdot \frac{(\tau-\xi)}{2.3} \left(10^{\frac{\Delta L}{10}} - 1\right) + 10^{\frac{L_{max}}{10}} \cdot \frac{\xi}{2} \right]$$

$$\text{(dB)} \quad \text{(A-8)}$$

The approximation to L_{eq} when ΔL is greater than 10 dB, for ξ small compared to τ, is:

$$L_{eq} = L_{max} - \frac{2.3\Delta L}{10} + 10 \log \xi \qquad \text{(dB)} \quad \text{(A-9)}$$

Noting the similarity between equations (A-3), (A-5), and (A-9), one can approximate L_{eq} for a series of trapezoidal pulses by suitably combining design data from Figure A-1 and A-2. That is, the approximate L_{eq} for a series of n trapezoidal pulses is obtained by the L_{eq} value for triangular pulses plus an additional term equal to $10 \log_{10} n\xi$, e.g.,

$$L_{eq} = L_{max} + 10\log_{10} \frac{n\tau}{2.3T} + 10\log_{10} n\xi \qquad \text{(dB)} \quad \text{(A-10)}$$

Time Patterns of Noise Having a Normal Statistical Distribution

Many cases of noise exposures in communities have a noise level distribution that may be closely approximated by a normal statistical distribution. The average sound level for the distribution can be described simply in terms of its mean value, which for a normal distribution is L_{50}, and the standard deviation, s, of the noise level distribution:

$$L_{eq} = L_{50} + 0.115\, s^2 \qquad \text{(dB) (A-11)}$$

A design chart showing the difference between L_{eq} and L_{50} as a function of the standard deviation is provided in Figure A-3.

It is often of interest to know which percentile level of a normal distribution is equal in magnitude to the L_{eq} value for the distribution. A chart providing this relationship as a function of the standard deviation of the distribution is provided in Figure A-4.

Various noise criteria in use for highway noise are expressed in terms of the L_{10} value. For a normal distribution, the L_{10} value is specified in terms of the median and standard deviation by the expression $L_{10} = L_{50} + 1.28\, s$. The difference between L_{10} and L_{eq} is given by $L_{10} - L_{eq} = 1.28\, s - 0.115\, s^2$. This expression is plotted as a function of s in Figure A-5.

It should be noted that traffic noise does not always yield a normal distribution of noise levels, so caution should be used in determining exact differences between L_{eq} and L_{10}.

COMPARISON OF L_e, AND L_{dn}, AND OTHER NOISE MEASURES

Relationships Between L_e and EPNL For Aircraft

Basic certification measurements for aircraft subject to FAR Part 36 certification rules are reported in Effective Perceived Noise Level (EPNL) in dB. These values differ from the L_e based on sound level-A primarily due to the difference in frequency weighting of the sound pressure levels. No unique relationship exists for the numerical difference between L_e and EPNL, the actual difference being a function of the spectral shape of the sound. Further, EPNL has a provision for assessing a numerical penalty for the presence of pronounced tonal components in the spectrum, while L_e does not.

The numerical differences between EPNL and L_e are thus a function of aircraft type, engine power setting and distance from the aircraft, since air absorption changes with distance affect the spectral shape of the noise signal. In general, EPNL will be numerically greater than L_e. Typical values of this difference, for takeoff power settings, are from 1 to 5 dB. The differences at approach power settings range typically from 2 to 8 dB.

Comparison of L_{dn} with Composite Noise Rating (CNR), Noise Exposure Forecast (NEF), and Community Noise Equivalent Level (CNEL).

CNR, NEF, and CNEL are all currently used expressions for weighted, accumulated noise exposure. Each is intended to sum a series of noises, frequency weighting their sound pressure levels, and then adding nighttime penalties. The older ratings, CNR and NEF, are expressed in terms of maximum Perceived Noise Level and Effective Perceived Noise Level, respectively; each considers a day-night period identical to L_{dn}.

The measure CNEL iteself is essentially the same as L_{dn} except for the method of treating nighttime noises. In CNEL the 24-hour period is broken into three periods: day (0700-1900), evening (1900-2200), and night (2200-0700). Penalties of 5 dB are applied to the evening period and 10 dB to the night period. For most time distributions of aircraft noise around airports, the numerical difference between a two-period and three-period day are not significant, being of the order of several tenths of a decibel at most.

One difference between these four similar measures is the method of applying the nighttime weighting and the magnitude of the penalty. The original CNR concept, carried forward in the NEF, weighted the nighttime exposure by 10 dB. Because of the difference in total duration of the day and night periods, 15 and 9 hours respectively, a specific noise level at night receives a penalty of $10 + 10 \log_{10} (\frac{15}{9})$ or approximately 12 dB in a reckoning of total exposure. Given the choice of weighting either exposure or level, it is simpler to weight level directly, particularly when actual noise monitoring is eventually considered.

There is no fixed relationship between L_{dn} or CNEL and CNR or NEF, because of the differences between the A-level and PNL frequency weightings and the allowance for duration, as well as the minor differences in approach to day/night considerations. *Nevertheless, one may translate from one measure to another by the following* approximate relationship:

$$L_{dn} \doteq \text{CNEL} \doteq \text{NEF} + 35 \doteq \text{CNR} - 35$$

For most circumstances involving aircraft flyover noise these relationships are valid within about a ±3 dB tolerance.

Comparison of L_{eq} with HUD Guideline Interim Standards (1390.2 chg. 1).

The interim HUD standards for outdoor noise are specified for all noise sources, other than aircraft, in terms of A-weighted sound level not to be exceeded more than a certain fraction of the day. Aircraft noise criteria are stated in terms of NEF or CNR.

The HUD exposure criteria for residences near airports are "normally acceptable" if NEF 30 or CNR 100 is not exceeded. A "discretionary acceptable" category permits exposures up to NEF 40 or CNR 115.

For all other noise sources the HUD criteria specify a series of acceptable, discretionary and unacceptable exposures. Since these specifications are similar to points on a cumulative statistical description of noise levels, it is of interest to compare the

HUD criteria with L_{eq} for different situations. For discussion purposes, consider the boundary between the categories "discretionary-normally acceptable" and "unacceptable."

The first criterion defining this boundary allows A-weighted noise levels to exceed 65 dB up to 8 hours per 24 hours, while the second criterion states that noise levels exceeding 80 dB should not exceed 60 minutes per 24 hours. These two values may be used to specify two limit points on a cumulative distribution function. The relationship between L_{eq} and the HUD criteria may then be examined for different types of distribution functions, restricting the shape of the distribution only so that it does not exceed these two limit points.

First consider two cases of a normal distribution of noise levels, comparable to vehicle traffic noise. For the first case, assume a distribution with quite narrow variance so placed on the graph that the 65 dB point is not exceeded (see Fig. A-6). For this curve, to the nearest decibel, L_{50} = 64 dB, and the corresponding standard deviation (arbitrarily chosen small) is 2.3 dB. The resulting L_{eq} is equal to 64.6 dB.

Now consider a normal distribution with the widest permissible variance (the curve marked Maximum Variance in Figure A-6); if the variance were any greater, the distribution would violate HUD's requirement that the level not exceed 80 dB for more than 60 minutes per 24 hours. This distribution, to the nearest decibel, has L_{50} = 60 dB, L_{10} = 74 dB, and a standard deviation of approximately 11 dB. The resultant L_{eq} = 74 dB, is almost 10 dB higher than for the previous case. Both curves meet HUD's interim standards.

Next, consider a series of intermittent high level noises, superposed on a typical urban/suburban background noise level, such that 80 dB is not exceeded more than 60 minutes per 24 hours, say 4%. Choosing a series of repeated triangular-shaped time signals of 90 dB maximum sound level will produce an L_{eq} value of 72.4 dB without exceeding an L_4 value of 80 dB.

However, one can allow the maximum level to increase indefinitely provided that L_4 remains at 80 dB or less. The limiting case is that of a square-shaped time pattern, switched on and off. In this instance, if the total "on-time" is 4% or less, the value of L_{eq} is equal to L_{max} - 14 dB, and both L_{max} and L_{eq} can increase without limit and still remain acceptable within the HUD interim standards. Maximum A-levels for an aircraft can be as high as 110 dB, which would permit L_{eq} values of 96 to be obtained without exceeding the L_4 limit of 80 dB.

It is clear that no unique relationship can be specified between the HUD non-airport standards and L_{eq}. Values of L_{eq} ranging up to 95 dB can be found in compliance with the HUD outdoor noise standard depending on the time distribution of noise levels considered. Even if the night-time penalty were applied to L_{eq} to yield L_{dn} there would still be no unique relation with the HUD standards.

Comparison of L_{eq} with Federal Highway Administration Noise Standards, PPM 90-2, February 8, 1973

The primary criteria of PPM 90-2 are that L_{10} for noise levels inside people-occupied spaces shall not exceed 55 dB, or for sensitive outdoor spaces "--in which serenity and quiet are of extra-ordinary significance---," 60 dB.

Highway noise characteristically yields a random distribution of noise level, the distribution function being approximately normal in many instances. In this case, the relationship between L_{eq} and L_{10} is given by the expression:

$$L_{eq} = L_{10} - 1.28\ s + 0.115\ s^2$$

where s is the standard deviation of the noise level distribution. The difference between L_{10} and L_{eq} for normal distribution of sound level is plotted in Figure A-5. It can be noted that $L_{eq} = L_{10}$ - 2 dB within ±2 dB, for s ranging from 0 to 11 dB. Highway noise rarely has a standard deviation of 11 dB; 2 to 5 dB is more typical.

Thus, setting L_{10} at 60 dB for highway noise impacting a sensitive outdoor space, we find that an L_{eq} value of 60 -2 = 58 ± 2 dB would meet the most sensitive FHWA criterion.

Relationship of L_{eq} with the Proposed FAA Aircraft Sound Description System (ASDS)

FAA is considering the adoption of ASDS for use as an airport noise descriptor. Basically, ASDS defines the extent of noise exposure, for each aircraft type, in terms of the area defined by the maximum A-weighted sound level, per aircraft event, equal to 85 dB, and a time constant per aircraft type and operation that provides a weighting based on the duration during which the level at various areas within the 85 dB contour exceeds 85 dB. While specific time constants are derived for different aircraft types, it is assumed that a 15 second duration could often be used as a nominal value for takeoff operations and 10 seconds for approach operations.

A second part of the ASDS is the computation of the Situation Index (SI) which is a linear summation of areas and durations obtained over all operations to obtain the quantity "acre-minutes."

The ASDS concept does not allow any direct comparison to energy equivalents except on the 85 dB boundary, since both sound level and duration vary continuously on either side of the boundary. The only comparison that can be made is the relationship between single event values of L_e at the boundary. For this case, L_e is approximately 98 dB on takeoff and about 93 to 95 dB on approach.

Using the above relationships, the L_e or L_{dn} values for a succession of identical events could be computed at points on the ASDS contour boundary. If different aircraft types are involved, no way exists to compare the total exposure unless the contours are identical. The ASDS approach is not amenable to determining cumulative noise exposure level at an arbitrarily selected point around an airport.

COMPARISON OF DAYTIME AND NIGHTTIME AVERAGE SOUND LEVELS WITH L_{dn}

The choice of a nighttime weighting factor should consider the normal variation between daytime and nighttime values of average sound level, abbreviated here as L_d and L_n, respectively. One way to consider this variation is to compare the difference between L_d and L_n, as a function of L_{dn}, for a range of values of L_{dn} and for different types of noise situations.

Data from 63 sets of measurements were available in sufficient detail that such a comparison could be made. These data are plotted in Figure A-7. The data span noise environments ranging from the quiet of a wilderness area to the noisiest of airport and highway environments. It can be seen that, at the lowest levels (L_{dn} around 40-55 dB) L_d is the controlling element in determining L_{dn}, because the nighttime noise level is so much lower than that in the daytime. At higher L_{dn} levels (65-90 dB), the values of L_n are not much lower than those for L_d; thus because of the 10 dB nighttime penalty, L_n will control the value of L_{dn}.

The choice of the 10 dB nighttime penalty in the computation of L_{dn} has the following effect. In low noise level environments, the natural drop in L_n values is approximately 10 dB, so that L_d and L_n contribute about equally to L_{dn}. However, in high noise environments, the night noise levels drop relatively little from their daytime values. In these environments the nighttime penalty applies pressure towards a "round-the-clock" reduction in noise levels if the noise criteria are to be met.

The effect of a nighttime penalty can also be studied indirectly by examining the correlation between noise measure and observer community response in the 55 community reaction cases presented in the EPA report to Congress (Ref. 1). The data have a standard deviation of 3.3 dB when a 10 dB nighttime penalty is applied, but the correlation worsens (std. dev. = 4.0 dB) with no nighttime penalty. However, little difference was observed among values of the penalty ranging between 8 and 12 dB. Consequently, the community reaction data support a penalty of the order of 10 dB but they cannot be utilized for determining a finer gradation. Neither do the data support "three period" in preference to "two-period" days, in assigning non-daytime noise penalties.

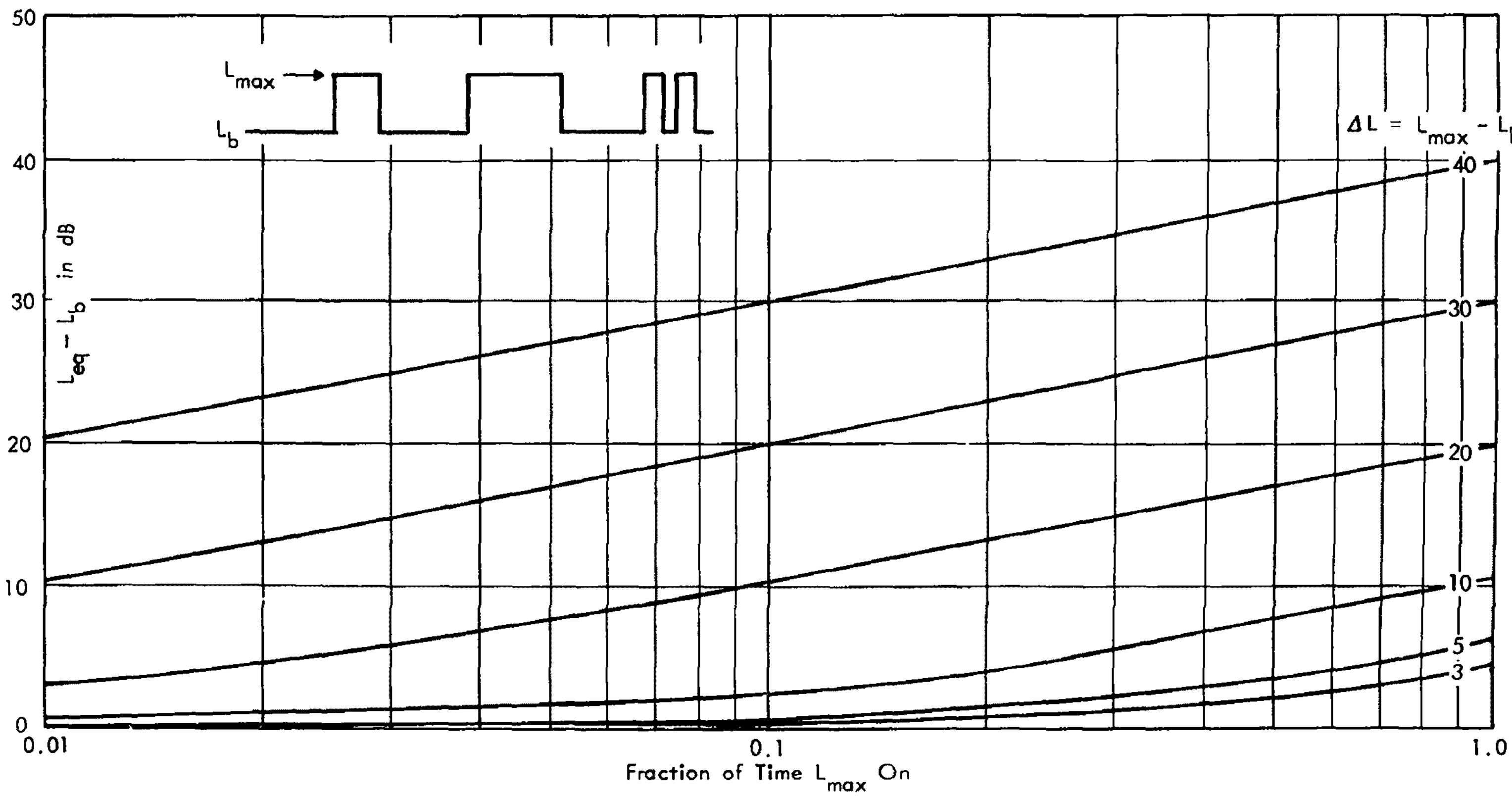

Figure A-1. L_{eq} for Intermittent L_{max} Added to L_b

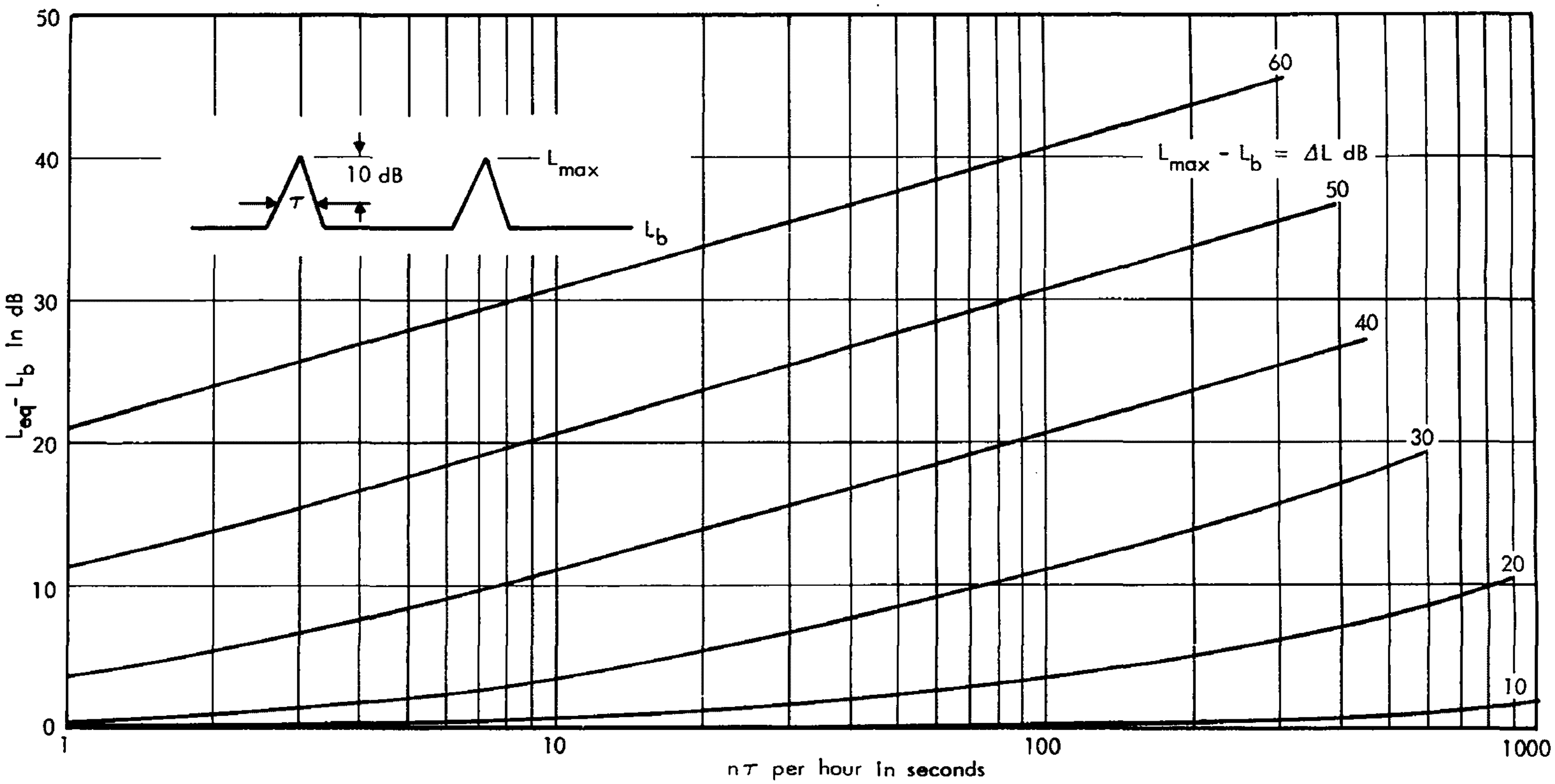

Figure A-2. L_{eq} for a Repeated Series of n Triangular Signals Overlaid on a Background Level of L_b dB and τ = Duration at L_{max} -10 dB in Seconds

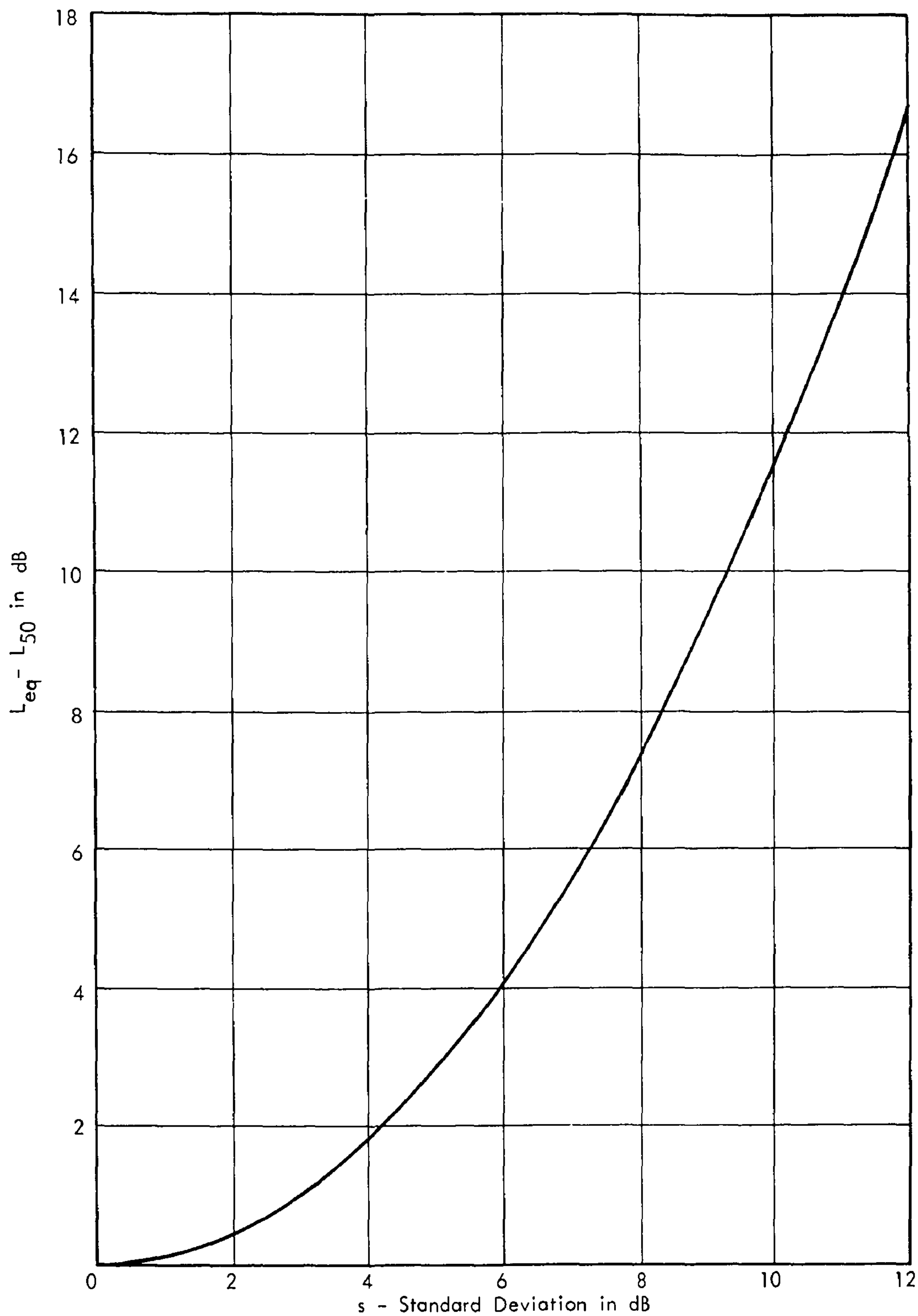

Figure A-3. Difference between L_{eq} and L_{50} for a Normal Distribution Having a Standard Deviation

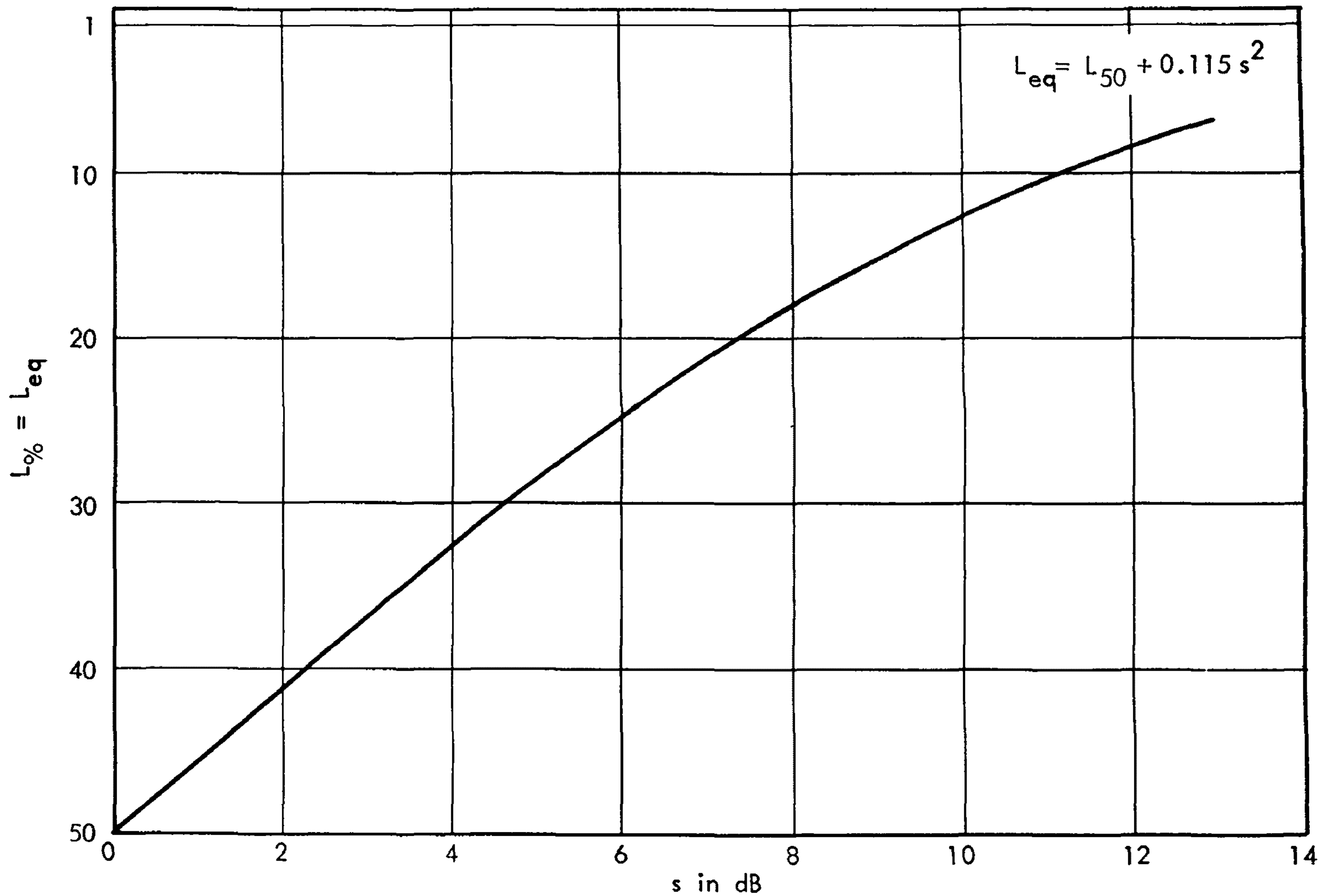

Figure A-4. Percentile of a Normal Distribution that is Equal to L_{eq}

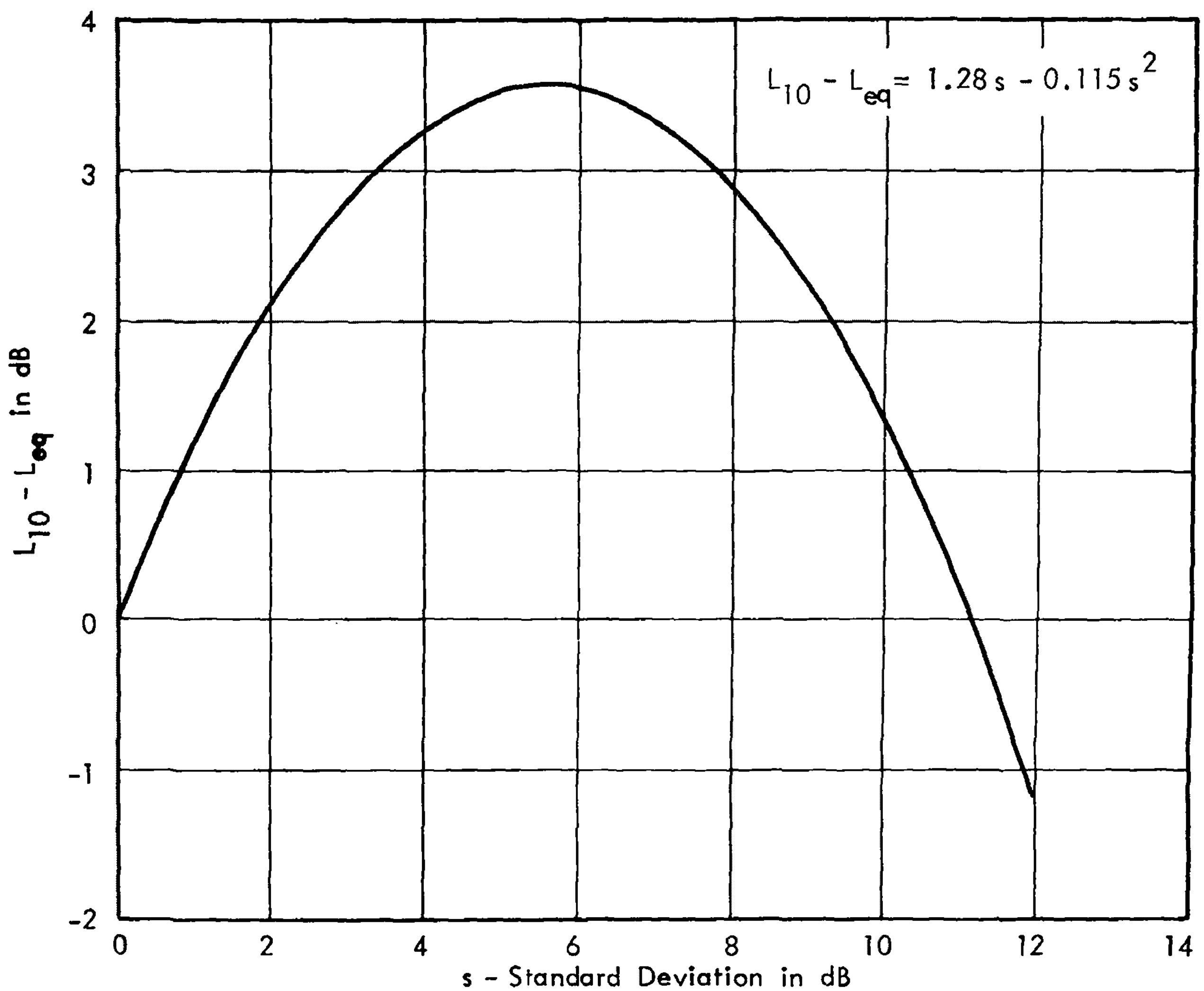

Figure A-5. Difference Between L_{10} and L_{eq} for a Normal Distribution

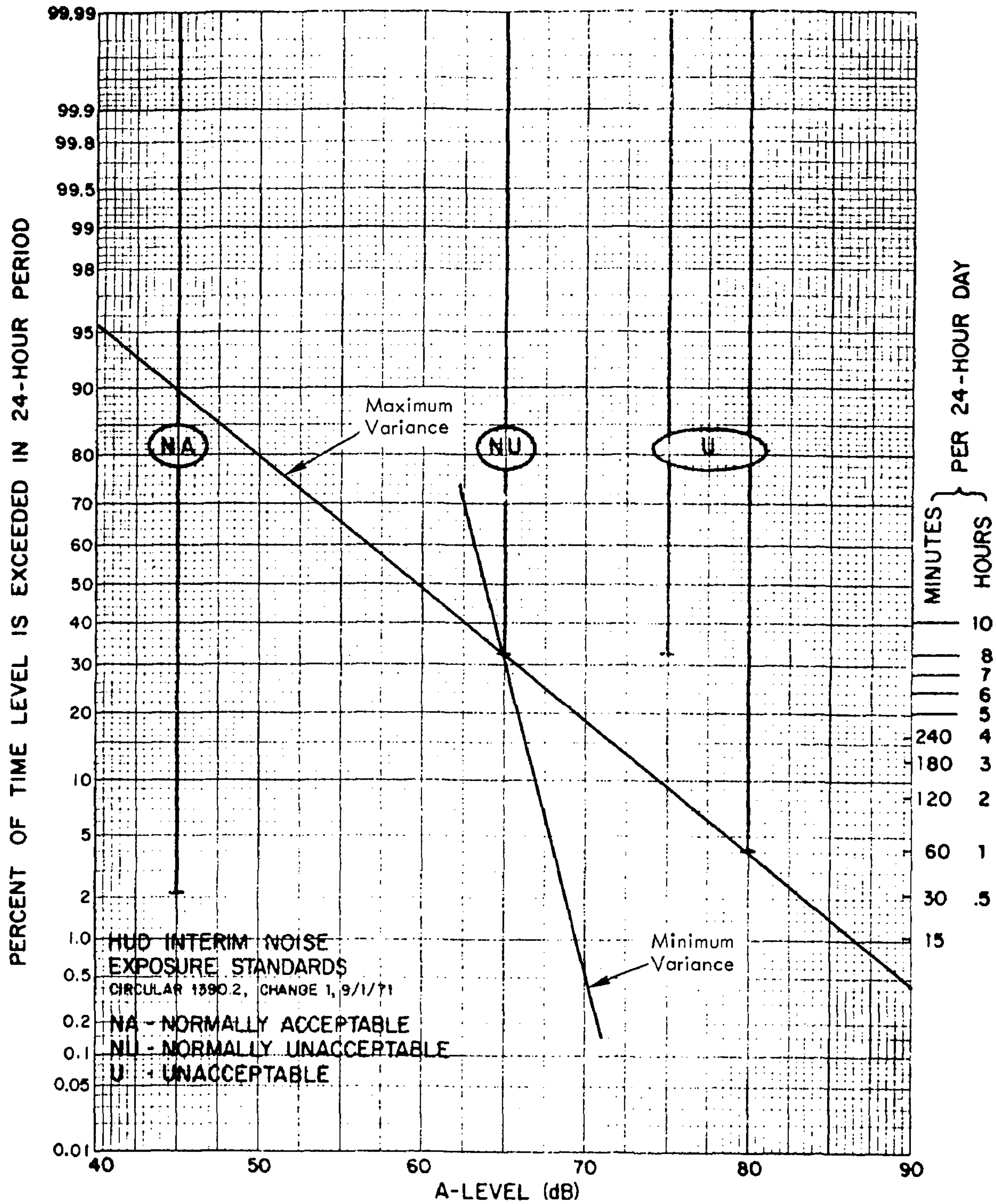

Figure A-6. Permissible Normal Distributions of L_{eq} Under HUD Standards

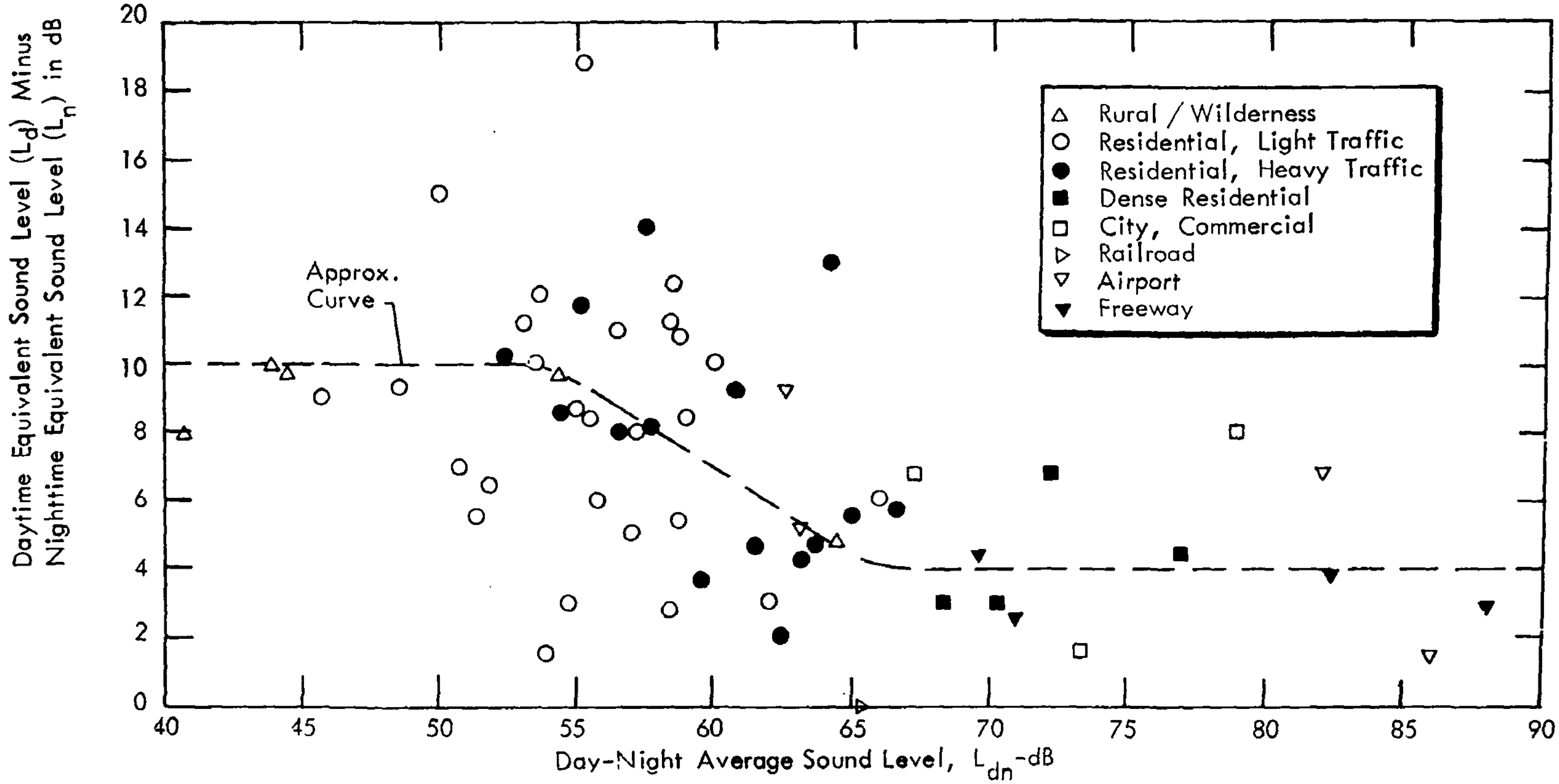

Figure A-7. Comparison of the Difference Between Day and Night Values of the Equivalent Sound Level with the Day-Night Average Sound Level, L_{dn}

APPENDIX B

HEARING LOSS EXPECTED FOR VARIOUS L_{dn} VALUES

There are two important considerations with respect to the health effects of environmental noise. The first is the amount of hearing change that results when the environmental noise level is high enough to cause direct hearing damage. The second is the extent to which environmental noise, at a level not high enough to cause direct damage, may yet prevent recovery of the hearing mechanism from an occupational or recreational noise over-exposure. Both considerations will be explored for typical environmental exposures in the next two paragraphs.

1. Tables B-1 and 2 summarize the direct hearing changes expected from exposures to various values of day-night average sound level, L_{dn}.

   (a) Explanation of terms in Table B-1.

   Four different measurement parameters are considered in Table B-1. These are:

   (1) Max NIPTS: Noise Induced Permanent Threshold Shift (NIPTS) is the permanent change in hearing threshold directly attributable to noise. The NIPTS for a person increases with his exposure duration, and Max NIPTS is the maximum value during a 40-year noise exposure that starts at age 20. The entries in this row apply to the most sensitive 10% of the population. Thus, the entries on this row signify that 90% of the population are expected to have less Max NIPTS than this value.

   (2) NIPTS at 10 years. The entries on this row also apply to the most sensitive 10% of the population; thus 90% of the population are expected to have less Max NIPTS than this value.

TABLE B-1

SUMMARY OF THE PERMANENT HEARING DAMAGE EFFECTS EXPECTED FOR CONTINUOUS NOISE EXPOSURE AT VARIOUS VALUES OF THE A-WEIGHTED AVERAGE SOUND LEVEL (ref 59)

	75 dB for 8 hrs		
	Speech (.5, 1, 2)	Speech (.5, 1, 2, 4)	4kHz
Max NIPTS (Most Sensitive 10%)	1 dB	2 dB	6 dB
NIPTS at 10 yr (Most Sensitive 10%)	0	1	5
Average NIPTS	0	0	1
Max Hearing Risk	N/A	N/A	N/A
	80 dB for 8 hrs		
	Speech (.5, 1, 2)	Speech (.5, 1, 2, 4)	4kHz
Max NIPTS (Most Sensitive 10%)	1 dB	4 dB	11 dB
NIPTS at 10 yr (Most Sensitive 10%)	1	3	9
Average NIPTS	0	1	4
Max Hearing Risk	5%	N/A	N/A
	85 dB for 8 hrs		
	Speech (.5, 1, 2)	Speech (.5, 1, 2, 4)	4kHz
Max NIPTS (Most Sensitive 10%)	4 dB	7 dB	19 dB
NIPTS at 10 yr (Most Sensitive 10%)	2	6	16
Average NIPTS	1	3	9
Max Hearing Risk	12%	N/A	N/A
	90 dB for 8 hrs		
	Speech (.5, 1, 2)	Speech (.5, 1, 2, 4)	4kHZ
Max NIPTS (Most Sensitive 10%)	7 dB	12 dB	28 dB
NIPTS at 10 yr (Most Sensitive 10%)	4	9	24
Average NIPTS	3	6	15
Max Hearing Risk	22.3%	N/A	N/A

Example: For an exposure of 85 dB during an 8-hour working day, the following effects are expected:

In the most sensitive 10% of the population, the Max NIPTS occurring during a 40-year working life-time, averaged over the four speech frequencies of 0.5, 1, 2 and 4 kHz, is 7 dB; averaged over the three frequencies of 0.5, 1 and 2 kHz, the expected max. NIPTS is only 4 dB; the Max shift at 4 kHz is 19 dB. For this same most sensitive 10% of the population, the expected NIPTS after only 10 years of exposure would be 6 dB averaged over the four speech frequencies, 2 dB averaged over three frequencies, and 16 dB at 4 kHz.

The NIPTS averaged over the entire population and over a 40-year working life-time is 3 dB averaged over four frequencies, 1 dB averaged over three frequencies, and 9 dB at 4 kHz.

And finally, out of the entire population, the percentage of people in a group exposed to this noise who have NIPTS greater than 25 dB, averaged over the three speech frequencies, would be 12 percentage points greater than expected in an otherwise similar group who are exposed only to levels of occupational noise significantly lower than 85 dB.

(3) Average NIPTS. The NIPTS averaged both over a 40 year exposure duration and over all the population. This figure differs by only a couple of decibels from the median NIPTS after 20 years of exposure for the entire population.

(4) Max Hearing Risk. Hearing risk is defined as the difference between the percentage of people with a hearing handicap in a noise-exposed group and the percentage of people with a handicap in a non-noise exposed (but otherwise equivalent) group. A person is said to have a hearing handicap if the average of his threshold shifts at the three audiometric frequencies 0.5, 1, and 2 kHz exceeds 25 dB. The hearing risk increases with the duration of the noise exposure and the Max Hearing Risk is defined as the highest value of hearing risk that occurs during 40 years of exposure.

(b) Derivation and explanation of Table B-1

(1) Derivation of NIPTS. Three different predictive methods were used to derive the values of Table B-1. These are the reports of Passchier-Vermeer[42], Robinson[43] and Baughn[44]. The NIPTS values of Table B-1 present an arithmetical average of the results of all three methods. The hearing risk values are an arithmetical average of Robinson's and Baughn's predictions (See ref 59, 60).

(2) Other Audiometric Frequencies. Table B-1 does not contain entries for all the audiometric frequencies commonly used in hearing tests; however, for most typical noises, 4 kHz is the most sensitive frequency, since the greatest NIPTS typically occurs at this frequency. A noise that does not cause excessive hearing change at this frequency will not normally cause a greater change in the other frequencies from 3000 - 10,000 Hz.

(3) Significance of the various hearing changes depicted in Table B-1.

75 dB for 8 hours: With one exception, the changes noted are less than normal audiometric error (±5 dB) and would not normally be perceived, even in the most sensitive 10% of the population. The exception is the 6 dB loss at 4 Hz for the most sensitive 10% of the population. The conclusion is that an exposure at a sound level of 75 dB (8 hours a day) corresponds to the threshold of measurable noise induced changes in hearing ability of the general population. Such an exposure is not considered hazardous to public health.

80 dB for 8 hours: As with the previous level, there are no significant hearing changes at speech frequencies. At 4 kHz, however, measurable changes in individual acuity for at least 10% of the population occur. It is estimated that 8 hour exposures to an L_{eq} of 80 dB will cause some hearing changes, especially of the higher audiometric frequencies such as 4 kHz, but that these predicted losses are of marginal significance.

85 dB for 8 hours: The NIPTS expected for speech frequencies is still less than 5 dB and, as such, is still not reliably measurable on an individual. The Maximum Hearing Risk, however, is slightly greater than 10%. That is, 10% more people in the noise-exposed group have average threshold shifts greater than 25 dB when compared to those in the group not exposed to as much as 85 dB during the 8 hour working day. Thus, L_{eq} of 85 dB for 8 hours causes a noticeable shift in hearing ability of the general population. The NIPTS at 4 kHz likewise begins to assume substantial proportions. Ten percent of the population will have NIPTS greater than 15 dB after 10 years exposure. The average, or even more resistant ears, according to Baughn's data, will show more than a 5 dB loss. In summary, at 85 dB for 8 hours there will be significant changes in hearing ability in the general population.

90 dB for 8 hours: The maximum change (7 dB) in the three-frequency speech hearing level for 10% of the population exceeds 5 dB for this SPL. Maximum Hearing Risk is slightly above 20%. This is 10 percentile points more than recommended by the ISO standard. Expected NIPTS at 4 kHz is large for all the population and is clearly very significant. Therefore it is considered that L_{eq} of 90 dB for 8 hours (85 dB for 24 hours) will produce a significant change in hearing ability that will be unacceptable to the general population under any circumstances.

(c) Derivation and Explanation of Table B-2

(1) Derivation of Table B-2

The derivation of Table B-2 was the same as B-1, except that the hearing risk data from Table XV of the National Institute for Occupational Safety and Health (NIOSH) criteria document are also included (ref 48).

(2) Explanation of Table B-2.

Table B-2 is included in order to show the relationship between exposure level and the percentage of persons showing a measurable hearing change (greater than 5 dB Noise Induced Permanent Threshold Shift) at 4kHz. (ref 60)

For Hearing Risk, linear interpolation was used to estimate the Hearing Risk values between 80 and 85 dB as well as between 85 and 90 dB, from Table B-1.

2. Corrections Required to Convert 8 hour Exposures to Noise Into Day-Night Average Sound Levels

a. The use of L_{dn} (which embodies the equal-energy concept) is a conservative approach with respect to hearing conservation. Even for a steady continuous noise, the Temporary Threshold Shift (TTS) is not predictable on a log linear basis for all possible time durations. The equal-energy

TABLE B-2

EXPECTED HEARING CHANGES FOR VARIOUS A-WEIGHTED AVERAGE SOUND LEVELS IN dB

Exposure Level						
	L_{eq}	72	75	80	82	85
	L_{dn}*	80	83	88	90	93
Percent of Population with NIPTS Greater than 5 dB at 4 kHz		4	15	44	66	92
Hearing Risk from Table B-1		0	0	5	8	12.5
Speech (.5,1,2 kHz) from NIOSH		0	0	3	8	15

*Valid for Fluctuating Noise such that $L_{dn} = L_{eq} + 8dB$

method predicts with reasonable accuracy the TTS at 4 kHz for durations from 8 hours to 30 minutes. Durations shorter than 15 minutes, however, are better predicted by a method which allows a 6 dB increase per halving of duration. The TTS for speech frequencies is predicted by a 5 dB increase/halving of duration. In summary, the effects of intermittent noises which are 15 dB or more greater than the 8 hour exposure average sound level (L_{eq}) are predicted too high. For a two minute exposure, the SPL required to produce the expected TTS of 4 kHz would have to be approximately 10 dB (20 dB for speech frequencies) higher than that predicted by the equal-energy concept. This conservatism, which is inherent in an energy-average method, applied to noises which fluctuate significantly in level, will be considered in the intermittency correction.

b. The 24 Hour Extrapolation

Exposures longer than 24 hours are not considered more noxious than 24 hour exposures because studies of Temporary Threshold Shift (TTS)[45,46,47] have shown that, for exposure to a specific noise level, TTS will not exceed a limiting value regardless of exposure duration. This limit is reached approximately at 24 hours of exposure. The same studies show that the TTS after 24 hours of exposure generally exceeds the TTS after 8 hours of exposure 5 dB or less. Thus the use of a 5 dB correction factor is suggested to correct the measured data for 8 hour exposure to apply to 24-hour exposure. For example, the predicted effects of a noise exposure of 75 dB for a 24 hour duration are equivalent to the effects estimated from industrial studies for an 8 hour exposure to a continuous noise with a level of 80 dB. This 5 dB correction is consistent with the equal-energy trade/off between exposure duration and noise level; that is, if the equal-energy rule is used to estimate the effects for 24 hour exposure, based on 8-hour exposure data, the correction factor between 8 hours and 24 hours is again 5 dB.

c. Intermittency

In practice, the noise to which people are exposed seldom remains continually at the same level; instead, the noise fluctuates or is intermittent. There is ample proof that intermittent noise is less harmful than continuous noise with the same L_{eq}. Page VI-17 to VI-23 of the 1972 NIOSH criteria[48] document contain a good resume of the effect of intermittent noise, and such a discussion will not be repeated here. In summary, however, intermittent noise whose peak levels are 5 to 15 dB higher than continuous noise may still produce equal hearing damage.

Investigations of typical noise patterns from the EPA document "Community Noise"[19] indicate that in typical environmental noise situations involving aircraft operations, the noise is very intermittent. For this reason, the L_{eq} measured near airports can be expected to produce <u>less</u> harmful effects than those depicted in Table B-1. Some correction factor is thus required for L_{eq} values describing noise exposure composed largely of aircraft noise, or other noises of intense, but intermittent nature. Assuming that the noise level between events is less than 65 dB for at least 10 percent of the time, a 5 dB correction is suggested. This may be low, but justification of a larger correction would require more detailed analysis and data than were available for this report.

d. Contribution of the Indoor Noise Environment to total Exposure

A person's 24-hour exposure will typically include both outdoor and indoor exposures. Since a building reduces the level of most intruding environmental noises by 15 dB or more (windows partially open), an outdoor L_{eq} will not adequately predict hearing effects, because the corresponding NIPTS estimates will be too high. Estimates based on indoor L_{eq} will likewise be too low. Consider a situation where the average sound level is 80 dB outdoors and 65 dB indoors. The effective noise exposure reaching the ear for some of the possible exposure situations are:

		24-hour L_{eq} in dB		
Indoor Time (65 dB)	Outdoor Time (80 dB)	Combined Indoor & Outdoor	Outdoor Only	(assuming 0 dB for the indoor time; i.e., ignoring its contribution to the total exposure)
24 hrs	0 hrs	65.0	-	
23	1	68.6	66.2	
22	2	70.5	69.2	
21	3	71.8	71.0	
20	4	72.9	72.2	
16	8	75.5	75.2	
8	16	78.3	78.2	
0	24	80	80	

The 24-hour value of the combined L_{eq} is essentially unchanged from the outdoor value (less than one dB) by the indoor noise exposure, so long as the outdoor exposure exceeds 3 hours. Thus, as long as the criterion is established with respect to outdoor noise exposure exceeding 3 hours per day, the contribution of the indoor noise environment may be neglected in computing the 24 hour L_{eq}. This conclusion does not depend greatly on the actual noise attenuation provided by the house so long as the attenuation is greater than 10 dB.

e. Values of the Day-Night Average Sound Level

It has been concluded that an A-weighted average sound level (L_{eq}) of 80 dB for 8 hours daily exposure corresponds to the threshold of measurable hearing change in the general population. This threshold includes a 5 dB correction to allow for intermittency in the noise events, a value that is appropriate for aircraft noise operation. Adoption, as a criterion, of a maximum permissible outdoor average sound level for an 8 hour daily exposure should protect those persons that have the greatest outdoor activity, including young children, and retired persons living in warm climates, and people in certain outdoor occupations. The general public, who are not outdoors for as much as 8 hours per day, will be better protected.

The values of L_{dn} corresponding to an A-weighted average sound level of 80 dB during daytime hours, range between 80 and 86 dB. The lower value corresponds to a situation where the average sound level during the night is 10 dB lower than that occurring during the day, whereas the higher value corresponds to the situation when the average sound level during the night equals that occurring during the day. The most probable difference between the daytime and nighttime values of L_{eq} is 4 dB, as shown for the noise levels of interest in Fig. A-7 of Appendix A. For this day-night difference, L_{dn} is three decibels above the daytime value of L_{eq}, or 83 dB. This value of 83 dB is considered to be the most probable value of L_{dn} to be found in real environments that have a daytime L_{eq} of 80 dB.

3. Basis for the "Quiet" Requirement for the Noise Exposed Population

Recent research by Ward (Reference 52) has shown that the quiet intervals between high intensity noise-bursts must be below 60 dB SPL for the octave band centered at 4 kHz, if recovery from the Temporary Threshold Shift (TTS) is to be independent of the quiet period SPL. A sound pressure level of 55 dB in the 4 kHz octave band is suggested as a goal for "effective quiet", based on the following assumptions: (1) TTS recovery from a 90 dB (8 hr) occupational exposure also requires a 55 dB level of effective quiet in the 4000 Hz band for some part of the 16 hrs before another exposure the following day, (2) total TTS recovery is required to prevent TTS from becoming NIPTS, and (3) 8 hours in the nighttime period is a reasonable minimum recovery time. For typical spectra of community noise, the requirement for 55 dB sound pressure level in the 4 kHz octave band translates to an A-weighted sound level indoors of 65 dB, or more. The house noise reduction of 15 dB for windows partially open allows the outdoor A-weighted sound level to be 80 dB, to achieve an indoor level of 65 dB. The values of day-night average sound level corresponding to an A-weighted average sound level of 80 dB during night-time range between 86 and 90 dB, depending of the differences between daytime and nighttime average sound levels. For a difference of 4 dB, the most probable value, the value of L_{dn} is 87 dB.

4. Supporting Studies

In the preceding sections of this Appendix the relationship of environmental noise to hearing level was based on the application of known relationships between noise exposure and hearing which primarily come from Industrial exposures. There is only one study available which attempts to directly relate actual community aircraft noise exposure to changes in hearing level.

In 1970 the Department of Transportation supported a study (ref. 58) of the hearing levels of a sample population taken from an area (Playa del Rey) next to the Los Angeles Airport as opposed to a sample taken from a nearby relatively nonexposed area. The authors of the report stated that from this study it was not possible to draw firm conclusions about the effects of the community aircraft noise exposure since results showed only small differences between the mean hearing level of the groups. At the low frequencies on the audiograms, the direction of these differences was equivocal, but at the high frequencies there were trends suggesting poorer hearing for the airport area residents. The average time spent in the Playa del Rey location by the test subjects was 9-17 years. The L_{dn} of the exposed area was not given, but using the raw data available in the report and the methodology of Appendix A, the L_{dn} can be estimated to be in the range of 80-83 dB. Using this range of values, the results of this study are not inconsistent with the effects predicted by this Appendix in that a L_{dn} of 83 dB is presented as the <u>threshold</u> of <u>measurable</u> effects for more than 90% of the population after 20-40 years of exposure. Using Table B-1, the average NIPTS for a L_{dn} of 83 dB (8 hour exposure of 75 dB) should be negligible (approximately 1 dB or less dependent on frequency) for exposures even longer than those experienced by the Playa del Rey community. The results of the Playa del Rey study, therefore, are exactly what should be expected if L_{dn} = 83 dB is at or close to the true threshold of hearing changes.

APPENDIX C

SPEECH COMMUNICATION

Speech communication has long been recognized as an important requirement of any human society. Interference with speech communication disrupts one of the chief specific distinctions of the human species, disturbs normal domestic activities, creates a less desirable living environment, and can sometimes, for those reasons, be a source of extreme annoyance.

Noise can disturb speech communication in a variety of situations encountered at work, in transportation vehicles, at home, etc. Of chief concern for the purposes of this report, however, is the effect of noise on speech communication at home, for face-to-face conversation indoors or outdoors, telephone use, and radio or television enjoyment.

The extent to which noise of the community affects speech communication around the home depends on the location (whether indoors or outdoors), the amount of noise attenuation provided by the exterior walls of the house (including windows and doors) and the vocal effort of the talkers. Certainly it is possible to maintain communication in the face of intruding noise if the voice level is raised; but in an acceptable noise environment one should not <u>have</u> to increase the voice level above a normal, comfortable effort in order to communicate easily.

SPEECH INTERFERENCE DUE TO NOISE

Research over a number of years since the late 1920's has made great progress in characterizing quantitatively the effects of noise on speech. A review of that work is contained in Refs. 21 and 49, and is summarized here.

The chief effect of intruding noise on speech is to mask the speech sounds and thus reduce intelligibility. The important contributants to intelligibility in speech sounds cover a range in frequency from about 200 to 6000 Hz, and at each frequency a dynamic level range of about 30 dB.

The intelligibility of speech will be nearly perfect if all these contributions are available to a listener for his understanding. To the extent that intruding noise masks out or covers up some of these contributions, the intelligibility deteriorates: more rapidly the higher the noise level, particularly if the noise frequencies coincide with the important speech frequencies.

It is no accident, from the evolutionary point of view, that the hearing of humans is most sensitive in the frequency range most important for understanding their speech. Therefore, it is not mere coincidence that the A-weighting, designed to imitate the frequency sensitivity of the human ear, should also be useful as a measure of the speech interference potential of intruding noise. A-weighting gives greatest weight to those components of the noise that lie in the frequency range where most of the speech information is compressed, and thus yields higher readings (A-weighted levels) for noises whose energy is concentrated in that frequency range.

For these reasons the results of rather complicated research studies can be easily simplified and summarized in terms of A-weighted sound levels, as shown in Figure C-1. This figure presents the distances between talker and listener for satisfactory conversations outdoors, in different steady background noise levels (A-weighted), for three degrees of vocal effort. This presentation depends on the fact that the voice level at the listener's ear (outdoors) decreases at a predictable rate as the distance between him and the talker is increased. In a steady background noise from the community, there comes a point, as the talker and listener increase their separation, where the decreasing speech signal is first equalled and then masked by the noise.

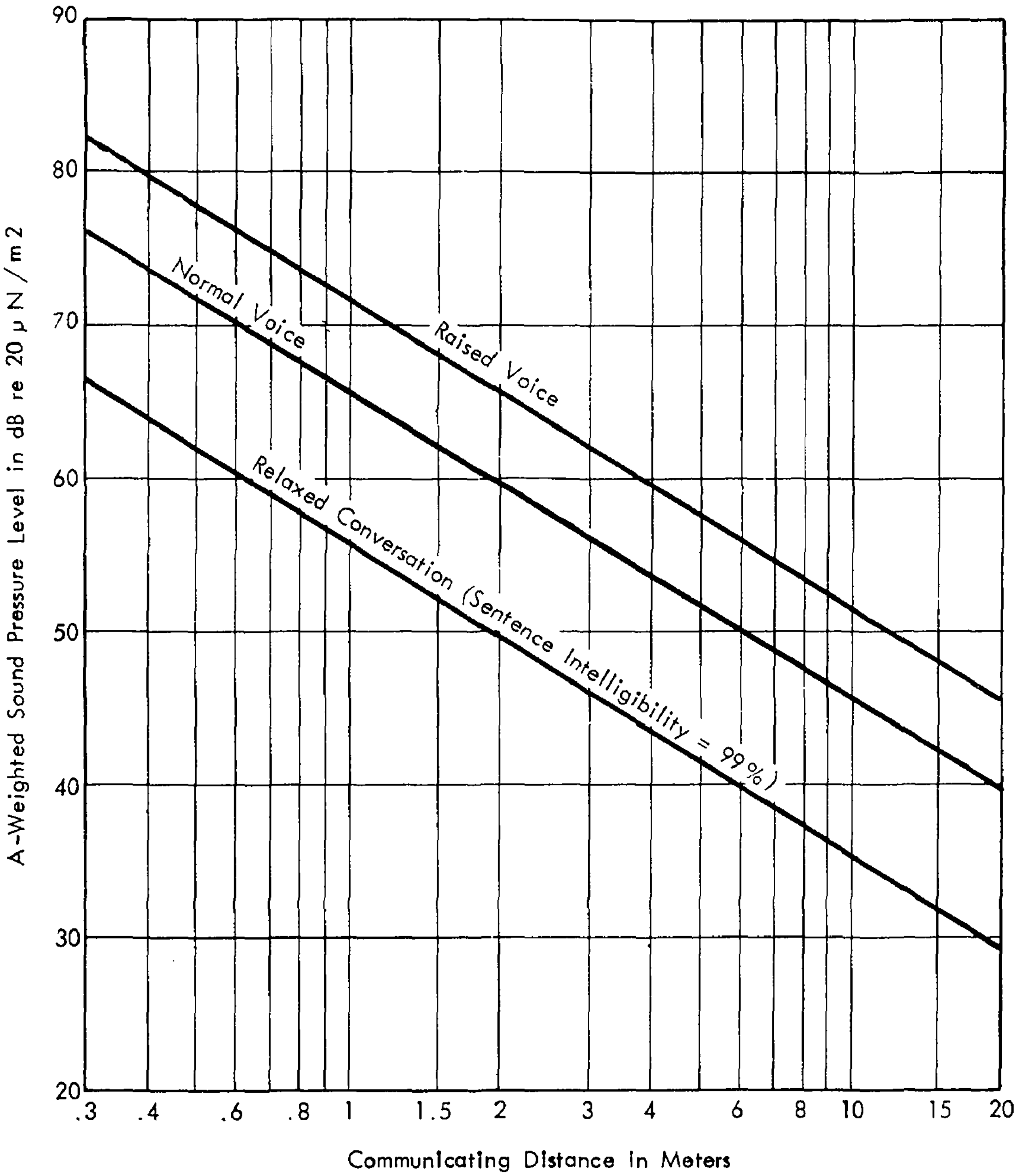

Figure C-1. Maximum Distances Over Which Conversation is Considered to be Satisfactorily Intelligible (Sentence Intelligibility = 95% Except as Noted) (refs 19 and 49)

The levels plotted in the figure do not permit perfect sentence intelligibility at the indicated distances; instead, the sentence intelligibility at each distance is 95 percent, meaning that 95 percent of the key words in a group of sentences would be correctly understood. 95 percent speech intelligibility permits reliable communication, because of the redundancy in normal conversation. That is, in normal conversations, many unheard words can be inferred since they occur in a particular and often familiar context; often the vocabulary is restricted which helps understanding. Therefore, 95 percent intelligibility is adequate for most situations.

Other factors, such as the talker's enunciation, the familiarity of the listener with the language, and the listener's motivation, also influence the intelligibility; but the plotted data are valid under average conditions.

The data of Figure C-1 are tabulated for convenience below:

Table C-1

STEADY A-WEIGHTED NOISE LEVELS THAT ALLOW COMMUNICATION WITH 95 PERCENT SENTENCE INTELLIGIBILITY OVER VARIOUS DISTANCES OUTDOORS FOR DIFFERENT VOICE LEVELS (ref 49)

VOICE LEVEL	COMMUNICATING DISTANCE (meters)					
	0.5	1	2	3	4	5
Normal voice	72	66	60	56	54	52 dB
Raised voice	78	72	66	62	60	58 dB

If the levels in Figure C-1 and Table C-1 are exceeded, the talker and listener must either move closer together or expect reduced intelligibility. For example, suppose a conversation at a distance of 3 meters in a steady background noise of 56 dB using "normal voice" levels. If this background level were increased from 56 to 66 dB, the talkers would either have to move from 3 to 1 meter separation to maintain the same intelligibility, or alternately, to raise their voices well above "raised voice" effort. If they remain 3 meters apart without raising their voices, the intelligibility would drop from 95 to 65 percent (this last conclusion is not deducible from the figure).

INDOOR SPEECH COMMUNICATIONS

The research results concerning the masking of speech sound out-of-doors are not valid indoors, because they depend on a predictable decrease of speech sound with increasing distance between talkers; the predictable relation is upset indoors because of reflections from the walls and other boundaries of the room.

Fortunately, however, there are well-known criteria of long-standing for acceptable noise levels indoors, appropriate to various indoor activities. These are tabulated in terms of A-weighted sound levels in Table C-2.

Note that the range of recommended A-levels for indoor spaces typical of dwellings (items 6-8) is from 34 to 47 dB, but for spaces used mostly during the day where speech communications are important (items 7 and 8) the emphasis is on levels between 38 and 47 dB. A typical recommended level from the upper half of this latter range is 45 dB. This level will allow relaxed, face-to-face conversation with essentially 100% sentence intelligibility for all locations of talker and listener in a typical room in a dwelling.

Assuming 15 dB of attenuation through a partially opened window, the steady outdoor noise level could reach 60 dB without exceeding the recommended indoor noise criterion of 45 dB for residences. With lower outdoor levels, the interior noise environment would shift toward the more favorable end of the recommended range listed for items 6 to 8 in Table C-2, leading to improved speech communications conditions.

Table C-2

ACCEPTABLE STEADY SOUND LEVELS FOR VARIOUS TYPES OF SPACES AND USES (from ref 57)

	Type of space (and acoustical requirements)	A-weighted Sound Level (dB)
1.	Concert halls, opera houses, and recital halls (for listening to faint musical sounds)	21 to 30
2.	Broadcast and recording studios (distant microphone pickup used)	21 to 30
3.	Large auditoriums, large drama theaters, and churches (for excellent listening conditions)	Not to exceed 30
4.	Broadcast, television, and recording studios (close microphone pickup only)	Not to exceed 34
5.	Small auditoriums, small theaters, small churches, music rehearsal rooms, large meeting and conference rooms (for good listening), or executive offices and conference rooms for 50 people (no amplification)	Not to exceed 42
6.	Bedrooms, sleeping quarters, hospitals, residences, apartments, hotels, motels, etc. (for sleeping, resting, relaxing)	34 to 47
7.	Private or semiprivate offices, small conference rooms, classrooms, libraries, etc. (for good listening conditions)	38 to 47
8.	Living rooms and similar spaces in dwellings (for conversing or listening to radio and TV)	38 to 47
9.	Large offices, reception areas, retail shops and stores, cafeterias, restaurants, etc. (for moderately good listening conditions)	42 to 52
10.	Lobbies, laboratory work spaces, drafting and engineering rooms, general secretarial areas (for fair listening conditions)	47 to 56
11.	Light maintenance shops, office and computer equipment rooms, kitchens, and laundries (for moderately fair listening conditions)	52 to 61

Table C-2 (Cont)

Type of space (and acoustical requirements)	Appropriate L_A, dBA
12. Shops, garages, power-plant control rooms, etc. (for just acceptable speech and telephone communication). Levels above PNC-60 are not recommended for any office or communication situation	56 to 66
13. For work spaces where speech or telephone communication is not required, but where there must be no risk of hearing damage	66 to 80

EFFECT OF NON STEADY NOISE

The data in Figure C-1 are based on tests involving steady, continuous noise, for which case the noise level is equal to the average sound level. It might be questioned whether these results would apply to fluctuating noises. For example, when intermittent noise intrusions, such as those from aircraft flyovers, are superimposed on a steady noise background, the average sound level is greater than the level of the background alone. If the sound levels of Figure C-1 (and of Table C-2) are interpreted as average sound levels, it could be argued that these values should be slightly increased (by an amount depending on the statistics of the noise), because most of the time......that is, except during the flyovers......the interfering noise level is actually lower than the average sound level.

The amount of this difference has been calculated for the two cases of urban noise and aircraft noise statistics shown in Figure C-2. The data in this figure (previously reported in Ref. 19) include a wide range of urban sites with different noise exposures, and an example of aircraft noise at a site near a major airport. In each case the speech intelligibility was calculated from the standard sentence intelligibility curve (ref. 50) for various values of the average sound level, first with steady noise and then with the two specific fluctuating noises of Figure C-2. The calculation consisted of determining the incremental contribution to sentence intelligibility for each level (at approximately 2 dB increments) and its associated percentage of time of occurrence, and summing the incremental contributions to obtain the total value of intelligibility in each case.

The results, shown in Table C-3, demonstrate that, for 95 percent sentence intelligibility, normal voice effort and 2 meter separation between talker and listener, the value of the average sound level associated with continuous noise is less than the value for an environmental noise whose magnitude varies with time. It is concluded that for a fixed value of the average sound level minimum intelligibility is associated with continuous noise. Almost all time-varying environmental noises with the same average sound level would lead to better intelligibility. Alternatively, for a fixed value for the average sound level, the percentage of interference with speech (defined as 100 minus the percentage sentence intelligibility) is greater for steady noise than for almost all environmental noise whose magnitude varies with time. The relationship between L_{dn} and the maximum percentage sentence interference (i.e., for steady, continuous noise) is given in Figure C-3.

Table C-3

MAXIMUM PERMISSIBLE AVERAGE SOUND LEVELS THAT PERMIT 95 PERCENT SENTENCE INTELLIGIBILITY AT A DISTANCE OF 2 METERS, USING NORMAL VOICE EFFORT

Noise Type	L_{eq} in decibels
Steady	60
Urban Community Noise	60 +
Aircraft Noise	65

An extreme example of an intermittent noise, is a noise, of constant maximum magnitude, that is suddenly switched on and off periodically, in such a way that it is the only significant contributor to the average sound level (that is, the background noise during the off-cycle is negligible); during the off-cycle. The background noise is chosen to be sufficiently low in value such that the intelligibility is 100 percent. Real-life environmental noises lie between this extreme example and the case of steady continuous noise.

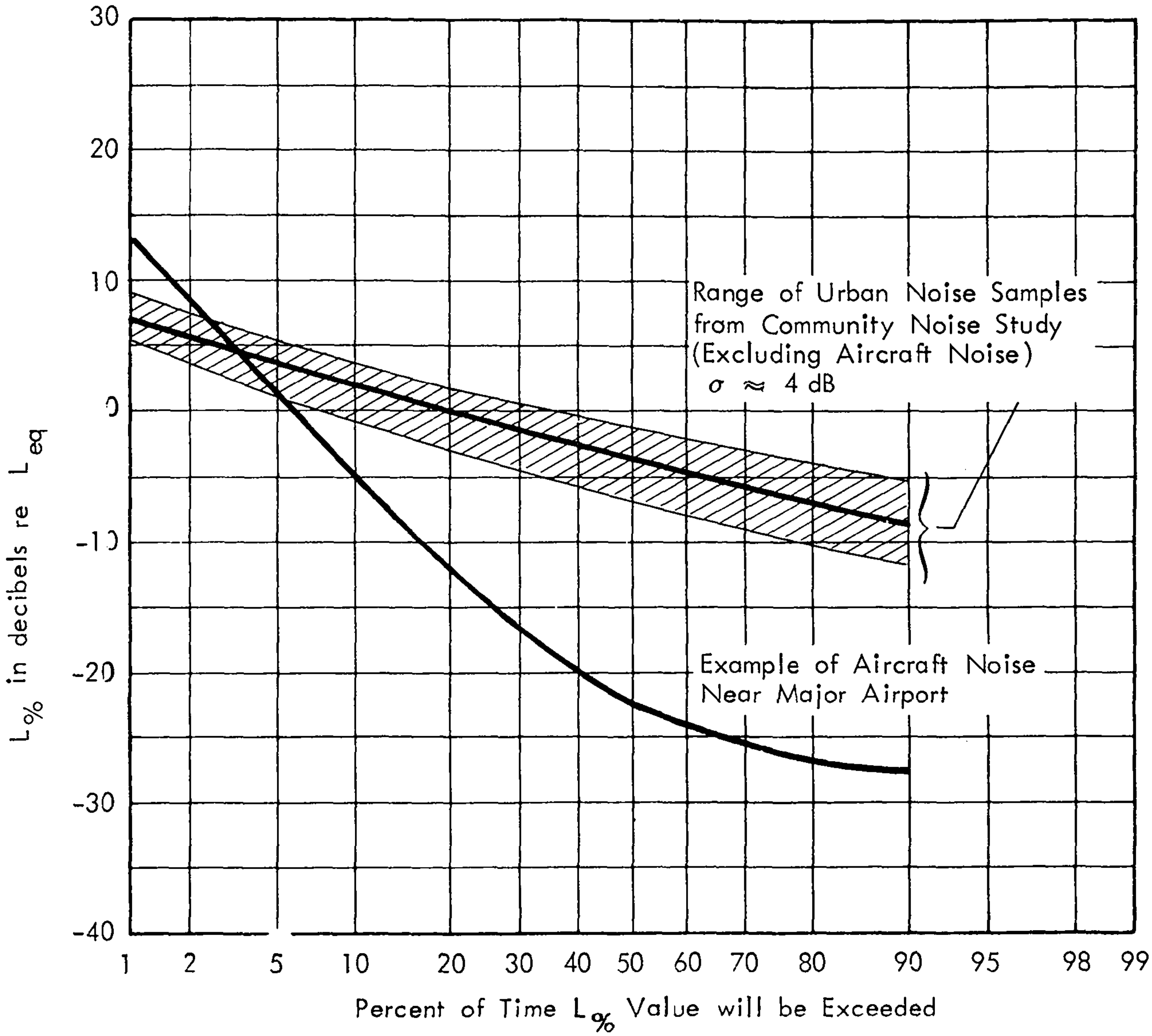

Figure C-2. Cumulative Distribution of Typical Community Noises During the Daytime

Table C-4 shows how the percentage interference with sentence intelligibility varies as a function of the level and on-time for a cycled steady noise whose level and duration are adjusted always to yield a fixed value for the average sound level. Two situations are envisaged: indoors, relaxed conversation, L_{eq} = 45 dB, leading to 100 percent sentence intelligibility in the steady continuous noise; and outdoors, normal voice effort at 2 meters separation, L_{eq} = 60 dB, leading to 95 percent sentence intelligibility in the steady continuous noise.

The combination of level in the first column and duration in the second column are such as to maintain constant L_{eq} for each situation, 45 dB indoors and 60 dB outdoors. The third column gives the percent interference with sentence intelligibility that would apply if the intruding noise were steady and continuous with the level indicated in column 1. The fourth column gives the percent interference for the cycled noise in each case.

The results for this extreme example of an intermittent intruding noise indicate that no matter how extreme the noise fluctuation for the indoor case, there is negligible speech interference for L_{eq} = 45 dB when speech interference is evaluated as a percentage of time. However, whenever the intruding noise exceeds 70 dB, all speech is interrupted until the end of the "on" cycle. Such an interruption is generally regarded as highly annoying. It is generally a greater problem when listening to radio or TV when there is no possibility of varying the speech level as can be accomplished in a conversation.

It is concluded that the use of average sound level as a measure is conservative when applied to non-steady environmental noises, when the noises are properly evaluated on the percentage of total time in which speech interference occurs. However, if the maximum values of the non-steady noise are sufficiently higher than the average value, complete interruption in speech communication can occur for small percentages of the time. When the environmental noise causes this result, the percent of time that communication is interrupted is probably a poor measure of the total effect, rather the effect is better measured in terms of the annoyance caused by the interruption. Consequently, it is concluded that the speech interference criteria with the average sound level measure are best applied to environmental noises which are steady or non-steady with maximum levels which do not constitute a complete interruption. Both steady noise and non-steady urban traffic noise are in this category. However, when the maximum levels are sufficient to cause complete interruption of speech

Table C-4

PERCENTAGE INTERFERENCE WITH SENTENCE INTELLIGIBILITY IN THE PRESENCE OF A STEADY INTRUDING NOISE CYCLED ON AND OFF PERIODICALLY IN SUCH A WAY AS TO MAINTAIN CONSTANT AVERAGE SOUND LEVEL, AS A FUNCTION OF THE MAXIMUM NOISE LEVEL AND DURATION
(Assumes 100% intelligibility during the off-cycle)

Situation	A-weighted sound level of intruding noise during on-cycle, decibels	Noise duration, as percent of cycle	Percent interference if noise were continuous	Percent interference in cycled noise
INDOORS, relaxed, conversation, L_{eq} = 45 dB, 100% intelligibility if noise were continuous	45	100	0	0
	50	32	0.5	0.16
	55	10	1	0.10
	60	3	2	0.06
	65	1	6	0.06
	70	0.3	40	0.12
	75	0.1	100	0.10
	80	0.03	100	0.03
OUTDOORS, normal voice at 2 meters, L_{eq} = 60 dB, 95% intelligibility if noise were continuous	60	100	5	5.0
	65	32	7.7	2.5
	70	10	53	5.3
	75	3	100	3.0
	80	1	100	1.0

communication, such as often occurs with aircraft noises, annoyance criteria are more applicable in assessing the effect on humans than are speech criteria stated in terms of percent of interference.

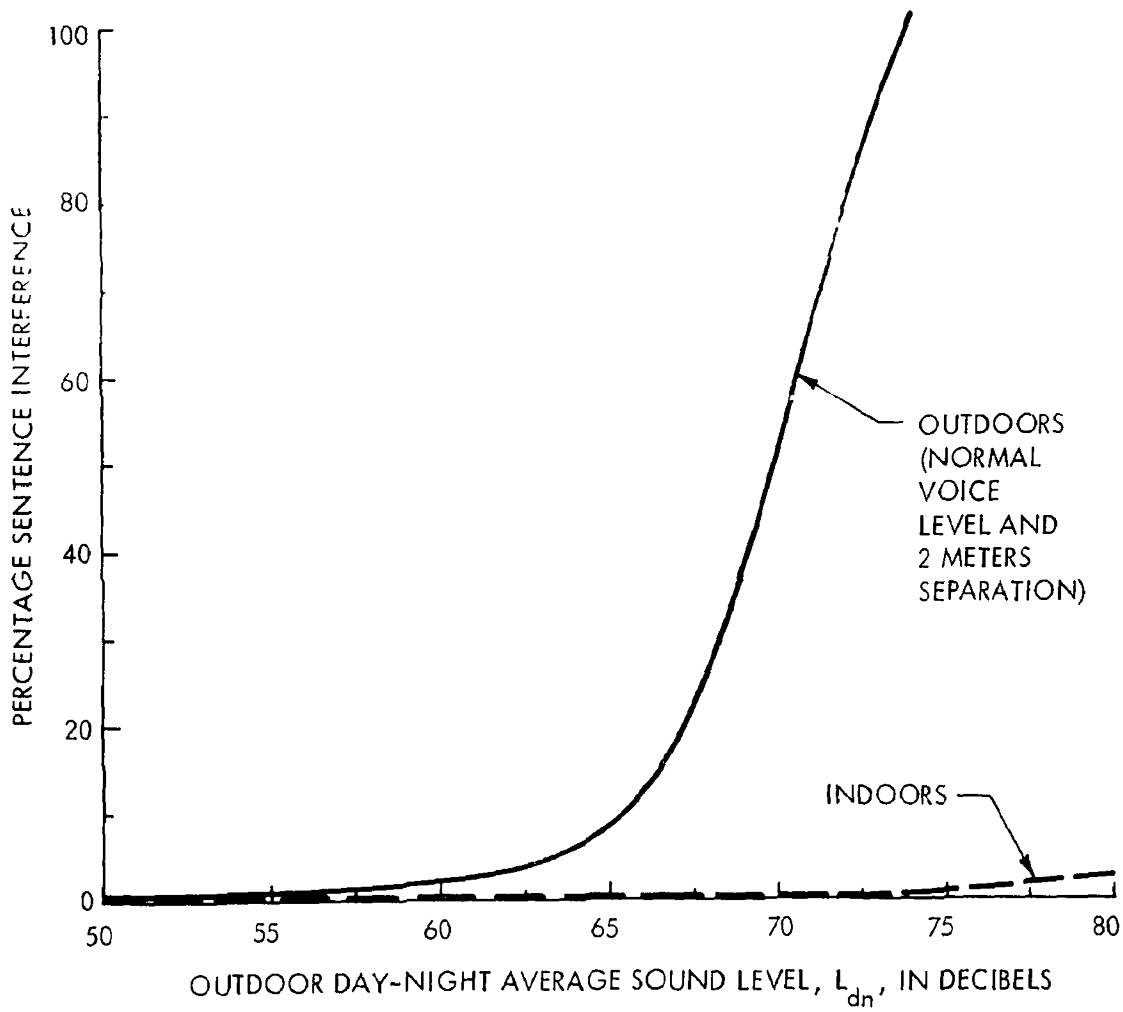

Figure C-3. Maximum Percentage Interference with Sentences as a Function of the Day-Night Average Noise Level. (Percentage Interference Equals 100 Minus Percentage Intelligibility, and L_{dn} is Based on $L_d + 3$)

APPENDIX D

RELATIONSHIPS BETWEEN ANNOYANCE AND AVERAGE NOISE LEVEL

FIRST LONDON-HEATHROW SURVEY

The first survey of about 2,000 residents in the vicinity of Heathrow airport was conducted in 1961 and reported in 1963 (Ref. 14). The survey was conducted to obtain responses of residents exposed to a wide range of aircraft flyover noise. A number of different questions were used in the interviews to derive measures of degrees of annoyance reported. Two results of this survey are considered here. The noise exposure levels reported in the survey have been converted to approximate values of L_{dn}.

A general scale aggregating all responses on a category scale of annoyance ranging from "not at all" to "very much annoying" is plotted as a function of L_{dn} in Figure D-1*. This figure presents a relationship between word descriptors and average noise level.

Among the respondents in every noise level category, a certain percentage were classified in the "highly annoyed" category. The percentage of each group is plotted as a function of L_{dn} on Figure D-2.

Comparison of the data on the two figures reveals that, while the average over the population would fit a word classification of "little" annoyed at an L_{dn} value of approximately 60 dB, more than 20% of the population would still be "highly annoyed" at this value.

*In Figures D-1 through 5 of the line indicated is the linear regression computed from the Pearson product moment correlation. The numerical value of the correlation coefficient, r, is given, as is the standard error of estimates, $s_{y/x}$.

COMBINED RESULTS OF SECOND LONDON SURVEY AND TRACOR SURVEYS

In 1967, a second survey was taken around Heathrow airport in the same general area as the first (Ref. 15). The results, while attempting refinement over the first survey, were generally the same. In 1971, the results of an intensive three year program, studying eight air carrier airports in the United States under NASA sponsorship, were reported by Tracor (Ref. 16). Since each of these efforts is discussed in detail in the references, only an analysis of their combined results is considered here. Borsky used the data from these studies to correlate annoyance with noise exposure level for people having different attitudinal characteristics and different degrees of annoyance (Ref. 18).

Utilizing his data for "moderate" responses to the attitudes of "fear" and "misfeasance," the relationship between percent "highly annoyed" and noise exposure level is plotted on Figure D-3. Again, noise levels have been converted approximate to L_{dn} values. It is worth noting that more than 7500 respondents are included in the data sets from which the computations were derived.

The comparison between the results shown on Figure D-2 and D-3 is striking in the near identity of the two regression lines--indistinguishable at any reasonable level of statistical confidence.

The importance of these two sets of data lies in the stability of the results even though the data were acquired 6 to 9 years apart, at nine different airports in two different countries.

JUDGMENT OF NOISINESS AT URBAN RESIDENTIAL SITES

In 1972, a study of urban noise was conducted primarily to evaluate motor vehicle noise for the Automobile Manufacturers Association (Ref. 51). As part of this survey, 20 different urban-suburban residential locations not in the vicinity of airports, were studied in Boston, Detroit, and Los Angeles. Noise measurements were acquired and a social survey of 1200 respondents was conducted. Part of the survey was directed towards obtaining the respondents' judgement, on a category scale, of the exterior noisiness at their places of residence.

The average judged noisiness values per site are plotted on Figure D-4 as a function of measured L_{dn} values. The significance of these "non-aircraft" data is the comparison they permit with other survey data acquired exclusively around airports.

Intercomparison of these data with the previous data indicate that for an L_{dn} value of 60 dB, the site would be judged "quite" noisy, the average annoyance over a group would be classed as "little," but about 25% of the people would still claim to be "highly annoyed."

COMMUNITY REACTION

Fifty-five cases of community reaction to noise were analyzed in the Community Noise section of the EPA report to Congress (Ref. 1, 19). These data comprise a variety of types of noise sources:

Aircraft	12 cases
Other Transportation	7 cases
Other intermittent operations	5 cases
Steady-state neighborhood	7 cases
Steady-state industrial noise	24 cases

Approximately one-half the cases were associated with daytime operations only and one-half with 24-hour operations. They contain a wide range of dynamic characterisitics, including both infrequent, high level short duration noises and steady-state continuous noises.

The data for the 55 cases were re-analyzed in terms of the day-night average sound level. Further, the individual cases can be grouped into three categories of community reaction, "none," "complaints or threats of legal action," and "vigorous community reaction", as evidenced by organized group activity or legal action. A relationship between the day-night average sound level and the corresponding community reaction can be represented by the arithmetic average of the noise levels for the cases in each reaction category. This result is:

Community Reaction	Day-Night Average Sound Level-decibels
None	55
Complaints and Threats of Legal Action	62
Vigorous Action	72

The functional relationship between reaction category and noise level must have a curvilinear relationship, since the community reaction is unbounded at the lower and upper extremes of noise level. That is, the range of "no reaction" obviously extends to all noise levels below a specified value, and similarly, the range of "vigorous" reaction is unbounded at very high noise levels. (This accounts for the short scale of community reaction on Figure 3.

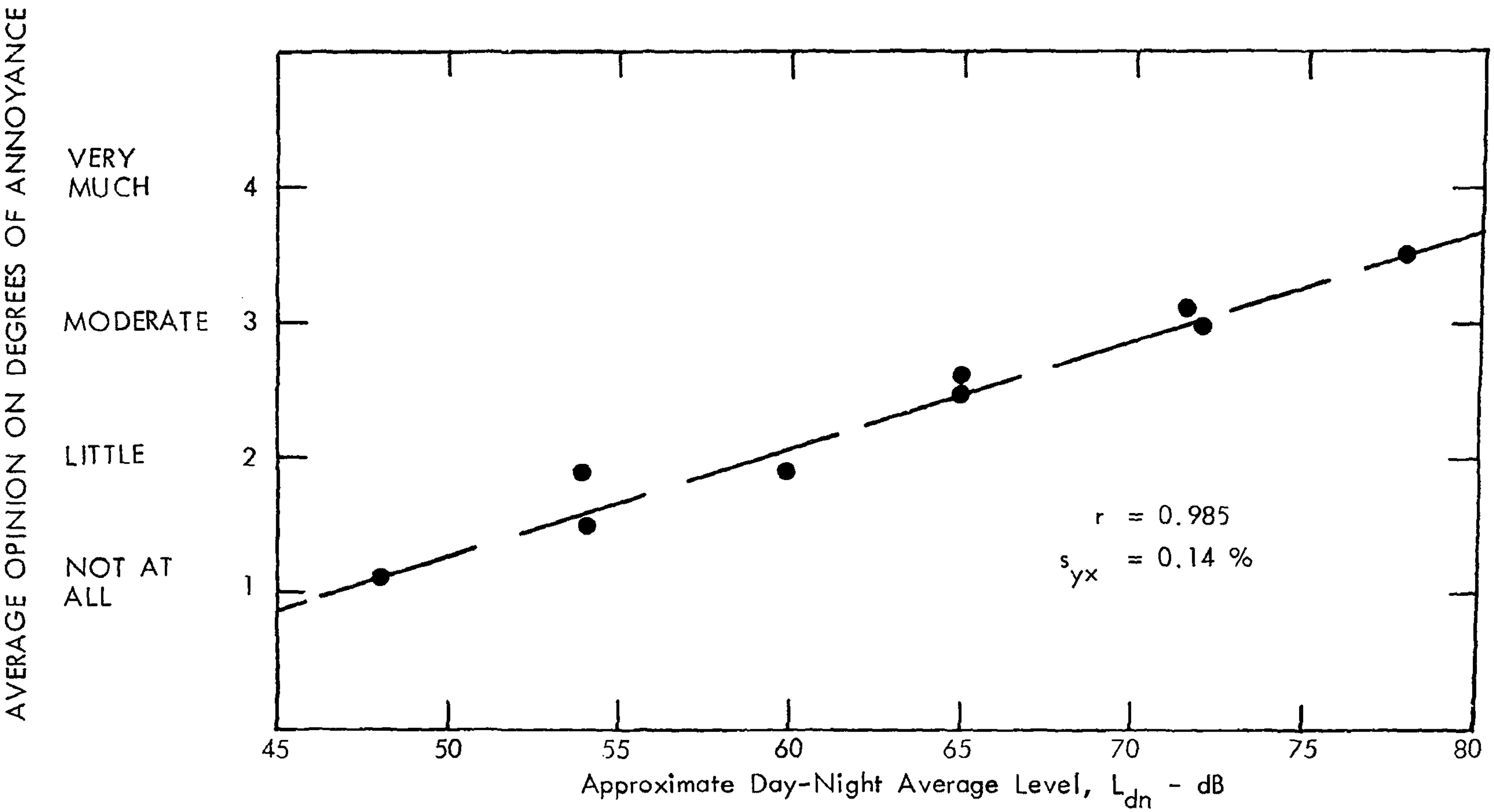

Figure D-1. Average Degree of Annoyance as a Function of the Approximate Day-Night Average Noise Level-Results of First London Heathrow Survey

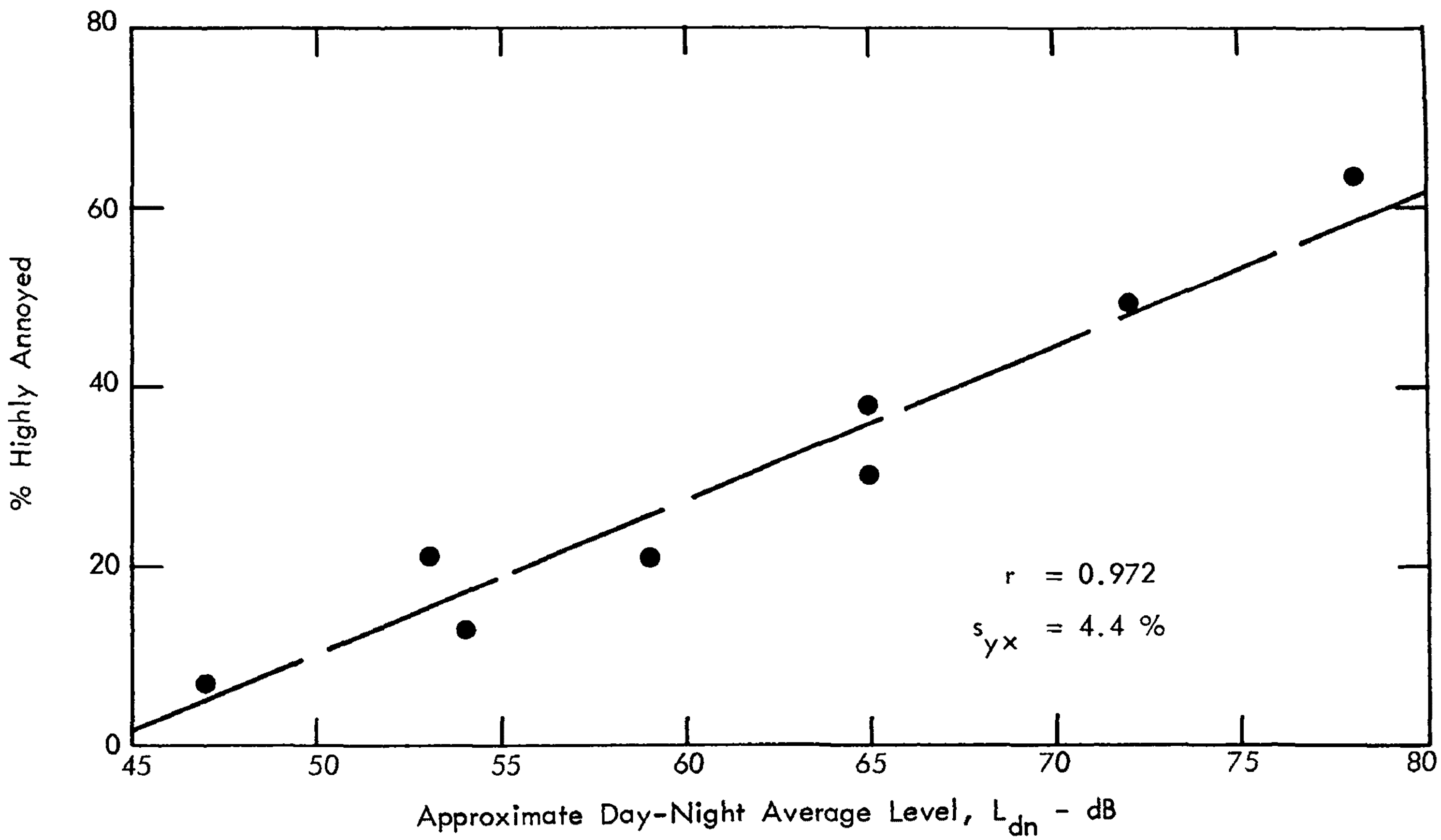

Figure D-2. Percentage Highly Annoyed as Function of Approximate Day-Night Average Noise Level-Results of First London Heathrow Survey

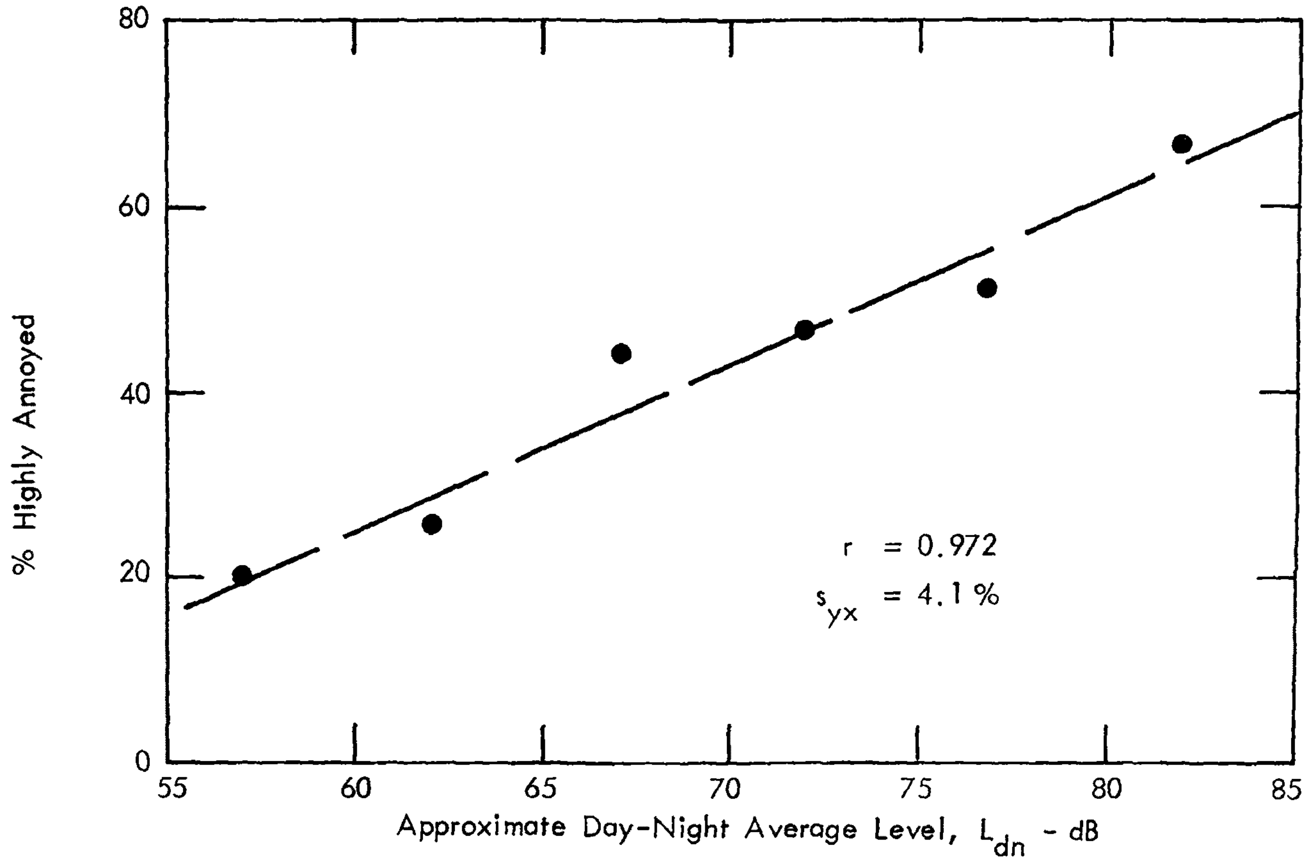

Figure D-3. Combined Results - British and U.S. Surveys (After Borsky, Ref. 18)

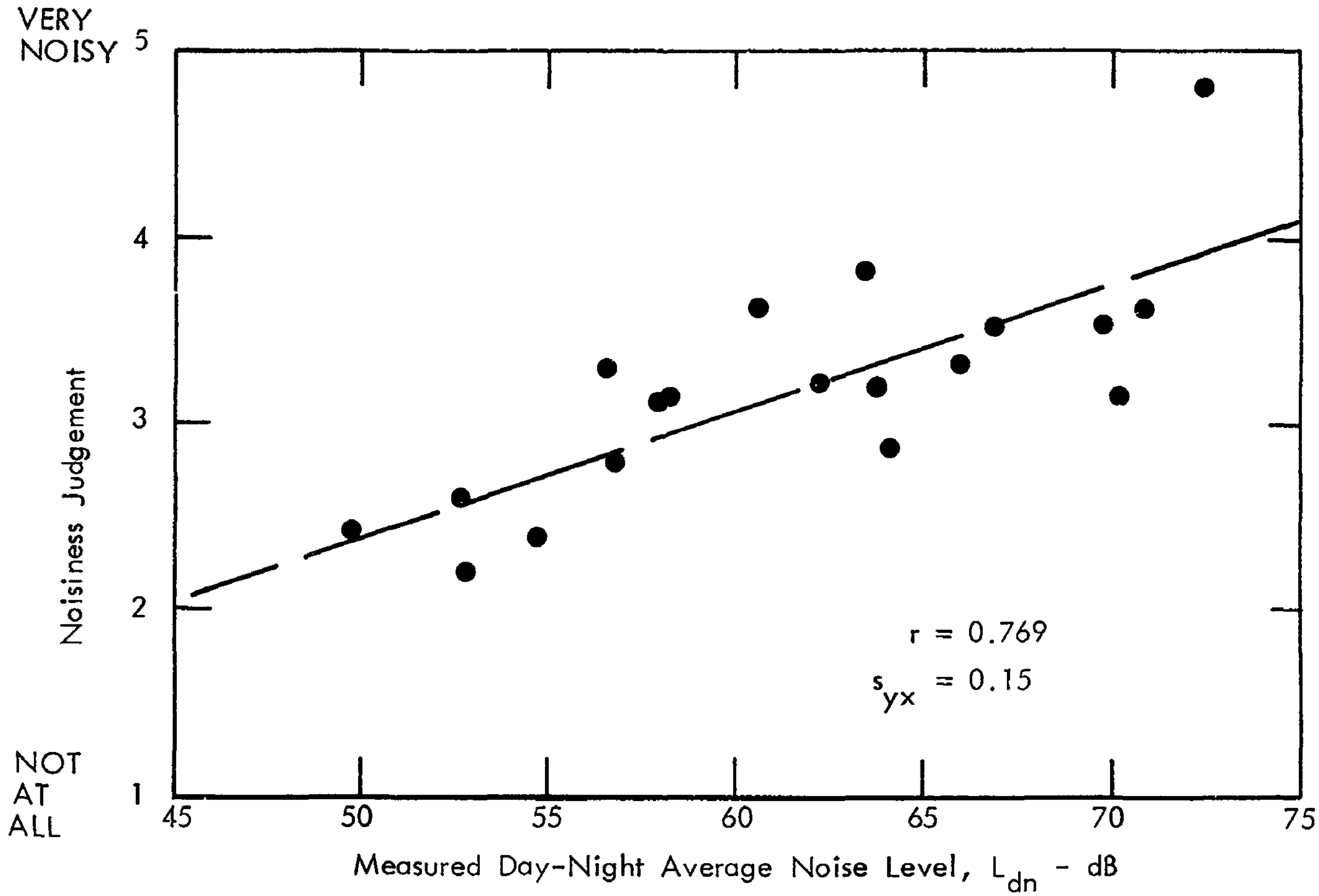

Figure D-4. Judged Noisiness at Automobile Manufacturers Association Survey Sites

APPENDIX E

SPECIFIC RECOMMENDATIONS FOR PREDICTING L_{dn} FOR AIRCRAFT/AIRPORT OPERATIONS

The following specific recommendations should be incorporated into the updating of procedures to predict the Average A-Weighted sound level from aircraft operations (Ref. 4).

1. The air absorption data contained in the latest revision of SAE ARP 866 (Ref. 9) are to be used in noise calculations until an updated standard on this subject is available.

2. The method for predicting ground propagation losses now being used in NEF calculations, and the algorithm now in use by FAA for transition between ground and air attenuation are to be employed in predicting noise from aircraft operations.

3. The data acquired for use in the aircraft noise model should allow incorporation of aircraft acceleration effects in the sound level contours.

4. Data on the effect of density/altitude on aircraft performance and noise effects should be included for various aircraft operating weights.

5. The acoustical standard day (15°C, 70 percent relative humidity) is to be used as the basis for noise contours, unless an examination of the mean monthly temperatures and relative humidities show three months during the year in which the product of temperature, in °C, and relative humidity, in percent, is less than 400. In such cases, the noise exposure calculations for the airport/airbase should utilize sound level versus distance curves based on the appropriate weather conditions.

6. Computations of the number of average daily operations should correspond to a "busy-day" if differences over weekly or monthly intervals occur.

7. Allowance for flight path dispersion should be included, based on a suitable model derived from flight path observation data.

8. Aircraft ground runup operations for maintenance purposes should be included in the noise calculations. Noise produced while the aircraft is on the runway and associated directly with takeoff operations should be included in the takeoff noise calculations, and thrust-reverser noise should be accounted for in landings.

APPENDIX F

MINUTES OF TASK GROUP 3 MEETINGS AND LIST OF ORGANIZATIONS AND INDIVIDUALS PARTICIPATING IN TASK GROUP 3 ACTIVITIES

F1.1 Minutes of Meeting Number 1, 15 February 1973.

F1.2 Minutes of Meeting Number 2, 27 February 1973.

F1.3 Minutes of Meeting Number 3, 10 March 1973.

F1.4 Minutes of Meeting Number 4, 4 April 1973.

F1.5 Minutes of Meeting Number 5, 11 May 1973.

ATTENDANCE

TG3/Meetings

NAME	MTGS ATTENDED	ORGANIZATION
Betsy Amin-Arsala	2, 4,5	GWU
Peter P. Back	2,3,4,5	EPA (Consultant)
William B. Becker	1,2,3,4,5	Air Transport Association
Lawrence P. Bedore	5	National Business Aircraft Assoc.
Robert S. Bennin	2,3,4,5	City of New York
Clemmine Blanchard	3	Los Angeles Airports
[illegible]	3,4	NIH
R. E. Coykendall	3,4,5	ATA (U.A.L.)
John Curry	2	United Airlines
Diane Donley	1, 3	Council of Environmental Quality
LCDR Leigh E. Dontis	2,3, 5	Dept of Navy - BuMed
Ken Eldred	2,3,4,5	BBN
Stephen A. Falk	4	NIH
Earl Fish	2, 5	Douglas Aircraft
Jack Fredrickson	3	Boeing Company
W. J. Galloway	1,2,3,4,5	BBN
H. von Gierke	1,2,3,4,5	EPA (Chairman - USAF)
Harvey Hubbard	1,2, 4	NASA-Langley
Raelyn Janssen	2,3,4	Environmental Defense Fund
Daniel L. Johnson	1,2,3,4,5	EPA (USAF)
John B. Kruk	3, 5	Piper Aircraft Corporation
David Lee	3,4,5	OSHA - DOL
Bert J. Lockwood	2,3,4,5	Los Angeles Dept. of Airports
A. L. McPike	1, 3,4	Douglas Aircraft
J. Miller	1, 4,5	HUD
Clifton Moore	3	Los Angeles Dept. of Airports
Robert Morse	1,2, 5	Pratt and Whitney Aircraft
Sidney J. Nethery	5	EPA (USAF)
Harvey J. Nozick	5	EPA (Consultant)
Shellie Ostroff	1, 3,4,5	Informatics
Noel A. Peart	2,3,4,5	Boeing Company
Arthur Rubin	1, 3	National Bureau of Standards
Harvey B. Safeer	5	DOT
Robert W. Simpson	3,4	MIT
M. C. Steele	3,4,5	Garrett-Airesearch
Jack Suddroth	5	NASA
Alice Suter	4	EPA
Brian Tennant	1,2	Boeing Company
J. R. Thompson	4	Lockheed Company
John M. Tyler	2,3,4	N.O.I.S.E.
W. Dixon Ward	3,4	EPA (Consultant)
John F. Waters	2	Environmental Defense Fund
Simone Yaniv	1,2,3,4,5	EPA/ONAC
Robert W. Young	4,5	Naval Undersea Center

LIST OF THE ORGANIZATIONS OF THE MEMBERS THAT ATTENDED TG3/MEETINGS

ORGANIZATION	MEETINGS ATTENDED
Government or EPA Consultants	
EPA	1,2,3,4,5
City of New York	2,3,4,5
Dept. of Navy	1,2,3,4,5
Bolt, Beranek and Newman	1,2,3,4,5
U. S. Dept. of Housing & Urgan Development	1, 5
Dept. of Labor	3,4,5
Informatics	1, 3,4,5
National Institute of Health	3,4
NASA	1,2, 4,5
National Bureau of Standards	1, 3
Dept. of Transporation	5
U. S. Air Force	1,2,3,4,5
Industrial	
Piper Aircraft Company	3, 5
Garrett-AirResearch	3,4,5
Air Transport Association	1,2,3,4,5
Pratt & Whitney Aircraft	1,2, 5
Douglas Aircraft	1,2,3,4,5
National Business Aircraft Assoc.	5
Los Angeles Dept. of Airports	2,3,4,5
Boeing Company	1,2,3,4,5
Lockheed Company	4
United Airlines	2,3,4,5
Private or Other	
Council of Environmental Quality	1, 3
George Washington University	2, 4,5
Massachusetts Institute of Technology	3,4
Environmental Defense Fund	2,3,4
N.O.I.S.E.	2,3,4

F1.1

DEPARTMENT OF THE AIR FORCE
6570TH AEROSPACE MEDICAL RESEARCH LABORATORY (AFSC)
WRIGHT-PATTERSON AIR FORCE BASE, OHIO 45433

REPLY TO ATTN OF: AMRL/BB

16 February 1973

SUBJECT:

TO: Participants in Activities of Task Group 3
Impact Characterization of
Aircraft/Airport Noise Study Task Force

1. Summary of first meeting on 15 Feb 73

a. The task group discussed implications of and approach to overall assignment on the basis of the attached subtasks. After considering the constraints imposed by the Noise Control Act the tentative conclusion was that the Noise Exposure Characterization and assessment method would have to be a weighted overall sound pressure level measure similar to the CNEL procedure. The chairman mentioned that a CHABA working group is working on such a procedure in connection with general Noise Environmental Impact Statements and that more information on this method would be available at the next meeting. The approach to recommending permissible limits was discussed; it was considered desirable to present all information in terms of percentage of people affected with respect to health (annoyance), etc., and leave final decision open for administrative/economic decision. It was decided that study of the economic impact of selecting specific permissible levels could not be an isolated task group 3 exercise but would have to be a joint task group 2, 3 and 4 exercise after these groups have completed their primary assignments. The steering committee will be made aware of this to prepare for this, probably through an additional economic consultant capability.

b. The task group discussed the following weighting factors for the noise exposure characterization:

1. frequency weighting: A-weighting appears the only possible solution for the moment, but most participants favored the possibility to go to N-(D-)weighting as soon as such a network is standardized and widely available.

2. tone correction - probably no

3. period of day - probably 2 periods

4. background noise - probably not to be included.

5. seasonal correction (ICAO)

2. All participants were asked to study the problems and to submit their position prior to or at the latest at the next meeting. I know it is

impossible for all of us to get an official position of the organizations we represent in such time periods. In spite of this it would help if you would submit your comments in two parts:

a. What do you think the official position of your organization will be on this matter. (This will help us to formulate our justifications.)

b. What is your personal technical recommendation regarding this subject.

Please be prepared to discuss and help with the actual work on the preparation of the task group subareas outlined on the attached. Please feel free to propose changes to the outline attached.

3. Our next meeting will be on Tuesday, 27 Feb 73 at 9:30 a.m. at EPA,* Washington, DC. My phone numbers are: office (513) 255-3602, home (513) 767-2181.

H. E. von Gierke
HENNING E. VON GIERKE
Director
Biodynamics & Bionics Division

Atch
Outline

*Meeting location will be 1111 20th Street, N.W.
5th floor, Room 531

Mailing address for EPA/ONAC remains unchanged:
Office of Noise Abatement & Control
Environmental Protection Agency
Washington, D.C. 20460

TASK GROUP 3

IMPACT CHARACTERIZATION

SELECTION OF NOISE EXPOSURE CHARACTERIZATION AND ASSESSMENT METHOD

- EVALUATION OF EXISTING AND PROPOSED METHODS WITH RESPECT TO TECHNICAL MERIT, ECONOMY AND ENFORCEMENT THROUGH MONITORING

- DETAILED DESCRIPTION OF SELECTED METHOD INCLUDING DECISION ON ALL PARAMETERS TO GUARANTEE UNIFORM AND ECONOMIC APPLICATION

- RELATION OF SELECTED METHOD TO NOISE IMPACT CHARACTERISTICS USED FOR OTHER PURPOSES (AIRCRAFT NOISE CERTIFICATION, HIGHWAY NOISE, LAND USE PLANNING, ETC.)

- PROCEDURE AND ECONOMY OF MONITORING NOISE EXPOSURE

SPECIFICATION OF MAXIMUM PERMISSIBLE NOISE EXPOSURE LEVELS

- DESIRABLE NOISE EXPOSURE LEVELS WITH RESPECT TO PUBLIC HEALTH AND WELFARE

- ESTIMATION OF ECONOMIC IMPACT OF SELECTING PERMISSIBLE LEVELS

- RECOMMENDATION OF MAXIMUM PERMISSIBLE LEVELS AND IMPLEMENTATION

- MONITORING OF MAXIMUM PERMISSIBLE LEVELS

F1.2

ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

TASK GROUP 3

MINUTES OF SECOND MEETING, 27 Feb 73

1. The chairman opened the meeting at 9:40 and welcomed the task group members, who had participated in the first meeting, and new participants. (See attached list.) He briefly reviewed the events of the first organizational meeting of the whole task force and of the first meeting of Task Group 3. The minutes of the first meeting, copies of the Noise Control Act 1972, assignments to the task force and time schedules discussed at the first meeting were distributed and discussed. The chairman asked all members to submit by the end of each meeting drafts of specific items they brought up at the meeting and want to have recorded specifically in the minutes. He also asked that members submit between meetings (a) technical papers, documents, position papers or statements which would support task group activity or are relevant to decisions reached or activities planned by the group, and (b) more formal position papers to be included in the final task group report, particularly if they desire their position to be recorded as being not in full agreement with the task group decision or course of action.

2. A detailed discussion of the work assigned to the task group and the chairman's proposed outline of task group activity and potential outline for the report followed. The chairman stressed that this outline is tentative and subject to change. A letter written by four Environmental Groups (N.O.I.S.E., E.D.F., E.A., A.C.A.P.) addressed to Mr. Schettino was introduced and distributed. Mr. Tyler expressed the concern of these groups in more detail and submitted another letter specifically addressed to task group 3. The main concerns of these letters were: 1. The task force study should deal not only with the adequacy of existing FAA measures and regulations with respect to noise but also should review the whole past history of FAA's dealing with the aircraft noise problem. 2. All reports, papers, government documents, etc., dealing with previous committees, actions, studies, regulatory histories, etc., concerned with the same issues should be made public and should be at the disposal of the task force. The chairman and most members of the group disagreed with Mr. Tyler and interpreted the Noise Control Act and the assignment to the group to review the adequacy of existing regulations, procedures, etc., and that nothing would be gained from a review of history. The chairman assured the concerned groups that all efforts would be made by EPA to have the relevant documents available at the task force headquarters for use in the study, that the Informatics noise information retrieval system would be available for task force use and that he himself and several other members of task group 3 had participated in most of the previous studies and conferences mentioned in the letter and that he thought most of the important documents could be made available from the personal files of these task group members.

3. At this time Dr. A. Meyer, Director of ONAC, EPA, joined the group for 45 minutes and restated EPA interpretation of the Noise Control Act and task force goal. Specifically he confirmed that the charge was to review the adequacy of existing noise control regulations and actions, etc., with respect to Public Health and Welfare. He emphasized that FAA never had the charge of taking action with respect to Public Health and Welfare and that it could not have been the intent of Congress to have EPA investigate the history of past FAA actions. He satisfied all task group questions and concerns regarding this problem. Dr. Meyer promised to take action with respect to participation of the following four government agencies, contributions from which are considered important for expedient, economic and unbiased task group 3 activity: DOT and FAA, Department of Labor and HEW. (Of the four all but DOL had been invited to participate. Dr. Meyer discussed the reservations DOT had at this time to participate in the task force effort and expressed hope that this question could be resolved soon.)

4. The task group (including Mr. Tyler) agreed on the proposed approach and report outline without alteration and addition. The chairman stressed the importance of agreeing on the basic approach since this decision on the measure for cumulative noise exposure is a prerequisite for efforts by other task groups. He mentioned another parallel study effort conducted by a National Academy of Sciences (CHABA) working group at the request of EPA to draft "Guidelines for Environmental Impact Statements" for all types of noise (not only aircraft noise). Dr. von Gierke, who is also chairing the CHABA working group, and Dr. Galloway presented details about the proposed CHABA approach and how the same approach, as tentatively agreed upon in the first meeting, could be selected by the task group as the basis for characterizing cumulative noise exposure. Everybody agreed that it was not only desirable but essential that any methodology proposed for cumulative noise exposure characterization must be applicable to all types of noises. The proposed method, selected as basis for further study, is a weighted noise exposure level (W N E L) similar to the CNEL based on the weighted energy time integral of sound level A with a correction for nighttime exposures.

5. As a continuation of meeting #1, specific details of the proposed W N E L were discussed on the basis of a rough draft document submitted by Dr. Galloway and distributed to all participants:

a. Frequency Weighting: Some objection was voiced to using the "A" weighting instead of the "D" weighting. Mr. Sperry (EPA) stated that he thought the whole method proposed was a step "30 years backwards" and intended to write a position paper against using the "A" weighting scale. Mr. Sperry was assured that selection of a common, relatively simple and practical method for measuring noise exposure of all noises does not mean that certification of aircraft and other equipment and type emission standards could not and should not use more refined methods and noise descriptors such as EPNdB in FAR-36. It was decided to make this point very clear and explicit in the written report of the task group. The nonavailability of a standardized D-network was felt by most members to dictate the use of the "A" scale at this time although the possibility of proposing a conversion to the "D" scale for a later date was discussed. However, it was felt by most that even such a step would require better data on the advantages of D over A as indicator with respect to Health and Welfare effects than are presently available. The chairman pointed out that annoyance is only one aspect of Health and Welfare.

b. Tone Correction: It was suggested that when recommending limits tones should be assumed present in the noise unless shown by a more sophisticated method not to be present. There was substantial argument against this idea and for the present tone correction will be neglected. It was felt that tone penalties should be in certification and emission requirements but should not be included in the WNEL because of the monitoring complications and because of several technical uncertainties regarding the penalties.

c. Period of Day: There was a consensus that two periods were required with the period at night to be 9 hours and weighted with a 12 dB (10-15 dB) correction factor. Mr. W. Becker pointed out the desirability to make the night period start at a uniform time. The task group will attempt to generate data to support the amount of the correction factor. (Action - Mr. Eldred).

d. Background Noise: The WNEL method provides no special correction for background noise; the WNEL measure itself includes automatically the background noise present. The task group agreed to this approach.

e. Seasonal Correction: The ICAO provision was discussed. This correction will probably be dropped from consideration. The rationale for omitting seasonal correction will be drafted by Mr. Tyler.

All task group members were asked to submit relevant data, draft justifications and/or position papers on the basic WNEL approach and on (a) to (e) above prior to or at the next meeting. The draft of the methodology document with supporting appendices will be compiled and further refined by Dr. Galloway.

6. Discussion of specification of maximum permissible noise exposure levels: The basis for selecting and recommending such levels with respect to public health and welfare were discussed. The following criteria will be considered in the decision process: (a) risk of hearing loss, (b) percentage of people severely annoyed, (c) requirement for speech communication, (d) "normal," natural background noise, (e) economic impact of selecting various exposure levels. It became clear that setting maximum permissible levels for cumulative exposures does not make the setting of limits for maximum sound pressure levels or the limitation of maximum nighttime noise levels superfluous. This must be made clear in the report, even if the task group attacks only the problem of cumulative noise exposure.

In preparation for more detailed committee discussion and decisions on this subject,background material on (a) to (e) is to be submitted for the next meeting.

Mr. Back and Mr. Eldred were assigned primary action to prepare such material. In particular data and graphs on a national basis are desired on: how much land is in the various noise exposure zones, what is the price of this land and how many people live in these zones? Rough estimates of these figures (not only for airports but for other noise exposure zones such as along highways) would assist to assess the economic impact of selecting specific permissible levels. The chairman proposed that such estimates should be available for zones equivalent to NEF 25 to 45.

Mr. Eldred will correlate information and submit approaches to select permissible WNELs.

The need for access to DOT contractor material (Wyle) was emphasized and desirability for HEW, DOT and HUD (Mr. Miller) participation in this phase of task group activity. The chairman will make efforts to obtain support from these agencies.

7. No specific material to be recorded in the minutes of this meeting were submitted by task group members.

8. The date for the next task group meeting was set for 20 March 1973, 9:30 AM at 1111 20th Street, NW, Washington DC. The following meeting will be on 4 April at the same time and place.

H. von Gierke
HENNING E. VON GIERKE
Chairman, Task Group 3

1 Attachment
Attendance List

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

Task Group 3

Minutes of Third Meeting, 20 March 1973

1. The Chairman, Dr. von Gierke, opened the meeting at 9:30 and welcomed 21 members who participated in the earlier meetings and 8 new members. The Department of Labor and the National Institute for Environmental Health Sciences (NIH) were represented for the first time. HUD had been requested by the Chairman to be present at this meeting; however, HUD did not feel that it was necessary to present an opposing view to the Task Group recommendations as stated up to the present.

2. A complete record of all reports, minutes, position statements, etc., of Task Group 3 is available in a Special File in the office adjoining the conference room (Room 531). Small reports and working papers will be distributed to each member, but the large documents with background material only will not be reproduced and/are available only in this file. All members are welcome to use the contents of this file, but the Chairman requested that the material not be removed from the office except for copying in this office. The large reports containing background material, as well as other references, will be available through Informatics, Inc. Attached is a list of the documents that are considered a part of Task Group 3's official file. Each document will have an I.D. number (e.g., TG3/14).

3. The Chairman received several letters on position papers, as well as replies, back from action items. The letters were distributed to each member and discussed as follows:

a. Lockwood's Letter (TG3/10)

Mr. Lockwood thought (1) that the method of Weighted Noise Exposure (W.N.E.) might be too complicated and (2) that it would be necessary to use a simple method that could be presented clearly in a law court. In fact he proposed that the task force's actions should be guided to a larger extent by past court decisions. Several members answered that with respect to (1) they thought the proposed W.N.E. would be such a simple method. It could either be accomplished manually over a 24 hour period with a dB(A) meter or could be accomplished by a simple dosimeter, probably costing under $1,000, that measures the total noise energy over the 24 hr period.

After considerable discussion, there seemed to be general agreement that use of W.N.E. would resolve most of Lockwood's objections to the impractical and hard to use methodologies of the past. With respect to use of past court cases, it was suggested that lack of uniform scientific and legislative guidance has produced many of the apparent idiosyncrasies in court judgments. Much of the problem can be resolved by a measurement system, such as the WNE, which is both simple and scientifically sound. The Aircraft Sound Descriptor System (ASDS) was brought up and discussed. Prof. Simpson of MIT explained what ASDS normally includes. He also discussed some of its shortcomings. Mr. Moore stated that ASDS as used by LA Airport is modified to include actual SPL. Dr. Galloway then pointed out that with such a modification, it would be an easy matter to convert the measurements to the single WNE number that is recommended.

b. Ken Eldred gave a progress report for looking at the rationale behind the 12 dB difference between daytime and nighttime exposure. By using 55 noise exposure cases, he believes that he can show that the optimum correction is between 8-12 dB. The final results and conclusions will be distributed prior to the next Task Group meeting.

At this time Mr. Coykendall brought up the point of separating the nighttime measurements from the daytime measurements and using two separate criteria. This was discussed in detail and the final consensus reached was that the night correction factor was a satisfactory approximation. The Chairman pointed out that having two measurements and criteria, daytime and nighttime, would prevent establishment of simple single average daily and/or yearly noise values.

c. A set of typical exposures measured in LEQ was distributed to all members. These had been prepared at the Chairman's request by Dr. Galloway and were a result of BBN's efforts of measuring actual noise levels in homes and offices. (Report is numbered TG3/11). These are to be used in further discussion of typical internally generated WNE's inside homes and in the decision if WNE limits are better recommended in terms of environmental outside noise levels or levels inside buildings; i.e., levels at the listeners' ears.

d. Peter Back presented the status of evaluating the economic impact of protecting the population against variousNEF doses. His results were not complete at this time. An estimate was given that the NEF 30 contour would enclose 2,000 square miles of land and that to buy such an amount of land would cost approximately 92 billion dollars. The amount of people inside such a contour for various noise sources were:

Aircraft Noise	7-1/2 to 16 million
Freeway Noise	2 to 5 million
Arterial Road Noise	7 to 14 million
Construction Noise	10 million

The Chairman requested such information for at least two more NEF values. Mr. Back said that he would try to have these available in two to three weeks.

e. John Tyler provided a status of his report on seasonal corrections. He indicated that essentially such corrections are best neglected as there are several opposing factors that enter into such a correction. Use of inside-the-house dose levels as exposure limits would even further reduce the need of such corrections. Tyler will write up the report by the next meeting.

f. Mr. Hubbard, as an action item of the last meeting, presented a paper on tone correction (TG3/8). His final conclusion was that tone correction was not necessary.

4. Other items discussed.

a. Mr. Coykendall pointed out a mathematical error in one of the formulas for defining W.N.E., page 2 of TG3/6, Draft text on "Noise Exposure Units." The correct formula is:

$$WNE = 10 \log\left[\frac{1}{15\cdot 3600}\left(\frac{15}{24}\right)\int_{0701}^{2200} 10^{\frac{L_A(t)}{10}}\,dt + \frac{1}{9\cdot 3600}\left(\frac{9}{24}\right)\int_{2201}^{0700} 10^{\frac{L_A(t)+12}{10}}\,dt\right]$$

b. Mr. McPike brought up the idea that the effective noise that is measured inside a typical house is more important than outdoor noise measurements. Currently aircraft are being designed to reduce outdoor noise. The design of aircraft for noise reduction is different if indoor noise is to be reduced; as such indoor noise comes more from the lower frequencies. The group did concur that the use of the measured or estimated indoor noise would lead in principle to better definition of the typical human noise exposure. Mr. McPike was asked by the Chairman to prepare a paper on the methodology and rationale of transforming outdoor noise measurements into an expected indoor noise level.

c. David Lee, Dept. of Labor, discussed the possibility that the methods and recommended limits provided by this Task Group might be in conflict with the jurisdiction of the Labor Department, particularly in the area of potential hearing impairment. The Chairman stated if such conflicts occur, resolution would be required at a higher level than available at this Task Group.

d. Mr. Cook mentioned that in the deeper stages of sleep, low frequencies were more likely to awake a person than the equally intense A-weighted sounds at higher frequencies.

e. John Tyler pointed out that the economic impact of the NEF contours could be significantly changed if technological or operational changes reduced the noise sources and thus reduced the area enclosed by an NEF contour. It was recognized that predictions based on existing NEF contours will be approximate only and will change with changing emission level reductions. Mr. Back pointed out that such improvements in noise sources may not be accomplished unless regulations based on many of the recommendations of this Task Group establish the need of such noise emission reductions.

f. The Chairman read various definitions of "Public Health and Welfare" (Clean Air Act, WHO, EPA) and distributed a copy of the same to each member.

g. Mr. Lockwood took as an action item to provide the Chairman and Mr. Back data of complaints and court cases versus NEF contours about the LA Airport.

5. The Chairman specifically asked Mr. Lee (Department of Labor) and Mr. Cook (NIH) to prepare papers representing the positions of their agencies concerning the methods proposed by the Task Group.

6. The Chairman emphasized that per the schedule, the next meeting is the last time for technical input. All technical papers should be ready by this 4 April 1973 meeting. The meeting will start at 0930 at the same location (1111 20th Street, NW, Washington DC).

7. No specific comments to be included in the minutes of this meeting were submitted by Task Group members.

Daniel L. Johnson for

HENNING E. VON GIERKE
Chairman

Task Group 3

Minutes of Fourth Meeting, 4 April 1973

1. The chairman, Dr. von Gierke, opened the meeting at 0930 and welcomed 23 members who had attended previous meetings and three new participants (see attached lists). The chairman mentioned that Dr. Karl Kryter was specifically invited by the EPA (ONAC) to attend the meetings in response to the specific request by N.O.I.S.E. submitted at a previous meeting, but was apparently unable to attend. The meeting was conducted in two sessions, both continuing the work planned or tentatively discussed or decided upon at previous meetings. The morning session considered the selection of a noise exposure characterization and assessment method while the afternoon session considered the bases for selecting and potentially recommending maximum permissible noise exposure levels.

2. Selection of a Noise Exposure Characterization and Assessment Method.

The chairman asked if there were any new comments on the following factors:

a. Use of A weighting scale. No new comments were presented. Mr. Becker did emphasize in the afternoon that he thought the use of dBA was a great idea. Reg Cook formalized his earlier complaint in his letter (TG 3/31 discussed later).

b. Equal Energy Rule. The chairman stated that for annoyance, research has indicated that equal energy is probably the best approach. The members were asked, however, if anyone knew of any data that would show that a 4 dB or 5 dB rule per doubling of exposure time was better than 3 dB per doubling (equal energy) for correlating with annoyance/community reaction. None of the members presented such data. The chairman then stated that for hearing conservation equal energy may not be the most accurate predictive method. It is a conservative approach, so the use of equal energy will have a tendency to overestimate the effects of noise exposure on hearing. Upon questioning, no members stated that they felt it necessary to use a system other than equal energy. The chairman pointed out that if two different methods of handling time were required, the research and preparation required for impact statements would be almost twice as much.

c. Seasonal Changes. Mr. Tyler's paper (TG 3/24) was presented and discussed. The recommendation of the paper was to treat noise exposure as that noise exposure that is expected to reach an individual. Thus evaluation must be based on what percent of time people are expected to be inside and outside a building. This then will give a basis for a correction factor that can be used for outdoor noise measurements. A correction for seasonal change is thus not required.

d. Outdoor/indoor attenuation. Mr. McPike presented a paper (TG 3/26) on the noise attenuation expected to be provided by a "standard" house for both northern and southern construction for a window open or window closed condition.

At this point a lengthy discussion evolved concerning a multitude of ideas on indoor-outdoor measurement and related exposure specification.

Galloway suggested that the indoor/outdoor situations are not so different as to be expected from house attenuation values as people will expect less noise intrusion indoors. McPike stated that he felt that there are more complaints from indoor problems. Simone Yaniv argued that the most sensitive groups, such as children and the aged, should be protected. Several members expressed the fear that focusing on the indoor noise exposure would entirely neglect the outdoor exposure.

John Tyler added that outside exposure is important. Apartment houses without yards can generally accept more noise than the residential single family dwelling. He suggested that one standard noise exposure or noise energy dose be allowed per individual. Each community could decide how to keep noise exposure under this limit. Thus, zoning laws and building codes might be different in each community as based on different living styles such as indoor/outdoor ratios. Tyler also presented the SAE report (TG 3/27) on House Noise Reduction Measurements.

Dr. Yaniv asked who was going to determine what indoor/outdoor ratios to use. This question was left open at the time of the meeting.

The chairman summarized that the noise exposure chosen to be used in the task group report will be based on the environmental exposure of people, i.e., that human exposure will be based on our estimate of his exposures to indoor and outdoor levels, which will be added to result in the total average daily noise exposure.

e. Nighttime Correction. Ken Eldred gave a rough draft of noise exposure measurements of 63 sites. He thought that a nighttime correction of 10 dB would be best. In most locations, 10 dB additions give approximately an equal distribution for 24 hours. If too high of a nighttime correction is used, then nighttime noise completely controls the exposure measure. He will prepare a final working paper on this subject incorporating results of the discussion.

3. Consideration/specification of Maximum Permissible Noise Exposure Levels. The following items were discussed by the task group.

a. NEF contours. Mr. Lockwood discussed his 27 March letter (TG 3/28) concerning the noise complaint history at the Las Angeles Airport. A map of the L.A. area was presented. Depicted on the map were various court cases and complaint areas. The NEF curves were also drawn on the map. Mr. Lockwood noted that there were more complaints in the summer than in the winter (200-300 complaints/month versus 40-50 complaints/month) and he guessed that only 2-3% of the complaints were outside the NEF-40 contour. The chairman noted that he thought the group should be guided by what is known about human effects, not just court cases. Bill Galloway stressed that there is a difference between complaint level and acceptability level. Lockwood replied that the courts will correct the results if the regulations are not good. The chairman requested that if some of the group members felt that NEF or a similar system as presently considered by the task group is not good, then what system can be used? In response, Mr. Becker asked if it was too late to submit a paper about the changes that would make NEF a better measure. The chairman said it would not be too late to submit such a paper and encouraged Mr. Becker to do so.

b. A paper (TG 3/29) "Hearing Loss Expected For Various Noise Exposure Values" was presented by Daniel L. Johnson. The conclusion reached was that for practical or typical environmental noise situations, a noticeable hearing change (90 percent of the population will have less than a 10 dB Noise Induced Permanent Threshold Shift at the most sensitive 4000 Hz frequency) will not occur for a Leq as measured outside that is below 85 dBA.

c. A paper (TG 3/30) "Percent of the Time that Speech Interference will Occur for Various Leq Values" was presented by Daniel Johnson. Ken Eldred suggested further that it would be helpful to determine how sensitive the calculated percentages were to the particular noise profile assumed. Johnson said that he would attempt to show how much the percentages change by assuming various other noise patterns. A limit for NE as required for Speech Interference was not recommended at this time.

d. Letter (TG 3-31) from Reginald Cook (NIH) was discussed. Dr. Falk (NIH) thought that noise would cause other physiological changes and suggested that future research in this area be recommended by TG3. Dr. von Gierke stated that he thought that it was not the primary purpose of the Task Group 3 to request future research but to make the best recommendations for practical use based on available data.

e. Letter (TG 3-32) from Dept of Labor was discussed next. Dave Lee of the Dept of Labor discussed the paper. He emphasized that what the Task Group 3 suggests must be enforceable. He then asked if Task Group 3 was at a point that it could write a standard? He thought that for the most part, firm conclusions were not coming out of the meetings. The chairman replied that perhaps time was too short to resolve all the problems, but many questions (such as use of A weighting) have been resolved. The outline (see TG 3/2) was reviewed at this point in response to several questions concerning where the task group was headed. In essence, the chairman will now coordinate the writing of a preliminary draft that will draw upon the items discussed in the previous meetings. Firm decisions will be made in this draft and presented for review to the Task Group members prior to the next meeting.

f. Letter (TG 3-33) from the Boeing Company was distributed and discussed.

4. No specific comments to be included in the minutes of this meeting were presented.

5. The chairman stated that the next task was to prepare a draft of the document required from Task Group 3. The next meeting was tentatively scheduled for 11 May 1973, 9:30 at 1111 20th Street, NW, Washington, D.C., but would depend on finishing the draft on time for review. Each member will receive confirmation of the date for the next meeting. If due to possible mail delays members do not have confirmation of the 11 May meeting date at the time they must make travel plans, they should check with EPA-ONAC or Dr. von Gierke by phone if the meeting takes place as scheduled.

HENNING E. VON GIERKE
Chairman

F1.5

ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

TASK GROUP 3

Minutes of Fifth Meeting, 11 May 1973

1. The chairman, Dr. von Gierke, opened the meeting at 0930 and welcomed two new members, Harvey Safeer of the Department of Transportation and Lawrence Bedore of the National Business Aircraft Association. Twenty four (24) members who had participated in earlier meetings were also present (see attached attendance list).

2. The draft report of Task Group 3 was completed and mailed to all members by 5 May 73. The meeting was devoted entirely to review of this draft report. The review consisted of two parts: (1) the questioning of each member present if the member had any major or significant criticism of the report and (2) recommended editorial changes.

a. Major Criticisms: The entire morning and part of the afternoon were used to discuss specific criticisms of the report. Individual comments are best described in the individual position papers on comments submitted by Task Group 3 members (see list of Key Documents). However, a general summary of the overall comments is as follows:

(1) All Task Group members present supported the intent and general goal of the written draft.

(2) Several members expressed that the specific maximum noise doses recommended (L_{dn} = 80 dB for immediate implementation and L_{dn} = 60 dB as a long range goal) were too low or the basis for recommending such levels not adequately described. This was especially true of the goal of L_{dn} = 60 dB. The chairman pointed out, in the final analysis, any limit is basically a value judgment that the EPA will be required to make. It was noted that time schedule for implementation of the 60 dB level was not suggested. Such a time schedule would depend on factors such as the economic impact, not considered in the draft report.

(3) The possibility of adding or expanding a number of sections in the report was discussed. Time permitting, it was generally agreed by the task group that the following items would be incorporated into the report of Task Group 3:

(a) A discussion of how the other task groups should or could use L_{dn} as a measure.

(b) A discussion of how L_{dn} could be used as a regulatory measure.

(c) A more detailed discussion of how L_{dn} relates to noise measures used in the past.

b. Editorial Comments: Detailed editorial comments were presented by many of the task group members and will be considered in the final draft report.

3. Any comments that concern the writing of the final task group report should be submitted by 21 May. Official comments for the Annex should be mailed by 24 May. Please address all comments in duplicate to Dr. von Gierke, Chairman, Task Group 3. The EPA address should be used for the original and the following address should be used for the copy:

Dr. H. von Gierke
Chairman, TG #3
6570 AMRL/BB
Wright-Patterson AFB OH 45433

The next meeting will be a general meeting of all task groups and is scheduled for 14 June 1973. The exact location in Washington DC will be announced later.

Daniel L. Johnson
Daniel L. Johnson

APPENDIX G

POSITION PAPERS AND MATERIAL SUBMITTED BY TASK GROUP 3 MEMBERS OR OUTSIDE ORGANIZATIONS

Letter from Environmental Defense Fund et al., dated 23 February 1973.

Memo from John Tyler (N.O.I.S.E.) "Comments on Proposed Scope of Activity of Task Group 3," dated 27 February 1973.

Letter from H. Hubbard (NASA), dated March 12, 1973, on pure tone considerations in measured community noise.

Letter from Bert J. Lockwood (Los Angeles Department of Airports), dated March 2, 1973, concerning Task Group 3 efforts on impact characterization.

Letter from William J. Galloway, dated March 9, 1973, transmitting 24-hour samples of indoor and outdoor noise exposures.

Memo from N.O.I.S.E. "Seasonal Changes" dated 4 April 1973.

"Determination of Indoor Sound Levels for Jet Transport Aircraft" prepared for Task Group #3 by Douglas Aircraft Co., dated 29 March 1973.

Letter from Bert Lockwood of March 27, 1973 concerning Noise Complaint History of Los Angeles Airport.

Letter from Richard H. Broun (Acting Director, Environmental and Land Use Planning Division, HUD), dated March 13, 1973, expressing HUD's position on development of a single noise measurement index, attaching HUD letters to FAA and AOCI.

Letter from Reginald Cook dated 3 April 1973 concerning NIH comments to Task Group #3 Impact Characterization Study.

Letter from Department of Labor dated 4 April 1973 concerning TG3 Aircraft/Airport Noise Study.

Letter from Boeing Company dated 2 April 1973 concerning various Boeing comments on EPA's Task Group #3 objective.

Letter (dated 13 April 1973) from James F. Miller, Director of Environmental and Land Use Planning Division, HUD, concerning reports presented at the 4 April 1973 Task Group 3 Meeting.

Letter dated 26 March 73 from Merle Mergell, Mayor of City of Inglewood, to John Schettino, EPA (ONAC) concerning recommendations to the Aircraft/Airport Noise Study Task Force.

Letter from Gordon L. Getline, Chairman, Subcommittee on Helicopter and V/STOL Noise, SAE Committee A-21 dated 3 April 73 concerning Selection of Noise Exposure Characterization and Assessment Method.

Memorandum from Robert W. Young to Task Group 3 chairman, dated 9 May 1973. Subject is Material for Report on Aircraft/Airport Noise.

Letter from Daniel L. Johnson, 10 July 1973, on an alternate method for considering the effect of average sound level on speech communication.

ENVIRONMENTAL
DEFENSE
FUND

1712
N STREET, N.W., WASHINGTON, D.C. 20036/202 833-1485

February 23, 1973

Mr. John Schettino
Office of Noise Abatement and Control
Environmental Protection Agency
1835 K Street, N. W.
Washington, D. C.

Dear Mr. Schettino:

As participants in the Environmental Protection Agency's Aircraft and Airport Noise Study Task Force, recently convened pursuant to Sec. 7 of the Noise Control Act of 1972, we have been invited to submit our views on the current agenda of the Task Force, and to supply or identify materials which should be before it.

I. The Agenda

With respect to the Task Force's agenda, we are deeply disturbed by statements made recently by EPA personnel, notably Mr. Alvin F. Meyers, Jr., that the Task Force is not concerned with past and present shortcomings of the FAA's efforts at regulating aircraft noise, but only with recommendations for future regulations, and that the Task Force is to avoid inquiries which might "embarrass the FAA."

As we read the Noise Control Act, an examination of the adequacy of the FAA's efforts to date is required in the plainest terms imaginable. Section 7(a) of the Act states:

> "The Administrator [of EPA], after consultation with appropriate Federal, State and local agencies and interested persons, shall conduct a study of the (1) adequacy of Federal Aviation Administration flight and operational noise controls; (2) adequacy of noise emission standards on new and existing aircraft, together with recommendations on the retrofitting and phaseout of existing aircraft; (3) implications of identifying and achieving levels of cumulative noise exposure around airports; and (4) additional measures available to airport operators and local governments to control aircraft noise. He shall report on such study to the Committee on Interstate and Foreign Commerce of the House of Representatives and the Committees on

> Commerce and Public Works of the Senate within nine months after the date of the enactment of the Act."

Section 7(b) of the Act makes plain that recommendations for new regulations are not to be made before completion of this study of the adequacy of existing FAA regulations. See Section 611(c)(1) of the Federal Aviation Act, as amended by Section 7(b). EPA has already lost nearly four months of the alloted nine, prior to setting up the Task Force. What little time the Task Force has left should be devoted to putting first things first, i.e., to studying the adequacy of existing regulations, as Congress directed, before proposing new ones.

II. Materials which should be before the Task Force

As to the question of identifying materials which should be available to the Task Force and its participants, we would begin by pointing out that this Task Force is by no means the first governmental body which has considered the problem of aircraft and airport noise. Accordingly, in light of the severe time constraints on the Task Force, it is urgent that the Task Force obtain and make conveniently available to its participants materials now in the hands of other agencies which bear on this problem. We would start with the following partial list of materials that are not currently in the Task Force's files:

1. With respect to each type of jet aircraft now operated or expected to be operated at American airports (specifically including the Concorde SST):

a. Noise contours (not just FAR 36 measurements) resulting from takeoff and approach, and the flight profiles and flap and thrust schedules used to obtain these contours, taking as a basis the actual procedures by which these aircraft are operated by the various air carriers, and the actual ambient temperatures and airport altitudes encountered, or, in the case of aircraft not now in use, the actual procedures by which they are expected to be operated--together with these actual temperatures and airport altitudes;

b. Variations in flight procedure (flight profile, flap and thrust schedule, etc.) with aircraft weight, and the accompanying changes in noise contours;

c. Noise measurements at the FAR 36 takeoff, approach and sideline measuring points, together with the flight profiles and flap and thrust schedules used;

d. Noise versus distance curves used in plotting the above contours for each of these aircraft for:

(i) Takeoff thrust;

(ii) Maximum continuous thrust;

(iii) Thrust used after power cutback following initial climb;

(iv) Thrust used on approach;

2. The transcripts and minutes of all meetings of the Program Evaluation and Development Committee (PEDC) of the White House Office of Science and Technology, which was established in 1965 to study aircraft and airport noise, including the transcripts and minutes of subcommittees formed to report to PEDC;

3. All materials pertaining to aircraft and airport noise or related matters in PEDC's files, including materials submitted to PEDC or its subcommittees by members or consultants;

4. The transcripts and minutes of all meetings of the Interagency Aircraft Noise Abatement Program (IANAP);

5. All material pertaining to aircraft and airport noise, or related matters, in IANAP's files including materials prepared by IANAP's members or consultants;

6. All federal agency files (including those of DOT, HUD, and DOD) pertaining to development and use of the concepts Composite Noise Rating (CNR) and Noise Exposure Forecast (NEF);

7. The report(s) on distribution of costs resulting from exposure to aircraft noise prepared by Prof. Paul Dygert;

8. The report(s) on the legal aspects of aircraft noise regulation prepared by Prof. William K. Baxter;

9. The reports and other materials prepared by or in conjunction with the Operations Research Project funded by the Aerospace Industries Association and the Air Transport Association (made available to the FAA in 1968 upon completion of the project through its methodology stage);

10. The complete files of the FAA's Office of Noise Abatement with respect to the draft Notice of Proposed Rule Making on aircraft operating procedures for noise abatement prepared in 1968;

11. The transcripts, papers, minutes and files of the London Conference on Aircraft Noise Abatement in November, 1967, and the files of all federal agencies with respect thereto;

12. A full set of all reports on aircraft noise or related matters prepared for federal agencies by outside technical consultants such as Bolt, Beranek and Newman and Wiley Laboratories;

13. The complete files of the FAA with respect to its Advanced Notice of Proposed Rule Making (ANPRM) on Civil Airplane Fleet Noise Requirements, 38 Fed. Reg. pp. 2769 *et seq*. (Jan. 30, 1973), including:

a. All documents which discuss the reason for the FAA's decision to make the proposed rule inapplicable to "airplanes engaged in foreign [or overseas] air commerce," after the FAA's "working draft" of this ANPRM dated November, 1972 specifically included such airplanes within the rule's coverage.

b. All documents which state or relate to the FAA's estimates as to

(i) What percentage of aircraft at each of the major U. S. airports would be exempt from coverage;

(ii) What percentage of the fleets of the major U. S. carriers would be exempt;

c. All documents which relate to the decision to delete the sideline noise measurement from the proposed rule, and as to possible tradeoffs between landing and takeoff noise, on the one hand, and sideline noise, on the other, with respect to each type of jet aircraft now operated or expected to be operated at American airports;

d. All documents considered by the FAA in assessing the environmental impact of the proposed rule, and weighing it against alternatives, as required by the National Environmental Policy Act.

14. All files, minutes and transcripts of the Aviation Advisory Commission which relate to aircraft and airport noise or related problems.

15. All documents in the files of the CAB which relate to elimination of duplicative flights through implementation of CAB-approved capacity limitation agreements among the airlines serving a given route.

This list, of course, is not by any means complete; rather it reflects the limited time available to us to date, and will be updated as the Task Force progresses. But the essential principle is clear: this Task Force cannot effectively appraise the work of the FAA, as Congress has explicitly required it to do, unless it has access to the same full range of data available to the FAA.

Additionally, we suggest that a great deal of useful information can be obtained, not from documents, but from people who can be invited to address one or another of the Task Groups and to answer questions from the participants. Our initial list of such persons would include:

1. <u>With respect to operating procedures that could be used to achieve noise abatement:</u>

Isaac H. Hoover, former director, Office of Noise Abatement, FAA;

Capt. Paul A. Soderlind, former director of flight operations (technical), Northwest Airlines;

Capt. Robert K. Baker, former director of flight training, American Airlines;

Robert Myersburg, Office of Flight Standards, FAA;

George Moore, Associate Administr r for Operations, FAA;

James Rudolph, Director, Flight S lards Service, FAA;

Joseph Ferreres Chi Operatio Division, FAA;

2. With respect to nt of n impact:

James Woodall, Chie ircraft se Abatement, FAA;

Karl Kryter, Stanfo Research itute;

3. With respect to eco ic aspect aircraft noise abatement:

Prof. Paul Dygert, versity c lifornia, Berkeley;

George Hunter, Chi Planning ff, Rocky Mountain Region, FAA;

4. With respect to legal aspects aircraft noise regulation;

Robert L. Randall, q., Washi n, D. C., former Deputy General Counsel, FAA;

Prof. William Baxter, Stanford versity Law School;

5. With respect to technology avai le for aircraft noise abatement:

Spiridon Suciu, Manager, Gas Tu e Technical Research Operations, General Electric;

John Large, Director, Institute of Sound and Vibration, University of Southampton, England (formerly in charge of aircraft noise abatement for the Boeing Co.)

Due to the very short period of time available to the Task Force and its participants, we would appreciate a response to this letter at the earliest possible date.

Many thanks for your help.

Sincerely yours,

The Environmental Defense Fund
John Hellegers
Raelyn Janssen
Geoffrey Vitt

National Organzation to Insure
A Sound-Controlled Environment
Lloyd Hinton
John Tyler

Aviation Consumer Action Project
Neil McBride

Environmental Action
Catherine Lerza
James Conroy

cc: Sen. Philip Hart
Sen. Edmund Muskie
Rep. Paul Rogers
Hon. Russell Train
Sen. John V. Tunney

National Organization to Insure a Sound-controlled Environment

Date: Feb. 27, 1973

To: Task Group 3 - Impact Characterization
Aircraft/Airport Noise Study Task Force

From: John M. Tyler, Executive Director, N.O.I.S.E.

Subject: Comments on proposed scope of activity of Task Group 3.

Impact Characterization of Noise Including Implications of Identifying and Achieving Levels of Cumulative Noise Exposure.

The EPA has invited participants in each task group to submit recommendations regarding the scope and focus of the work of their respective task group. This participant wishes to refer to Public Law 92-574 which specifies in Section 7(a) the work to be done in the 9 month study and report to Congress. It states:

> "The Administrator [of EPA], after consultation with appropriate Federal, State and local agencies and interested persons, shall conduct a study of the (1) adequacy of Federal Aviation Administration flight and operational noise controls; (2) adequacy of noise emission standards on new and existing aircraft, together with recommendations on the retrofitting and phaseout of existing aircraft; (3) implications of identifying and achieving levels of cumulative noise exposure around airports: and (4) additional measures available to airport operators and local governments to control aircraft noise. He shall report on such study to the Committee on Interstate and Foreign Commerce of the House of Representatives and the Committees on Commerce and Public Works of the Senate within nine months after the date of the enactment of the Act."

Section 7(c) specifies that the "EPA shall submit to the FAA proposed regulations --- (such) as EPA determines necessary to protect the public health and welfare." This work is scheduled for the latter part of 1973. It should not be confused with the 9 month study being conducted during the first part of 1973.

The item in Section 7(a) which specified the work to be done by Task Group 3 is "--- (3) implications of identifying and achieving levels of cumulative noise exposure around airports;--". This would seem to focus this Task Group's attention on the following:

1. Implications of identifying levels of cumulative noise exposure vs identifying levels in other units, for example, CNR, NEF or CNEL vs dBA, EPNdB, ASDS or PNL.

2. Implications of achieving specific levels of cumulative noise exposure for various purposes such as achieving compatibility with various land uses.

3. Implications of achieving specific levels of cumulative noise exposure vs specific levels in other noise units.

4. Adequacy of the data base for cumulative noise exposure units including CNR, NEF, CNEL, NNI, $\bar{Q}$, [illegible], etc.

5. The agreement among established units of cumulative noise exposure to achieve compatibility with various land uses.

The law requires in 7(a), the 9 month study, that the implications of using cumulative noise exposure be studied. In 7(c) where regulations are to be proposed it would be appropriate to decide on a specific unit of cumulative noise exposure, specific methods of monitoring and/or measuring aircraft noise and handling the data to insure compliance with noise limits, etc. If all of this work is attempted in the one month available for input to this 9 month study the participants will be stretched too thin.

The law also requires in 7(a), the 9 month study, that the EPA study the implications of achieving levels of cumulative noise exposure. This asks the question, "Why specific levels?" and calls for the information available on cumulative noise exposure level vs compatible land use. It also asks the question, "How can specific levels be achieved, i.e., by what means technically, and by what means legally and at what cost?" These questions are also asked in Task Groups 4 and 5. It would seem that the questions of the technical means for achieving specific noise levels and cost would most logically be handled by Task Group 4 and the legal, or regulatory means for requiring the noise reduction by Task Group 5. Thus Task Groups 3, 4 and 5 will need to correlate the results of their studies to answer the questions concerning means and cost of achieving specific levels.

Due to the lack of time since the first meeting of this Task Group the details to be filled in under the five headings listed above have not been worked out. This will be supplied as needed.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
LANGLEY RESEARCH CENTER
HAMPTON, VIRGINIA 23365

March 12, 1973

REPLY TO
ATTN OF:

Dr. Henning Von Gierke
Biodynamic and Bionics Division
Aerospace Medical Research Lab
Wright-Patterson AFB, OH 45433

Dear Henning:

The attached w...eup entitled "Pure Tone Considerations in Measured Community Noise" has been prepared to fulfill a writing assignment given out at the second meeting of Task Group No. 3 of the EPA noise study.

Note that I was unable to reference the Canadian document on pure tone evaluations that was discussed briefly at the last meeting. If a copy can be furnished, it could also be incorporated as a reference.

Sincerely,

Harvey H. Hubbard
Head, Acoustics Branch

cc:
Dr. Bill Roudebush, NASA, Code RL.

PURE TONE CONSIDERATIONS IN MEASURED COMMUNITY NOISE

A number of systematic studies have been performed to evaluate the contribution of noisiness of aircraft noise due to the presence of pure tone components. In this work a large number of human judgments have been made for noise levels representing those in airport communities due to low altitude aircraft operations, and the results of these judgments have been correlated with various physical measures of the noise. These measures have included A-scale, N-scale, and D-scale data as well as a number of EPNL units involving tone correction factors. The results from these studies as documented in reference 1 through 5 adequately support the fact that a simple weighting system for the noise such as the A-scale system does not properly account for the noisiness of the superposed pure tone components. It has thus been indicated that pure tone components in aircraft noises can contribute substantially to noisiness judgments and are identified as worthwhile targets for noise reduction.

For noise certification of aircraft, units making special allowance for pure tones are thus needed in order to properly evaluate the noise for subjective reaction purposes. It may very well be found in noise emission control considerations for other vehicles and items of equipment that tones will also play an important part and may have to be properly accounted for in certification procedures.

In community measurement situations, however, it is believed that there is a lesser need for a measurement concept or system that especially accounts for pure tone effects. The reasons for this judgment are as follows:

a. Pure tone exposures of people in community situations are judged to be generally short in duration compared to the overall noise exposure.

b. The proper application of noise emission standards for transportation vehicles of all kinds and for industrial noises can be expected to result in a relatively lower level of tone content in community noises in the future.

CONCLUSIONS

1. A useful measurement procedure for cumulative noise exposure in the community need not require tone adjustment factors. Hence, a relatively simple system involving "A-scale" or "D-scale" measurements is probably adequate (The D-scale is shown to be preferred based on noisiness judgments.).

2. Evaluation units involved in noise certification and in noise emission standards can be expected to require provision for pure tone corrections.

REFERENCES

1. Little, J. W.: Human Responses to Jet Engine Noises. Noise Control, vol. 7, 1961, pp. 11-13.

2. Kryter, K. D.; and Pearsons, K. S.: Some Effects of Spectral Content and Duration on Perceived Noise Level. NASA TN D-1873, April 1963.

3. Kryter, K. D.: Review of Research and Methods for Measuring the Loudness and Noisiness of Complex Sounds. NASA CR-422, April 1966.

4. Pearsons, K. S.; Horonjeff, R. D.; and Bishop, D. E. The Noisiness of Tones Plus Noise. NASA CR-1117, August 1968.

5. Pearsons, K. S.: Combination Effects of Tone and Duration Parameters on Perceived Noisiness. NASA CR-1283, February 1969.

CITY OF LOS ANGELES
DEPARTMENT OF AIRPORTS
1 WORLD WAY · LOS ANGELES, CALIFORNIA 90009
TELEPHONE (213) 646-5252 · TELEX 65-3413

ONTARIO

CLIFTON A. MOORE
GENERAL MANAGER

March 2, 1973

Ref: AMRL/BB 16 February 1973
Impact Characterization of
Aircraft/Airport Noise Study
Task Force

Mr. Henning E. Von Gierke
Chairman, Task Group 3
Aircraft/Airport Noise Study Task Force
Office of Noise Abatement and Control
Environmental Protection Agency
Washington, D. C. 20460

Dear Mr. Von Gierke:

After a review of the summary of the first meeting of 15 February 1973 and my notes on the meeting of 27 February 1973, I feel that as an airport representative comments are appropriate. The comments are submitted in the recognition that the work that is accomplished in this task group will have an impact on aircraft and airports and, also, on other forms of transportation and city activities.

It would appear that prior to the meeting a decision was made that the noise characterization and assessment method would have to be a weighted overall sound pressure level similar to the CNEL procedure. It appears that this decision was reached with little consideration of ASDS or any other simplified methodology. This may or may not be good, however, there was a minimum of discussion. In considering the approach to recommending permissible limits, it appears again that the information was to be presented in terms of percent of people affected with respect to health and annoyance. There appeared to me to be only a passing reference to previous studies attempting to correlate annoyances with sound level frequency of operations and time of day. These studies, many of which were done in foreign countries, should be reviewed in greater depth before acceptance of their results as a guide for this group.

We would agree that the A-weighted decibel appears to be the best method for measurement. When we consider that measurements and monitoring that will probably have to be accomplished and that the methodology should be as simple and least complicated as can be achieved, this method seems to be most practical. When sophisticated measurements are required, EPNdb can be utilized. In reviewing Dr. Galloway's working paper I question whether or not a time integral of the sound pressure level in the A scale is a necessity in all cases. Experience in California with SENEL indicates that this complicates the process of monitoring and measuring. This is something that should be discussed at the next meeting when we consider Dr. Galloway's working paper.

We would agree that the tone correction is probably not necessary when we consider monitoring procedures and acceptable cumulative levels. If pure tone or spike frequency corrections are needed, EPNdb can be used for the specific application.

We would also agree that a night impact number is possibly desirable and feel that two periods per day is adequate. We would, however, suggest flexibility in the night impact time. Somewhere between 10 and 11 p.m. for the start of night impact and somewhere between 6 and 7 a.m. for the end of night impact would seem most practical. This would seem to be a decision that should be left to the local community to best suit their specific needs.

In considering impact guidelines for all forms of transportation, I strongly feel that Task Group 3 must consider the impact of all court actions to date. While an idealistic approach to this impact problem may appeal to certain individuals, I fear it does not recognize the facts of life in this situation. I think we all recognize that any regulation can be challenged in the courts and successfully overturned. Therefore, to avoid a proliferation of lawsuits and lengthy litigation, full recognition of past court action should be a part of Task 3 consideration.

These are my comments on the Task 3 work effort to date.

Very truly yours,

Bert J. Lockwood
Assistant General Manager
Operations

BJL:sm

BOLT BERANEK AND NEWMAN INC
CONSULTING DEVELOPMENT RESEARCH

LOS ANGELES OFFICE
21120 VANOWEN STREET
CANOGA PARK, CALIFORNIA 91303
TELEPHONE (213) 347-8360

9 March 1973

Dr. Henning E. Von Gierke
Chief, Biodynamics and Bionics Division
Biomedical Laboratory
6570 AMRL (MRBA)
Wright-Patterson AFB, Ohio 45433

Subject: Inside/Outside Noise Exposures

Dear Henning:

You asked for some samples of inside and outside noise exposures. The attached sheet summarizes some typical situations. The data were obtained from continuous samples of A-level with the L_{eq} for the day, evening and night periods computed. These values are listed first in the table. I then proceeded to calculate the L_{eq} for a 24-hour period; i.e., "no nighttime penalty." In the next column I calculated a weighted exposure in which day and evening are combined, but nighttime has a 12 dB penalty on level. The last column is the same computation with a 10 dB weighting on the nighttime levels.

The inside levels for the first example "residential/ suburban" may be a little high. The threshold was set at about 33 dBA which resulted in an overstatement of the L_{90} values during part of the daytime period, a substantial overstatement of all nighttime levels between 1:00 and 5:00 a.m.

Also note that the interior noise levels during the daytime period in all cases are substantially affected by noises inside the spaces; e.g., TV, talking, etc.

If you would like the information, I can give you plots of the L_1, L_{10}, L_{50}, L_{90} and L_{eq} on an hourly basis for the data on the enclosed sheet.

Sincerely,

Bill

William J. Galloway

WJG:bml

Enc.

CAMBRIDGE NEW YORK CHICAGO LOS ANGELES SAN FRANCISCO

Hour Lc Values

D = 0700 - 1900 = 12
E = 1900 - 2200 = 3
N = 2200 - 0700 = 9
24

Residential Suburban - not near airport or highway

In/Out	Time Δ	L_c'	$10^{L_c/10}$	No night penalty	12 dB night penalty	10 dB
OUT	D	59.0	8.0×10^5			
"	E	53.7	2.35×10^5	56.6	59.9	58.4
"	N	49.7	9.35×10^4			
IN	D	45.0	3.16×10^4			
"	E	48.0	6.30×10^4	44.5	49.1	47.7
"	N	39.8	9.55×10^3			

Residential - close to LAX airport

In/Out	Time Δ	L_c'	$10^{L_c/10}$	No night penalty	12 dB night penalty	10 dB
OUT	D	79.8	9.55×10^7			
"	E	83.0	2.0×10^8	80.3	87.8	86.1
"	N	79.5	8.9×10^7			
IN	D	65.0	3.16×10^6			
	E	60.5	1.1×10^6	62.5	64.1	63.5
	N	51.5	1.4×10^5			

Suburban - close to busy freeway

In/Out	Time Δ	L_c'	$10^{L_c/10}$	No night penalty	12 dB night penalty	10 dB
OUT	D	79.0	8.0×10^7			
"	E	76.8	4.8×10^7	77.6	83.7	82.2
"	N	75.0	3.16×10^7			
IN	D	57.5	5.5×10^5			
"	E	57.0	5.0×10^5	56.0	60.6	59.3
"	N	51.3	1.35×10^5			

Urban office - downtown LA business district

In/Out	Time Δ	L_c'	$10^{L_c/10}$	No night penalty	12 dB night penalty	10 dB
OUT	D	69.0	8.0×10^6			
"	E	68.2	6.6×10^6			
"	N	67.0	5.0×10^6	68.2	75.4	73.7
IN	D	52.0	[illegible]			
"	E	44.8	3.0×10^5			
"	N	43.9	2.45×10^5	49.6	53.6	52.4

SEASONAL CHANGES

Submitted to Task Group 3 - by N.O.I.S.E.

Changes in weather brought about by changes in seasons have an important effect on the reaction of people to aircraft noise. The most dramatic effect occurs in cities near airports at latitudes where houses have well insulated walls and well sealed storm windows to keep out the winter cold. Good thermal insulation normally provides good sound insulation. When the first warm days of spring call for open windows these houses suddenly lose 10dB or so of outer wall sound insulation. The complaints about aircraft noise onthese days every year indicate the impact of this loss of outer wall protection against noise.

There are at least two methods of handling this change in impact of noise on people as a result of seasonal changes. One method is to vary a noise weighting factor to compensate for the variation in house outer wall attenuation. This weighting factor would vary with the amount of time the temperature would be above the level at which doors and windows would be open. This method indicates a higher weighted noise exposure level when doors and windows are open. It has the disadvantage that it is unlikely that the noise could be reduced more in hot weather than in cold weather to compensate for the weighting.

Another method of handling this seasonal factor is to rate outdoor noise on the same basis at all locations and take care of the variation in outer wall attenuation at the local level in noise and building codes.

A standard for noise attenuation for house outer walls has been developed in SAE AIR 1081. This AIR presents an outer wall attenuation which is the average of four sets of attenuation data. Two sets are for the averages of houses in cold winter U.S. areas (New York and Boston); one for windows open and one for windows closed. The other two sets are for warm winter U.S. areas (L.A. and Miami); one for windows open and one for windows closed. The bouses in cold winter areas have more outer wall sound attenuation than those in warm winter areas for both open and closed windows. The difference presented in the SAE AIR 1081 between the New York and Miami houses is about 12dBA for both open and closed windows.

Obviously houses built in other locations where building practices are different will have different out wall attenuation levels. Also the magnitude of the temperature variation will vary greatly with locations in the U.S. In the middle west the winters are extremely cold and the summers extremely hot. By comparison the coastal regions of southern U.S. are relatively uniform in termperature throughout the year. Therefore any correction factor for seasonal changes would have to be adapted to the local termperature range and cycle.

At the local level it is necessary to establish land use zones with noise limits to insure acceptable noise levels inside houses. When this is done land use may be defined in terms of building codes. Thus a house with an outer wall sound insulation similar to the ones tested in Miami might be unsuitable in a New York area zoned for single family dwellings. And of course, another house or apartment building with more outer wall sound attenuation and air conditioning could be acceptable in a higher noise exposure area in New York.

Thus there are three factors to deal with in protecting people in homes from outdoor noises:

1. Noise exposure level
2. House outer wall insulation
3. Variation in temperature which may,or may not, mean variation in outside to inside attenuation.

It is felt that these factors are local problems because:

1. Where the seasonal temperature variation is small the effect on people is small.
2. It can be minimized by house design practices,i.e.,air conditioning or sound treated ventilation systems.
3. It can be handled by noise zoning practices,i.e., adjusting noise exposure levels to compensate for minimum permissible house outer wall attenuation with windows open so as to achieve a specified maximum house inside level.

Therefore it is recommended that noise exposure levels be considered with respect to noise impact on persons living in houses which have average outer wall attenuations and that seasonal effects of noise be handled by the local zoning and building code authorities.

DETERMINATION OF INDOOR SOUND LEVELS FOR JET TRANSPORT AIRCRAFT

29 March 1973

Prepared by

Douglas Aircraft Comapny
McDonnell Douglas Corporation
Long Beach, California

For Submittal to the
Environmental Protection Agency
Washington, D.C.

29 March 1973

DETERMINATION OF INDOOR SOUND LEVELS FOR JET TRANSPORT AIRCRAFT

INTRODUCTION

Currently, all methods in use or being considered for evaluation of aircraft noise in communities around airports, e.g., References 1-4, use outdoor noise levels measured at certain specified locations. The choice of an outdoor noise level measurement was made on the basis of convenience and uniformity. Measurement of indoor noise levels was not practical because there was no accepted definition of standard dwellings in various climates and at various times of the year.

The results of various surveys made in communities around airports, e.g., References 5 and 6, have consistently indicated that the bulk of the complaints against aircraft noise are due to interference with various indoor activities, such as TV/radio reception, face-to-face or telephone conversation, and sleep. With the current emphasis on the cumulative noise exposure experienced by airport neighbors, it is appropriate to consider development of methods to evaluate aircraft noise at the actual location of the listener, i.e., indoors in the majority of instances. It would be feasible, in isolated cases, to actually measure the noise levels inside an individual's home. For general application, it is necessary to utilize either standard dwellings or to apply standard house noise reduction values to appropriate outdoor noise measurements. With the recent development of standard house noise reductions, Reference 7, it has become feasible to define generalized procedures for estimating indoor noise levels based on outdoor noise measurements.

The purpose of this report is to describe the results of analyses of representative aircraft flyover sounds and to recommend specific noise reduction values suitable for interim application to the problem of assessing the response of airport neighbors to aircraft flyover noise. The results presented here are intended only to give an indication of the order of magnitude of the correct noise reductions. More-refined analyses would be required to develop precise values suitable for general application. For an interim procedure, however, the results presented herein should be acceptable.

ANALYSES

Measurements of the outdoor noise levels presented by two aircraft types representative of jet transports in wide use and powered by low-bypass-ratio turbofan engines and by one of the new wide-body transports powered by high-bypass-ratio engines were examined. The specific airplanes considered were the McDonnell Douglas DC-8-55, DC-9-15, and the DC-10-10. The noise produced by the DC-8-55 should be representative of that produced by other members of the DC-8 family powered by short-duct versions of the JT3D engines and of that produced by the 707-320 family of airplanes. Similarly, the noise of the DC-9-15 should be representative of the rest of the DC-9 models as well as the 727 and 737 airplanes. The noise of the DC-10-10 should be similar to that of the DC-10-30 and DC-10-40 as well as the various models of the 747 family and the L-1011-1. Thus, the three airplanes studied should be representative of most of the jet transports in use today.

For the purpose of this study, only the sound pressure levels (SPLs) at the time of the maximum perceived noise level (PNLM) were examined. The 1/3-octave-band SPLs and PNLM for maximum takeoff and for various distances were conveniently available as a result of actual flyover noise testing for the selected aircraft.

The aim of the studies was to develop a method of estimating the indoor A-weighted SPL, or the indoor sound level. This quantity is widely used for evaluating various sources of noise, including, in some instances, aircraft noise, e.g., Reference 4. Because of the transient nature of a flyover noise signal, the specific quantity selected was the maximum sound level occurring during the flyover.

Indoor noise levels for two different types of house constructions, with windows open and windows closed, were calculated from representative outdoor noise levels by applying the average noise reduction values from Tables VIII-IX of Reference 7. Since these noise reductions were for 1/1-octave-band analyses, the 1/3-octave-band SPL spectra from the outdoor flyover noise measurements were first converted to equivalent 1/1-octave-band SPLs before applying the house noise reductions. Equivalent slow-scale A-weighted SPLs were then calculated from the outdoor and the indoor SPLs using weighting factors from Table 1 of Reference 8.

Figure 1 shows representative outdoor SPL spectra and corresponding A-weighted levels for the three selected aircraft, at a distance between the listener and the aircraft of approximately 1000 ft, for maximum takeoff thrust. The large reductions in low-frequency noise achieved by the new high-bypass-ratio turbofan engines at takeoff thrust is readily apparent in Figure 1.

RESULTS

Figures 2-4 present the results of the analyses in the form of the calculated differences between the maximum outdoor and the maximum indoor sound levels as a function of distance to the aircraft for the DC-8-55, DC-9-15, and DC-10-10 respectively. This difference represents the quantity that would be subtracted from an outdoor sound level to obtain an indoor sound level.

Comparison of the results in Figures 2-4 showed a remarkable consistency in the differences for the three aircraft. Inspection of the plotted values indicated that single-valued correction factors for the four locations/conditions could be selected to represent the power settings with a tolerance of approximately ± 2 dB. Table I tabulates the approximate values that were derived from the results shown in Figures 2-4. The indicated trends are as expected with the cold climate houses having larger noise reductions than warm climate houses and with windows open showing significantly less noise reduction than windows closed for both warm and cold-climate construction.

RECOMMENDATIONS

As an interim standard, it is recommended that the values shown in Table I be used as the basis of developing a method of evaluating airport community noise based on indoor noise levels. The house noise reductions of Reference 7 should be used as the foundation for additional indoor noise studies, although additional refinement may be needed to develop appropriate average noise reductions for 1/3-octave band analyses. (Development of these 1/3-octave-band noise reduction values should be feasible since Reference 7 also contains basic 1/3-octave-band values.)

For the long-range approach, it is further recommended that evaluation methods be developed that would be based on the concept of a suitable average standard dwelling construction. Flyoyer noise analyses could be based on the use of a suitable filter network whose frequency response would approximate the noise reduction of the standard dwelling.

In developing new regulations governing allowable aircraft flyover noise levels, the use of indoor noise levels is considered most appropriate. As a matter of fact, the use of indoor noise levels is considered to be better able to protect the general health and welfare of the public than outdoor noise levels and to be less discriminatory. Those dwellings that have good insulation, are well-maintained, have tight-fitting windows, or are airconditioned will, by definition, have lower indoor noise levels than those that do not.

Any new regulations, based on indoor noise levels, should, of course, also prevent the escalation of outdoor noise levels. However, it also should encourage the wider use of better construction techniques, acoustical insulation, and better windows. These recommendations then, ultimately, should lead to the design of aircraft that minimize noise exposure at the location of the listeners rather than at locations where there rarely are any listeners, as is current practice.

REFERENCES

1. Anom.; Noise Standards: Aircraft Type Certification; Part 36 of Volume III of the Federal Aviation Regulations, Federal Aviation Administration, Department of Transportation, 1 December 1969
2. Anon.; International Standards and Recommended Practices: Aircraft Noise; Annex 16 to the Convention on International Civil Aviation, International Civil Aviation Organization, 6 January 1972
3. Anon.; ISO Recommendation: Procedure for Describing Aircraft Noise Around An Airport; ISO R507-1966, International Organization for Standardization
4. Anon.; California Noise Standards; California Depratment of Aeronautics, Title 4, Register 70, Number 48, 1 December 1971
5. Committee on the Problem of Noise (Sir Alan Wilson, Chairman); Noise, Final Report; Cmnd, 2056, HMSO, London, July 1963
6. TRACOR, Inc.; Community Reaction to Airport Noise, Volume I; NASA CR-1761, July 1971
7. SAE Committee A-21; House Noise Reduction Measurements for Use in Studies of Aircraft Flyover Noise; Society of Automotive Engineers, Aerospace Information Report, AIR 1081, October 1971
8. Anon.; American National Standard Specification for Sound Level Meters; American National Standards Institute, ANSI S1.4-1971.

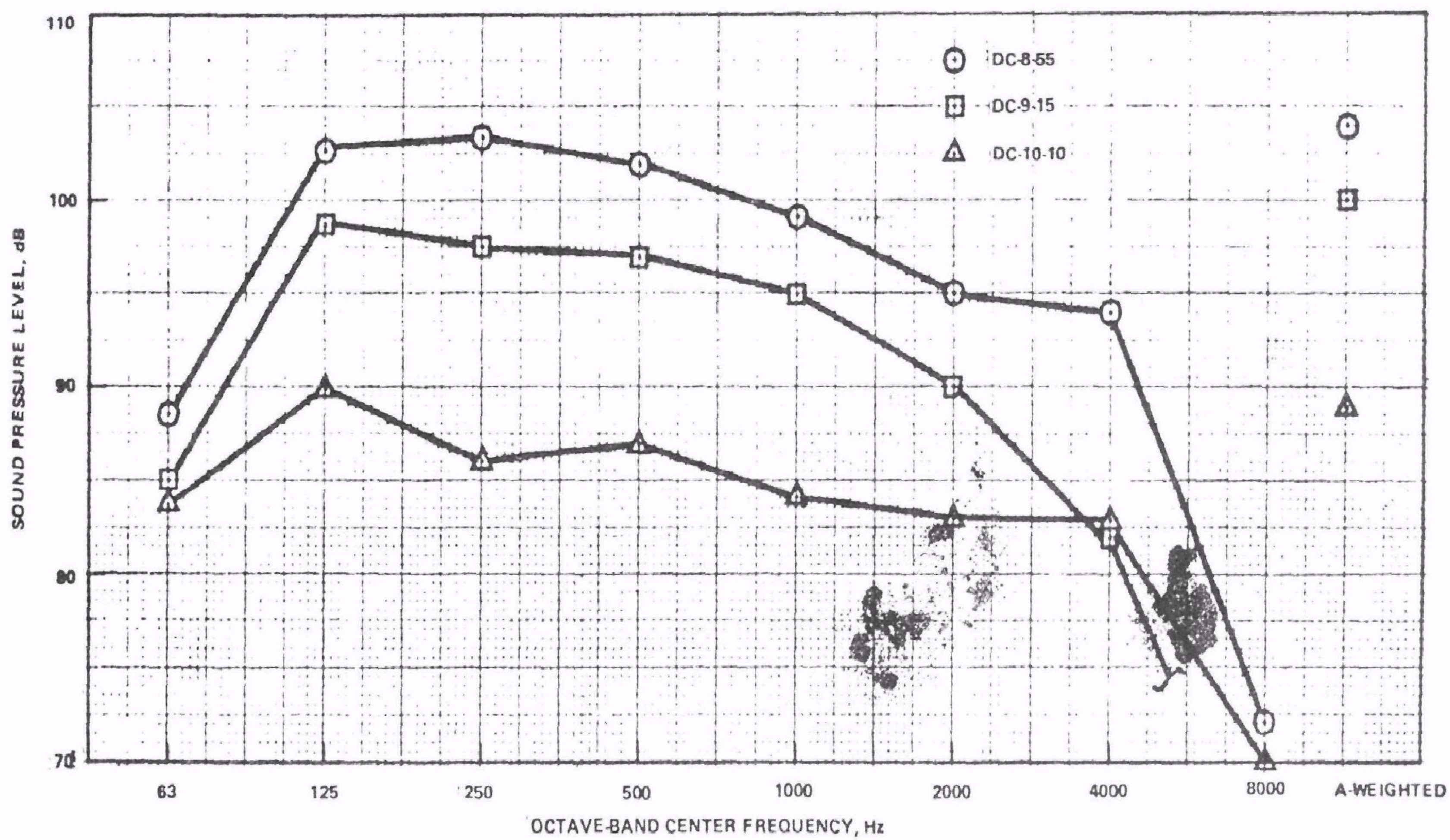

FIGURE 1. REPRESENTATIVE OUTDOOR SPL SPECTRA AT THE TIME OF THE MAXIMUM PERCEIVED NOISE LEVEL FOR AIRPLANES AT MAXIMUM TAKEOFF THRUST AND A DISTANCE OF APPROXIMATELY 1000 FEET

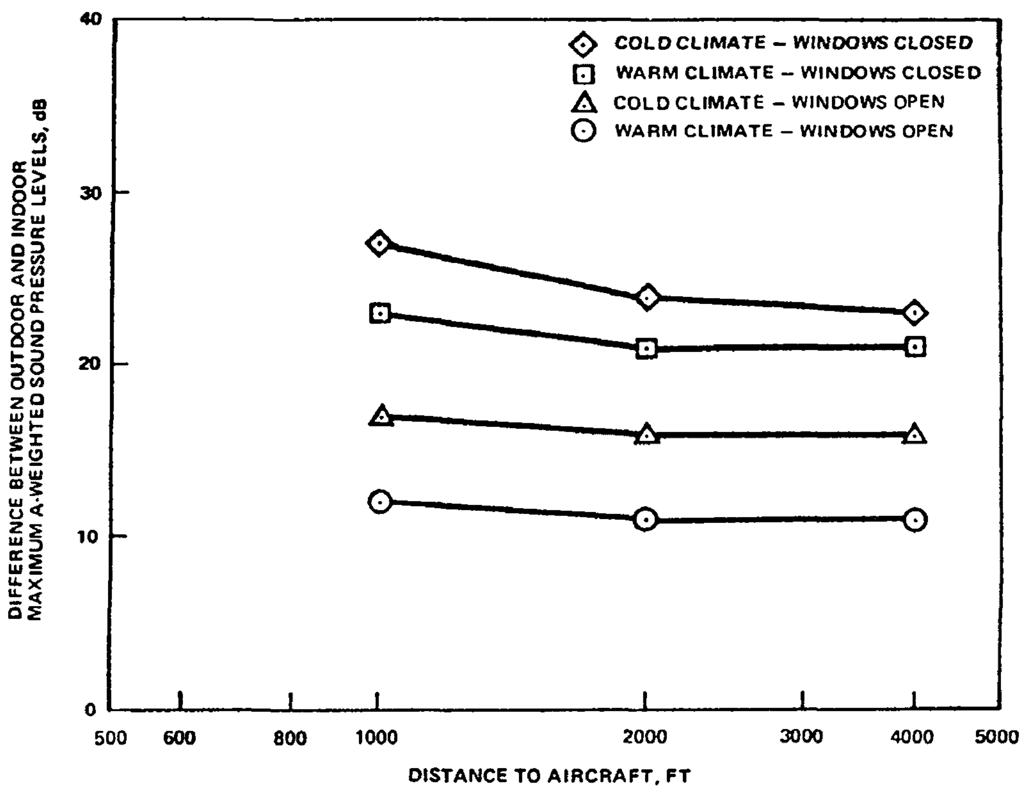

FIGURE 2. DIFFERENCE BETWEEN OUTDOOR AND INDOOR SOUND LEVELS FOR DC-8-55 AIRCRAFT (SHORT DUCT JT3D ENGINES), TAKEOFF THRUST

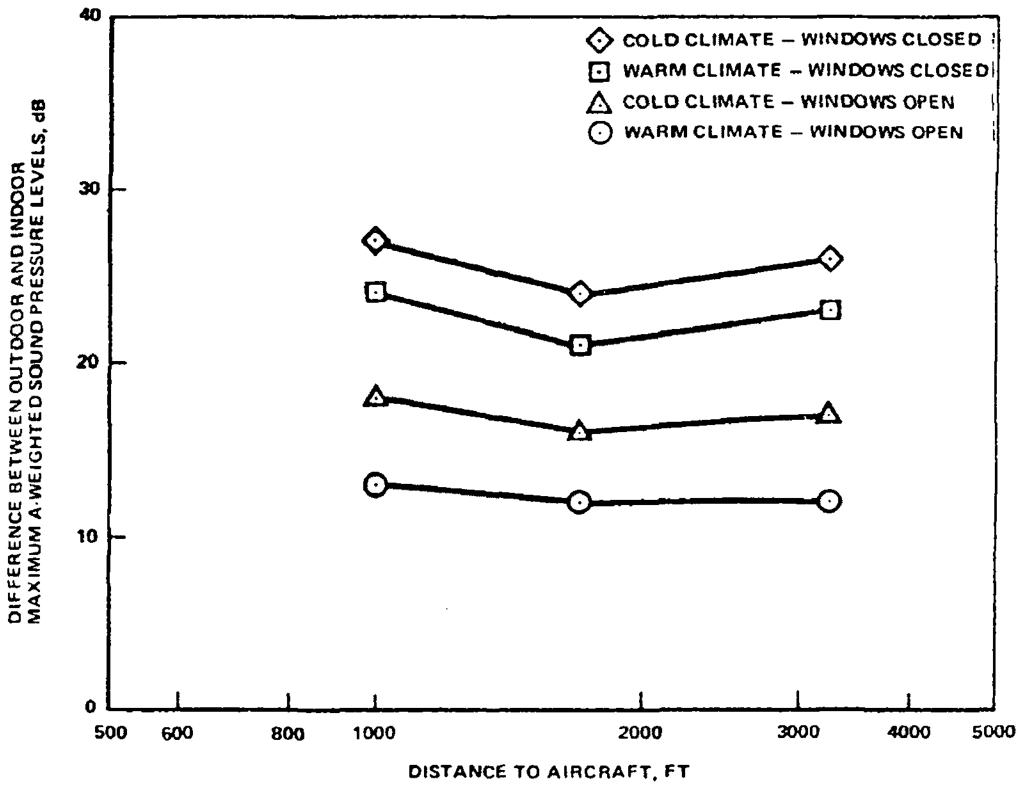

FIGURE 3. DIFFERENCE BETWEEN OUTDOOR AND INDOOR SOUND LEVELS FOR DC-9-15 AIRCRAFT (JT8D ENGINES), TAKEOFF THRUST

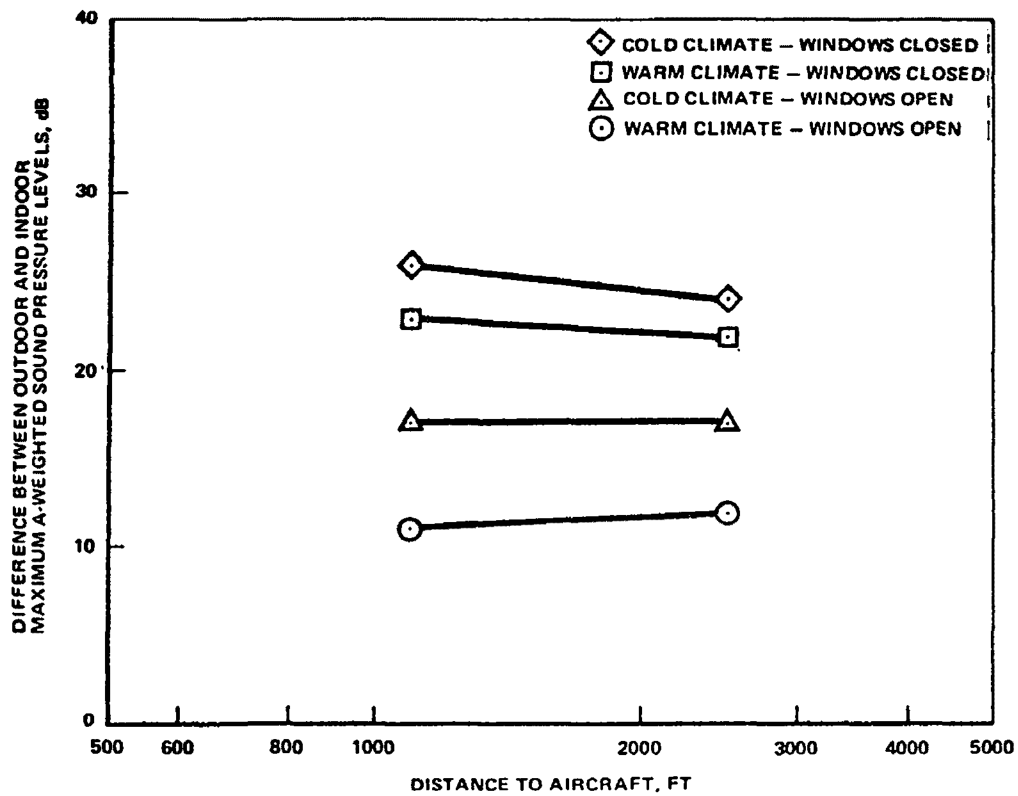

FIGURE 4. DIFFERENCE BETWEEN OUTDOOR AND INDOOR SOUND LEVELS FOR DC-10-10 AIRCRAFT (CF6-6D)ENGINES), TAKEOFF THRUST

TABLE I - CORRECTION FACTORS FOR INDOOR SOUND LEVELS

Location - Condition	Amount to be subtracted from maximum outdoor A-weighted sound pressure level to obtain maximum indoor A-weighted sound pressure level, dB
	Takeoff Thrust
Warm Climiate - Windows Open	12
Cold Climate - Windows Open	16
Warm Climate - Windows Closed	22
Cold Climate - Windows Closed	24

TABLE I - CORRECTION FACTORS FOR INDOOR SOUND LEVELS

Location - Condition	Amount to be subtracted from maximum outdoor A-weighted sound pressure level to obtain maximum indoor A-weighted sound pressure level, dB	
	Takeoff Thrust	Approach Thrust
Warm Climate - Windows Open	12	13
Cold Climate - Windows Open	16	19
Warm Climate - Windows Closed	22	27
Cold Climate - Windows Closed	24	31

CITY OF LOS ANGELES
DEPARTMENT OF AIRPORTS
1 WORLD WAY · LOS ANGELES, CALIFORNIA 90009
TELEPHONE (213) 646-5252 · TELEX 65-3413

CLIFTON A. MOORE
GENERAL MANAGER

March 27, 1973

MEMORANDUM

TO: Mr. Henning E. Von Gierke
Chairman, Task Group 3

FROM: Bert J. Lockwood
Assistant General Manager
Operations

SUBJECT: Task Group 3 Report

Attached is an exhibit print that was prepared in accordance with the discussions at our last Task Group 3 meeting on March 20, 1973. As it was necessary to place a large amount of data on a single print for comparison purposes, I found it a requirement to use a large print to the scale of 1 inch equals 1,000 feet. It should be pointed out that this is the type of data that is utilized in the various airport court cases. I will bring 25 copies of this letter to our next committee meeting on April 4 and I will be prepared to make a complete presentation on this chart to the entire committee at that time. After your review I would like to request that you bring this exhibit chart to our next meeting.

The following is an explanation of the information shown on the chart:

The boundaries of LAX are shown in blue, as is the runway layout. I have also shown the extended runway centerlines and the distance from touchdown in the approach areas.

PNdb Contours. These contours are the result of studies by Bolt Beranek & Newman and Wyle Laboratories under contract to the Department of Airports. According to the reports by these acoustical consultants the contours are the result of field measurements taken in the vicinity of LAX and represent actual conditions from flight operations. The solid purple contour is the largest impact condition and shows the 100 PNdb contour for the Boeing 707-320c. This can be considered representative of this narrow bodied 4-engine jet transport. The dashed purple contour is the 100 PNdb contour for the 4-engine 747-200 Part 36 aircraft. This demonstrates the great acoustical improvement achieved by the new technology wide bodied aircraft using high bypass engines. The green contour is the 105 PNdb contour for the 320 Boeing and is generally representative of the narrow bodied 4-engine transport.

The 100 and 105 contours were shown as they seem to define the repetitive and serious complaint areas for LAX. The approach problem area is best shown by the 105 contour, while the sideline problem area from takeoff operations is best defined by the 100 contour. This observation results from a study of records of the Sound Abatement Coordinating Committee.

Noise Exposure Forecast (NEF). The NEF studies were done for LAX by Bolt Beranek & Newman in a series of contracts. They represent a split of operations between the runway complexes of 65% on the south complex and 35% on the north complex. They are representative of todays operations and should be valid through 1976 or 1977, at which time the impact of the Part 36 fleet will be reflected. At that time the contours should start shrinking in size in spite of an anticipated increase in the volume of flight operations. What is clearly demonstrated here, however, is the fact that within the 30 and 40 NEF contours there are extremely large areas that are well outside of the problem areas of the airport as we know them. All major airports feel that these contours over describe the actual problem areas and are, therefore, not a good descripter of the airport noise problem. The NEF 40 is shown in red, while the NEF 30 is shown in blue. As you will note, the NEF 30 contour extends approximately nine miles from touchdown on approach.

Legal Action. I have shown in yellow on the print the areas involved where the courts determined a "taking" has occurred as a result of operations at the airport. To date there have been three note worthy cases -- Munger Case, Aaron Case, Erwin Case. Two of them involved areas under the approach path, while the Munger Case involved a sideline takeoff noise problem. The chart clearly indicates the sound levels involved in each of these cases as well as the relationship of the property to the 30 and 40 NEF contours. Judge Jefferson, in the

Aaron Case utilized the NEF 40 for a sideline boundary, however, he indicated no taking beyond Hass Avenue which is midway the length of the 40 NEF contour. Even within the alleged take area in the 40 NEF contour many plaintiffs were dismissed as they could not in any way demonstrate a taking due to airport operations. Only in those cases where a loss of value was demonstrated to the satisfaction of the court was a small award made in this case.

As I had indicated in my previous letter and I feel is demonstrated by this exhibit, when a determination is made as to the limit of acceptability of noise we must be guided by court decisions if a truly acceptable methodology is to be developed. As I indicated earlier, I will be ready to make a complete presentation on this exhibit at the next meeting.

Very truly yours,

Bert J. Lockwood
Assistant General Manager
Operations

BJL:sm

Attachment

DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
PUBLIC HEALTH SERVICE
NATIONAL INSTITUTES OF HEALTH

April 3, 1973

NATIONAL INSTITUTE OF
ENVIRONMENTAL HEALTH SCIENCES
P.O. BOX 12233
RESEARCH TRIANGLE PARK, N.C. 27709

Dr. H. E. Von Gierke, Chairman
TG3 EPA Aircraft/Airport Operations
Noise Study
Biodynamics and Bionics Division
Aerospace Medical Laboratory
Wright-Patterson Air Force Base, Ohio 45433

Dear Sir:

At the culmination of the last meeting, you made a request that a position paper from HEW be prepared for this meeting regarding TG3's approach to assessment of aircraft/airport noise impact. As we understand it, the fundamental assumptions underlying TG3's approach are that both auditory (hearing loss) and non-auditory (annoyance, physiological effects) effects of noise are "sufficiently" approximated by the total sound energy experienced over a twenty-four hour period. HEW is working on a position paper but is not ready to comment at this time because of the short time span available for preparation and the unavailability to us of the epidemiological data from which the hypothesis that equal growth of deleterious health effects corresponds to equal growth of total sound energy was inferred.

On a personal basis, I am enthusiastic about the concept of using some form of frequency weighted total sound energy [L_{WNE}] as an indicator of noise environments, taking into account L_{WNE}'s simplicity, practicality, and low cost vs. benefits. It seems a logical first step for a national noise assessment program. I do feel very strongly, however, that language should be incorporated (in whatever standard emerges) which would require that noise dosimeters be equipped with readout algorithms such that one could get at the cumulative L_{WNE} at any time within the twenty-four hour time period. This feature would make standard setting possible on other than a twenty-four hour--3 dB vs. doubling of time basis, within the same measurement scheme.

And, along with some other members of the committee, I am inclined to believe that a D or N type frequency weighting scheme which discriminates less against the low frequencies and emphasizes the mid-range will give results which better relate to human response where health effects other than hearing loss are concerned. If this scheme is subsequently adopted, noise dosimeters would require two parallel systems, one for dBA with no nighttime penalty and one with dB"D" and nighttime penalty, which brings up an interesting question--how will the nighttime penalty for non-hearing loss effects, and the no nighttime penalty for hearing effects be handled by the dosimeter as presently conceived?

Sincerely,

Reginald O. Cook

Reginald O. Cook

U.S. DEPARTMENT OF LABOR
Occupational Safety and Health Administration
WASHINGTON, D.C. 20210

Office of the Assistant Secretary

APR 4 1973

Dr. Henning von Gierke
Chairman, Task Group 3
Aircraft/Airport Noise Study
Task Force
U. S. Environmental Protection Agency
Washington, D. C. 20460

Dear Dr. von Gierke:

Pursuant to the authority provided in the Walsh-Healey Public Contracts Act, as amended, and the Occupational Safety and Health Act of 1970, the Department of Labor has promulgated occupational noise exposure regulations. These regulations are applicable to practically all employment situations. Exclusions include employees working for a State or political subdivision of a State and certain situations where jurisdiction is included in that of another Federal regulatory agency. The requirements of the Occupational Safety and Health Administration are applicable to Federal installations per Executive Order 11612. When agreements are effected between the Secretary of Labor and a State pursuant to the authority in Section 18(b) of the Occupational Safety and Health Act of 1970, OSHA requirements could extend also to the employees working for the State and political subdivisions thereof.

Current OSHA Occupational Noise Exposure limits are based on a cumulative noise exposure during an 8-hour work day as determined by octive band analysis or the equivalent A-weighted sound level. Permissible 8-hour exposure is 90 dB(A). Greater levels are permitted for shorter exposure levels.

The National Institute for Occupational Safety and Health has submitted recommendations for changes to 29 CFR 1910.95 to OSHA. Comments that the current regulations are both overly restrictive for certain environments and that they are not sufficiently restrictive have been received by OSHA. The NIOSH recommendation has been submitted along with others to a Standards Advisory Committee on Noise. Committee recommendations are due by the end of 1973.

OSHA compliance officers and industrial hygienists located throughout the United States are responsible for enforcement of these regulations. There has also been significant voluntary activity. Goals for most occupational noise abatement programs are for reductions in noise to no more than 90 dB(A) for all conditions. As indicated by OSHA regulations feasible engineering and other forms of noise control are preferred over the use of personal protective equipment. There have been situations reported where noise abatement using only engineering methods has caused or is causing some difficulties. Included are situations where noise reduction technology is not yet available, where noise reduction program is associated with a high economic cost, and where noise reduction program introduces other safety and health problems.

In standards development and review activity, some of the considerations that OSHA feels must be included in any evaluations performed are listed below:

1. Assurance of safety and health.
2. Practicality of implementation.
3. Feasibility of implementation.
4. Enforceable
5. Essential
6. Introduction of other unsafe conditions and health hazards.

OSHA considers the points addressed in this letter relevant to the work of the EPA Aircraft/Airport Noise Study Task Force.

Very truly yours,

Chain Robbins

Chain Robbins
Deputy Assistant Secretary of Labor

COMMERCIAL AIRPLANE GROUP P.O. BOX 3707 SEATTLE, WASHINGTON

April 2, 1973

6-8400-RER-351

Dr. Henning E. von Gierke
Office of Noise Abatement and Control
Environmental Protection Agency
Washington, D. C. 20460

Dear Dr. von Gierke:

The Boeing Commercial Airplane Company appreciates this opportunity to participate in formulation of the report which will be submitted to Congress by the Environmental Protection Agency, as required by the Noise Control Act of 1972. The purpose of this letter is to present some Boeing comments on the EPA's Task Group 3 objective of characterizing the impact of aircraft/airport noise.

The Boeing Company has encouraged and participated in the development of methods for rating human response to noise. Several noise rating scales have been developed in an effort to account for both the variability in individual response to a given noise, and the multitude of different sounds to which people are exposed. At present, no subjective scale can provide more than a crude estimate of community response to a complex sound, and experts in the field generally agree that no existing rating scale can be identified as consistently superior.

Subjective scales developed for single noise events in the laboratory have been used as a basic element in defining community reaction to noise. Methods for extending subjective sound measurement units from single to multiple sound intrusions have been derived from community surveys, and have been used in the attempt to relate aircraft noise exposure to community reaction.

Such community surveys have, however, indicated similar community reactions for variations of as much as 10 dB in the cumulative noise exposure. This variation is illustrated in the attached figure which was extracted from the EPA Report to the President and Congress on Noise, December 31, 1971. Social survey data (Ref. 1) have also indicated that noise alone is a rather poor predictor of airport community annoyance. From our understanding of this and related data, we believe that any attempt to precisely define community noise exposure limits of acceptability would seem to be premature and arbitrary.

Environmental Protection Agency

The Boeing Company recommends that the Federal Government accelerate the search for a more accurate scale for defining community noise acceptability, annoyance, or whatever term is appropriate. The aviation industry urgently needs a reliable scale to use in the initial planning of airports, aircraft, and aircraft engines in order to insure a community acceptable design.

In view of the existing technology associated with relating cumulative physical noise exposure to sleep disturbance, indoor and outdoor speech interference, and subjective response, we have concluded that the meaningfulness of cumulative noise exposure is questionable at levels below those where hearing damage could occur.

We feel the above comments will be of value to EPA in preparing the Task Group 3 recommendations.

Very truly yours,

BOEING COMMERCIAL
AIRPLANE COMPANY

V. L. Blumenthal
Director, Noise and
Emission Abatement Programs

Reference:

(1) NASA Contractor Report NAS CR-1761, Community Reaction to Airport Noise, Vol. 1; Tracor, Inc., Austin, Texas, July 1971.

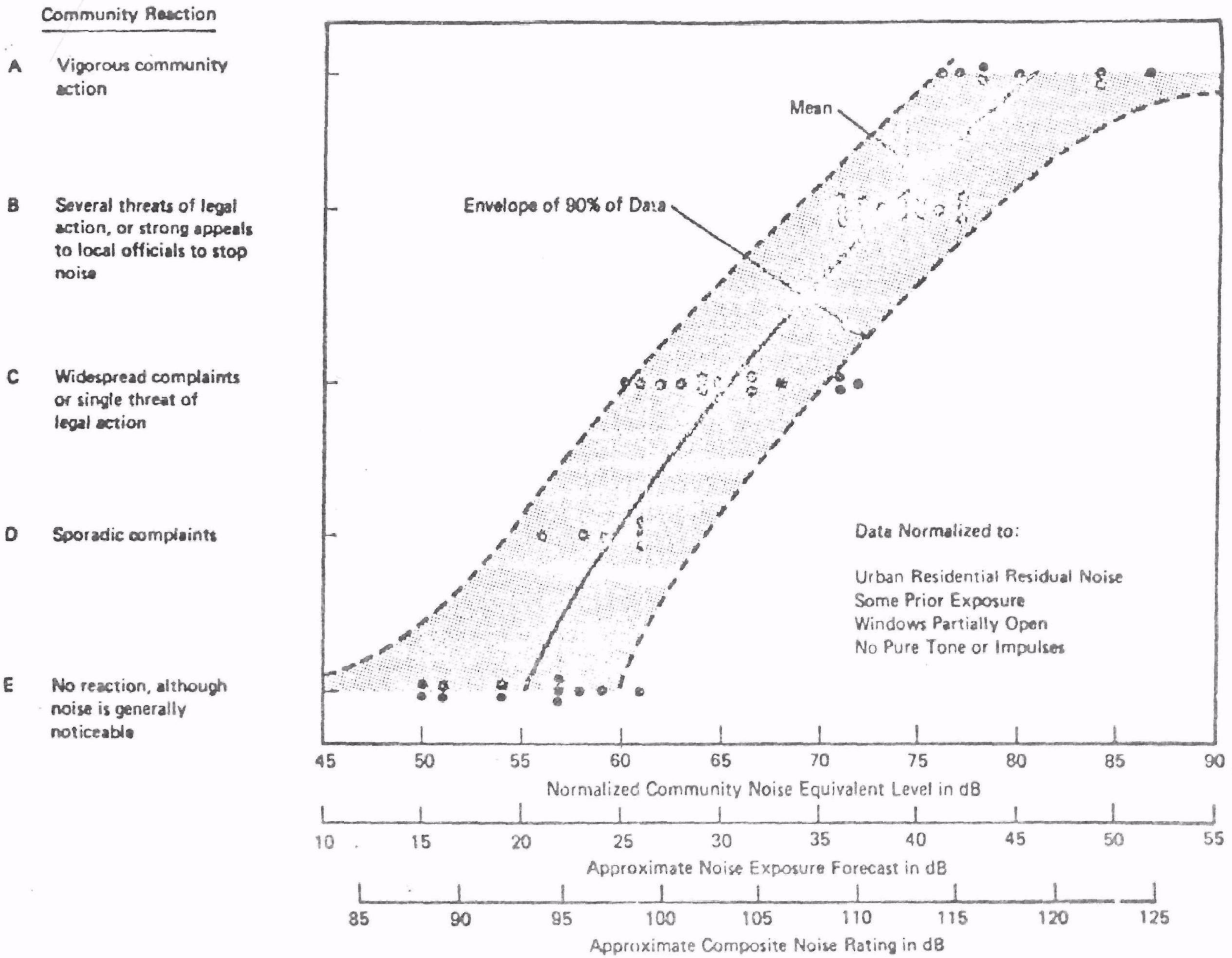

Figure 2-9. Community Reaction to Intrusive Noises of Many Types as a Function of the Normalized Community Noise Equivalent Level

DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT
WASHINGTON, D. C. 20410

OFFICE OF THE ASSISTANT SECRETARY FOR COMMUNITY PLANNING AND MANAGEMENT
Environmental and Land Use Planning Division

IN REPLY REFER TO:

April 13, 1973

Dr. Henning E. Von Gierke
Aircraft/Airport Noise Study Task Force
Office of Noise Abatement and Control
Environmental Protection Agency
Washington, D. C. 20460

Dear Henning:

The following are my comments on the Douglas Aircraft Company report of March 29, 1973, "Determination of Indoor Sound Levels for Jet Transport Aircraft". This and the related reports and discussion on April 4, 1973, seem intent on forcing a choice between standards specific to the indoor environment and those concerned only with external noise exposures. It is folly to argue that one set of standards must be chosen at the expense of the other when experience tells us that both the indoor and the outdoor environment are important considerations in establishing minimum standards for aircraft noise. The obvious point, of course, is that one must develop a dual set of standards plus information sufficient to compute the degree of attenuation accorded by different types of building construction.

HUD is in the process of extending its standards into greater depth to include a set of interior standards, which, in combination with exterior standards, will define the degree of attenuation required in a dwelling in order to meet the interior standards at various levels of exterior noise. The above referenced report is laudable to the extent that it furthers that goal. We welcome further work toward developing interior standards as a complement, rather than as a replacement for exterior standards, and in providing data on attenuation characteristics of alternative construction assemblies.

Sincerely,

James F. Miller
Director

CITY OF INGLEWOOD CALIFORNIA
CIVIC CENTER
105 EAST QUEEN STREET / INGLEWOOD, CALIFORNIA 90301

March 26, 1973

Mr. John Schettino, Director
Regulation and Standards Development Staff
Office of Noise Abatement and Control
Environmental Protection Agency
1835 "K" Street, N.W.
Washington, D. C. 20460

Dear Mr. Schettino:

The City of Inglewood welcomes the opportunity of submitting to the Environmental Protection Agency pertinent information, data and experiences relating to aircraft noise. Inglewood will support the Aircraft/Airport Noise Study Task Force in the effort to formulate meaningful aircraft noise standards as mandated by the Noise Control Act of 1972.

We feel that the following steps should be taken without delay in order to improve the compatibility between airports and neighboring communities:

1. Implement steep approaches under visual flight rules immediately.

2. Implement steep approaches for instrument flight rule conditions as soon as special navigational aids are introduced to ensure a safe performance of the procedure.

3. Require jet engine retrofit for aircraft not meeting FAR Part 36 standards.

4. Lower FAR Part 36 noise levels in time intervals to provide for continued reduction of future jet noise levels.

5. Consider lowering of the present community noise equivalent level (CNEL) criterion of 65 dBA as acceptable limit value for residential areas. This criterion should not be applied uniformly to all residential areas around airports.

Sincerely,

Merle Mergell
Mayor

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3 April 1973

Dr. Henning vonGierke
Chairman, Task Group 3
EPA Aircraft/Airport Noise Study Task Force
MRBA
Wright-Patterson AFB, Ohio 45433

Subject: Selection of Noise Exposure Characterization and Assessment Method

Dear Dr. vonGierke

I am writing this letter as Chairman of the Helicopter and V/STOL Noise Subcommittee, SAE Committee A-21 on Aircraft Noise. At meetings of both the Subcommittee and full committee on 26-27 March 1973, I was informed that your EPA Task Group 3 was considering some form of time-integrated dB(A), or equivalent, as a tool for the evaluation of noise around airports.

If one considers that air traffic at an airport may include a mix of propeller and rotorcraft, as well as jet aircraft, the SAE A-21 Committee has serious reservations concerning the equability and suitability of rating all types of aircraft noise on a power based, rms measuring scheme, particularly one which de-emphasizes the low frequency end of the spectrum. Enclosed herewith is an advance copy of SAE Aerospace Information Report 1286, "Helicopter and V/STOL Aircraft Noise Measurement Problems;" this AIR has final approval and is presently being published by the SAE. I have flagged out sections of this document as being of particular interest in connection with the subject of this letter.

Please let me know if I can provide any further assistance in connection with your work as Chairman of EPA Task Group 3.

Very truly yours,

Gordon L. Getline

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AIR 1286

Helicopter and V/STOL Aircraft Noise Measurement Problems

<u>Note:</u> This draft approved by Committee A-21/SAE ltr dtd 21 Sept. 1972 and incorporates comments submitted 21 September 1972.

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AIR 1286

Helicopter and V/STOL Aircraft Noise Measurement Problems

Purpose

The noise signatures of vertical and short takeoff and landing (V/STOL) aircraft can differ substantially from those of conventional takeoff and landing (CTOL) aircraft for which measurement procedures have been standardized. It is the purpose of this document, therefore, to review the more important factors associated with the measurement of external noise of V/STOL aircraft and to provide general guidance for the acquisition and analysis of such data. In this document, the term V/STOL aircraft is understood to include all aircraft which may operate in:

a. The VTOL mode, exclusively, where the aircraft takes off and lands vertically and horizontal transition is made in the air.

b. The STOL mode, exclusively, where the aircraft takes off and lands with a relatively short ground roll and is capable of steep climbout and approach angles.

c. The VTOL, STOL or CTOL mode.

These aircraft, therefore, include helicopters, tilt rotor configurations, propeller and prop-fan aircraft, combination lift-fan and cruise engine configurations, and various types of externally and internally blown flap installations.

Problem Areas

1. Because of the wide variety of aircraft which must be considered, the acoustic frequency range of interest must be extended well below that presently considered for CTOL aircraft which are for the most part powered by turbojet or turbofan engines. For example, the rotor-rotational noise on large helicopters has maximum energy at infrasonic frequencies with the fundamental in the range of 10 to 20 Hz, [illegible] perceived aurally as repetitive impulses.

2. It is well known that the shape of the annoyance response curve, reference SAE ARP865A, is most heavily weighted in the frequency range from 3 to 4 kHz. It has also been shown that the preferred octaves with 63, 125 and 250 Hz geometric mean frequencies, are the most important from an aircraft detection standpoint. However, it is the distinctly separable acoustical "events" taking place 10 to 20 times per second in rotorcraft that appear to elicit significant subjective reaction. It is therefore considered necessary to measure the fundamental and lower order harmonics of the rotational noise, as well as the higher harmonics, to provide data for correlation with observed subjective reactions and analytical noise prediction methods. Information that can be lost by a noise measurement system that does not have adequate low frequency capability, e.g., suppression of high crest factors, is shown by Figure 1.

3. An aspect of the noise measurement problem associated with some types of rotor and propeller aircraft relates to the impulsive and impact characteristics of the noise signatures. Impulsive noise is characterized by pulses of extremely short duration and extremely short rise time to their maximum levels. Rotors emit high amplitude, modulated and repetitive impulse noise at relatively low frequencies as well as at high frequencies. Propellers have similar characteristics but at higher associated frequencies. Thus, to "capture" peak amplitudes accurately, the acoustical data acquisition systems must have very wide frequency response and high crest factor capability. Experience indicates that power measuring systems such as *rms* type analyzing circuits and graphic level recorders are not suited to analyze and present such data. Spectral displays lose relative phasing information, which an amplitude-time histogram preserves, however. A systematic approach is needed to develop common descriptors and instrument systems for waveform characteristics related to subjective response.

4. Another problem area related to V/STOL aircraft noise measurements is the probable, eventual standardization of noise measurement distances. For example, distances as short as 150 to [illegible] feet have been used to establish baseline [illegible]

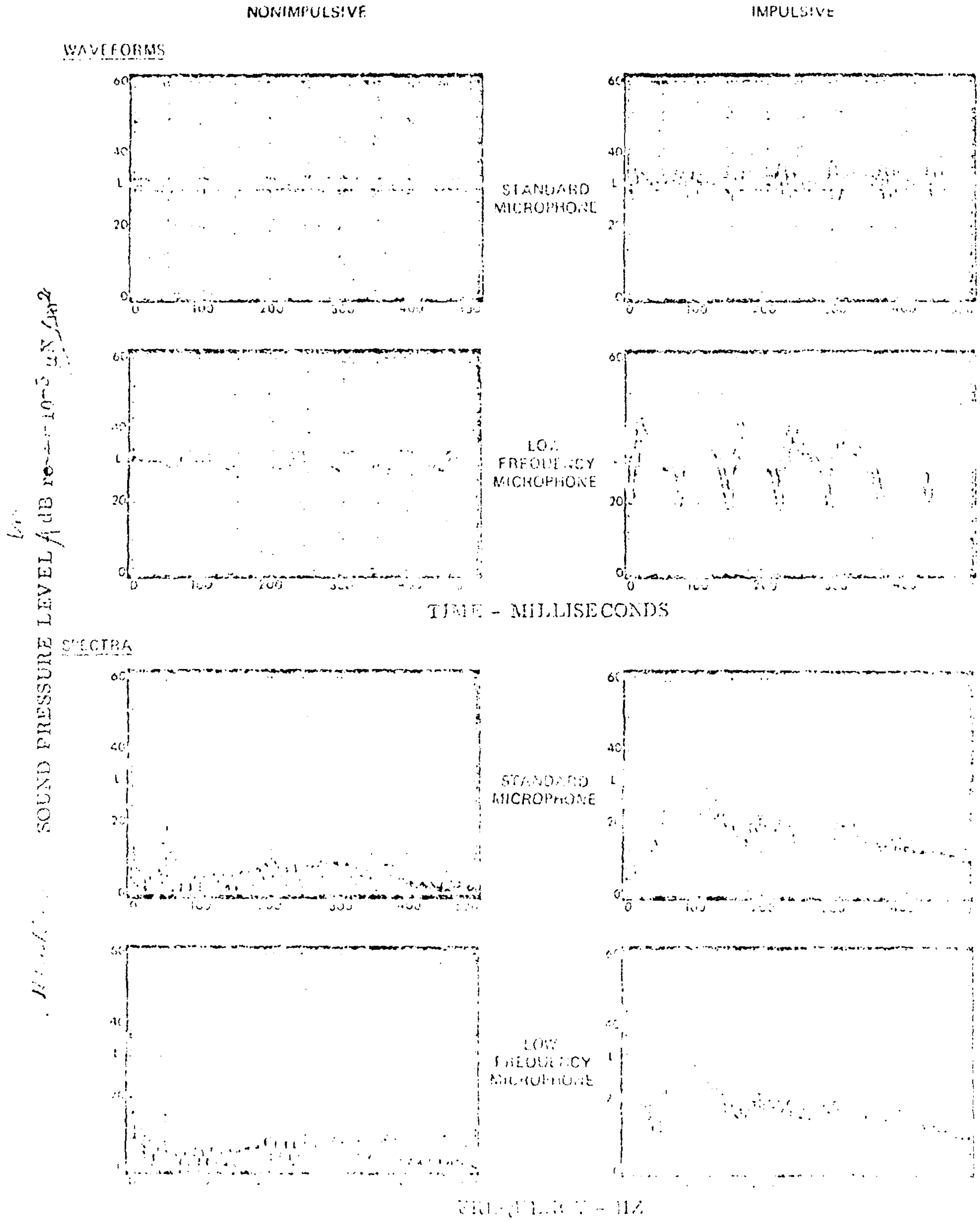

Figure 1. Comparison of Waveforms and Spectra Measured With Standard Microphones and With Low Frequency Microphone Systems

ment perimeters for CTOL transport aircraft to assure that data are reasonably representative of the acoustic far field. For conventional turbofan aircraft such as the 707 or DC-9, for example, these distances may be satisfactory. However, for some types of V/STOL aircraft, such as those which might employ large tilting rotor-props at the wing tips, a 200 foot distance may still be in the acoustic near field because of the physical separation of the various noise sources and the long wavelengths associated with low frequency noise. Delineation of the boundary between the near and far fields may also be difficult for aircraft with large, distributed, line noise sources such as internally blown flap systems. This situation should be thoroughly investigated before any attempt at standardization of noise measurement distances is made, since it has an important bearing on the ability to correlate predicted noise levels with field measurements. Present experience with CTOL aircraft has shown that nominal boundary between the near and far fields is within about two major noise source dimensions or two wave lengths of the lowest frequency of interest, whichever is greater. Whether these criteria are valid for a large, distributed line source should be verified.

5. The one feature of V/STOL aircraft that, perhaps more than any other, differentiates them from CTOL aircraft, is the use, in general, of some form of powered lift augmentation. This distinction holds true whether one considers helicopters (as a class), configurations with blown flap systems, tilt cruise engines or the use of lift fans, etc. For some configurations, such as helicopters or aircraft employing tilt cruise engines, the power system which is used to provide lift is also used to provide cruise thrust. In others, such as those employing lift engines and independent cruise engines, the lift engines are used only for takeoff and landing and are shut-down for cruise conditions. Since concern is with the total noise picture, measured noise levels must be the sum at the point of measurement of all the noise sources on the aircraft. However, at measurement points close to the V/STOL port, each of the sources may be changing its noise characteristics independently of the other sources on the aircraft. [illegible]

modulation of power (and noise) is an additional variable in the description of community noise. Although the goal of the operator will be that the aircraft is always operated in its most efficient and economical mode, the socio-economic makeup of a community adjacent to a V/STOL port or its topography may require the imposition of certain operational noise constraints. Thus, it is conceivable that on a given route a V/STOL aircraft might operate as a CTOL at one airport, as a STOL at another and as a VTOL at a third. Therefore, a meaningful noise estimation procedure and measurement program will require that the temporal characteristics of each of the noise sources be taken into account for all potential terminal area and low altitude cruise modes of operation.

6. Processing of acoustic data involving very low frequency and/or repetitive impulse or impact noise should be approached with caution, particularly where the end product of the data reduction process is to be a subjective rating number such as Effective Perceived Noise Level (EPNL). The EPNL rating scheme was developed on the basis of broad band noise corrected for discrete tones and duration. In addition, the lowest one-third octave band center frequency considered is 50 Hz. The difficulty of objectively quantifying subjective response to repetitive impulsive noise, such as helicopter rotor blade slap, is reflected by the fact that no criteria for acceptability have been agreed on. Similarly, with respect to noise resulting from relatively high propeller tip speeds, i.e., at Mach numbers greater than approximately 0.8, the effect of many harmonically related tones has not been evaluated, although it is known that the harmonic relationships significantly affect annoyance. The establishment of criteria in this area is mandatory before progress can be made towards designing propeller/rotor V/STOL aircraft that will have acceptable community noise levels.

7. Another consideration related to some types of low frequency, repetitive, impulsive noise sources, is that physiological reaction (annoyance, loudness, startle or fear) may be due to [illegible]

the ears, ref. NASA Bioastronautics Data Book, SP-3006, dated 1964 and "Compendium of Human Responses to the Aerospace Environment," NASA CR-1205; Lovelace Foundation for Medical Education and Research, Nov. 1968. Discussion in this area is beyond the purview of this document. However, the situation does point up the difficulty of extending the existing subjective rating scheme for low frequency and impulsive noise. Whatever procedure may be eventually established it must, of course, fair smoothly into other subjective rating procedures.

8. No "best" data processing system can be defined for low frequency and impulsive noise at this time since it will be dependent to a large extent on the data requirements for whatever subjective rating scheme is eventually adopted. It must be assured, however, that all recorded data are undistorted and that the processing system enables complete retrieval and definition of the mathematical and acoustical properties of the signals.

The above paragraphs have described, in general, the more important problem areas related to the acquisition and processing of meaningful noise data for V/STOL aircraft. The following paragraphs deal with special instrumentation requirements. Where applicable, of course, data, instrumentation, techniques and procedures described in the SAE and ANSI documents listed in the Appendix, are recommended.

Instrumentation Requirements

1. When the noise signature of a V/STOL aircraft is characterized by a very low frequency and/or repetitive impulse noise, the data acquisition instrumentation system must have the capability of covering the frequency range from 2 to 3 Hz up to 11,200 Hz and an amplitude range from 40 to 120 dB. Microphones are commercially available, along with their ancillary equipment, which have the required sensitivity and can cover the wide frequency [illegible]

frequency modulation (FM) recording system should be used to assure adequate low frequency coverage. An additional benefit of an FM system is that it is also capable of recording data such as wind direction and velocity, so that they may be correlated with acoustic data. High frequency FM recording requires high tape speeds of 15 to 60 inches per second (ips). If these tape speeds are not available on a particular recorder, the acoustic signal may be split with the low frequencies recorded on FM and the high frequencies recorded direct. IRIG wideband Group I FM allows DC to 10 kHz at a tape speed of 15 ips, with a dynamic range of 43 dB, ref. Inter Range Instrumentation Group Telemetry Standards - Document 106-72. If the noise under consideration spans an amplitude range of over 40 dB (the effective dynamic range of most recording systems) one method of covering the large dynamic range is to record the noise on two channels with a combined dynamic range of approximately 80 dB.

2. Recognizing the possibility of high crest factors in rotor and propeller noise (peak/rms ratios on the order of 30 dB) the signal should be monitored on an oscilloscope and provisions made to insure that clipping does not occur.

3. Data must be displayed and presented in a form which permits interpretation of low frequency noise (say, below 300 Hz) in some detail, e.g., in terms of Fourier harmonics with phasing of the lowest frequency significant periodic noise in the range. In addition, data should be presented as 1/3 octave band sound pressure levels and as A-weighted sound level. Oscillograms to convey the pressure history of a wave are also useful where complex waves are involved, as an additional tool in the evaluation of the psychoacoustic effects of a non-sinusoidal wave. It has not been conclusively shown that a complex wave can be properly evaluated for subjective annoyance by use of a simulation based solely on the signal's Fourier harmonic components.

Summary

The above discussion provides a brief summary of the more important factors related to noise measurements of undefined V/STOL aircraft types. These factors are in addition to those encountered in obtaining meaningful data on CTOL aircraft. It appears that standard measurement procedures and data presentation schemes for very low frequency and repetitive impulsive noise must wait until generally agreed-on subjective reaction criteria are developed. As in the case of CTOL aircraft, it is recognized that there may be factors other than the physical characteristics of the noise signature that are significant in community reaction. Consideration of these non-acoustic factors is beyond the scope of this document.

APPENDIX

SAE COMMITTEE A-21 PUBLISHED DOCUMENTS

ARP 796	Measurements of Aircraft Exterior Noise in the Field.
AIR 817	A Technique for Narrow Band Analysis of a Transient.
AIR 852	Methods of Comparing Aircraft Takeoff and Approach Noises.
ARP 865A	Definitions and Procedures for Computing the Perceived Noise Level of Aircraft Noise.
ARP 866	Standard Values of Atmospheric Absorption as a Function of Temperature and Humidity for Use in Evaluating Aircraft Flyover Noise.
AIR 876	Jet Noise Prediction.
AIR 902	Determination of Minimum Distance from Ground Observer to Aircraft for Acoustic Tests.
AIR 923	Method for Calculating the Attenuation of Aircraft Ground to Ground Noise Propagation During Takeoff and Landing.
ARP 1080	Frequency Weighting Network for Approximation of Perceived Noise Level for Aircraft Noise.
ARP 1264	Airplane Flyover Noise Analysis System Used for Effective Perceived Noise Level Computations.

and — the following American National Standards Institute (ANSI) documents:

S1.1-1960	Acoustical Terminology (Including Mechanical Shock and Vibration) Revision and Consolidation of Z24.1-1951 and Z24.1a (ISO R16, R131, and IEC50(08).
S1.2-1962	Physical Measurement of Sound, Method for (Revision of Z24.6-1950).
S1.4-1961	General-Purpose Sound Level Meters, Specification for (Revision of Z24.3-1944)(IEC 123).
S1.6-1967	Preferred Frequencies and Band Numbers for Acoustical Measurements (Agrees with ISO R266).

S1.8-1969 Preferred Reference Quantities for Acoustical Levels.

S1.10-1966 Calibration of Microphones, Method for the (Revision and Consolidation of Z24.4-1949 and Z24.11-1954).

S1.11-1966 Octave, Half-Octave, and Third-Octave Band Filter Sets, Specification for (Revision and Redesignation of Z24.10-1953)(IEC 225).

DEPARTMENT OF THE NAVY
NAVAL UNDERSEA CENTER
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IN REPLY REFER TO

9 May 1973

MEMORANDUM

From: Robert W. Young
To: H. E. von Gierke, Chairman, EPA Task Group 3
Aircraft/Airport Noise

Subj: Material for report on aircraft/airport noise

Encl: (1) Symbols and abbreviations in noise control
(2) Glossary for noise environment
(3) Definitions of environment noise level noise dose

1. The number of symbols and abbreviations that will be required for the subject report is sufficiently great that a separate appendix for that purpose would be very helpful. I offer enclosure (1) as a framework for such an appendix, and as the list of symbols to be used in the main text. Only letter symbols ought to be used in equations, but abbreviations are also provided here for those who may want them. For symbols that should be added to the list for quantities in the most recent Task Group 3 draft, I suggest:

L_{dn} day-night average sound level (DNAL), an average A-weighted sound level for a day, with nighttime levels increased 10 dB

D_A difference in A-weighted sound levels; same as noise level reduction (NLR)

D noise dose, the equivalent duration of exposure to a criterion sound level. The unit is a time unit, or a percentage of a rating time

2. Dictionary-style definitions for many of the terms encountered in noise control are given in enclosure (2). I offer such a glossary as an appendix to the report, to be selected for terms actually used in the report. I suggest adding the definitions of enclosure (3), for environment noise level and noise dose.

Robert W. Young

day-night average sound level. An average sound level during 24 hours, with a ten-decibel weighting of noise during the night from 10 pm to 7 am. Technically, the day-night average sound level is a time-weighted mean-square A-weighted sound pressure level

noise dose. The equivalent duration of exposure to a given criterion sound level. The rule of equivalence between sound level and duration must be somewhere indicated. A noise dose may be expressed as a fraction, or a percentage, of a rating time such as 8, 24, or 40 hours.

The noise dose of a succession of sounds is the sum of the noise doses of the individual sounds. The noise dose D, as a fraction of a rating time t_r, can be calculated from

$$D = t_1/T_1 + t_2/T_2 \; \ldots = t_n/T_n, \qquad (1)$$

where t_i (standing for t_1, t_2 ... t_n) is the total time within a period of observation during which the sound level, A-weighted, is near a given level L_i, and T_i is the permitted duration of exposure to the given sound level L_i. In principle, a "give· sound level" is simply one of a continuous distribution of sound levels, althou· , it may be practical to change the level in steps of one or two decibels. The su . in equation (1) is to extend from a ratio t_i/T_i that is small at low sound l· ·l (where $1/T_i$ is small) to the ratio t_i/T_i that is small at high sound levels (· · re t_i is small). The "permitted" duration T_i is calculated from $T_i = t_r 2^{-(L_1 - L_r)/n}$, where t_r is a "rating time" such as 8 hours, and L_r is the corresponding soun· ·evel for which the rating is to occur. The exchange rate between sound level ·· duration of exposure is n, given in decibels per halving of permitted duratio· T_i. For example, if n = 3 dB/ time halving, T_i will be halved every time L_i i· increased 3 dB.

The required information can be supplied, for example, by a label for the reading x of noise dosimeter, in the form x % 8hr 90 dB A5. This means a noise dose of x percent of 8 hours equivalent duration of exposure to 90 decibels A-weighted sound level with an exchange rate of 5 decibels per halving of duration.

Reprinted from NOISE/NEWS 1, 124 (1972)

Quantity Symbols and Abbreviations in Noise Control

This list is being published by courtesy of Dr. R. W. Young, Naval Undersea Center, San Diego, California 92132.

Symbols and abbreviations for some quantities encountered in noise control are listed below. The letter symbol appears before the name of the quantity; a capital-letter abbreviation suitable for computer printout is given in parentheses.

As explained in "Letter Symbols for Quantity Symbols used in Electrical Science and Electrical Engineering," American National Standard Y10.5 - 1968, when printed quantity symbols appear in italics. Quantity abbreviations, in contrast with quantity symbols, are printed in roman (vertical) type.

An abbreviation for a unit - the unit symbol - is also printed in roman type and generally in small letters. The first letter of the symbol, however, is a capital if the unit is derived from a proper name: for example, the unit of frequency is the hertz and the unit symbol is Hz. The bel (unit symbol B) is a unit of level; preceded by the standard symbol for the prefix deci, the unit symbol for decibel is dB.

In text, the name of a unit is to be spelled out, but if it is preceded by a number, the unit symbol may be used. Examples: . . . the sound level was 92 dB; sound level is measured in decibels.

L	level (L) of a kind defined in an accompanying text.
L_a	acceleration level
L_v	velocity level
L_d	displacement level
L_p	sound pressure level (SPL)
L_A	sound level, A-weighted (SLA)
L_{Af}	sound level, A-weighted, fast response (SLAF)
L_{As}	sound level, A-weighted, slow response (SLAS)
L_{AI}	impulse sound level, A-weighted (SLAI)
L_{max}	sound level, A-weighted, maximum (SLAM)
L_{min}	sound level, A-weighted, minimum (SLAN)
L_r	rating sound level, being the sound level A adjusted for spectrum character and duration (RSLA)
L_{10}	ten-percentile sound level, the A-weighted sound level equalled or exceeded 10% of time
L_{50}	median sound level, the A-weighted sound level equalled or exceeded 50% of time
L_{eq}	equivalent sound level, A-weighted (SLAQ)
L_{AT}	noise exposure level (NEL), the time-integrated A-weighted sound level
L_h	hourly noise level (HNL)
L_{hd}	hourly noise level, day time (HNLD)
L_{he}	hourly noise level, evening (HNLE)
L_{hn}	hourly noise level, night (HNLN)
L_C	sound level, C-weighted (SLC)
$L_{1/1}$	octave band sound pressure level (OBSPL)
$L_{1/3}$	one-third octave band sound pressure level (TOBSPL)
L_{NP}	noise pollution level (NPL)
L_{PN}	perceived noise level (PNL)
L_{PNM}	perceived noise level, maximum (PNLM)
L_{PNT}	perceived noise level, tone-corrected (PNLT)
L_{EPN}	effective perceived noise level (EPNL)
$L_{P1/1}$	octave band sound power level (OBPWL)
$L_{P1/3}$	one-third octave band sound power level (TOBPWL)
L_V	voltage level
I_a	airborne sound insulation index
I_i	impact-sound index
R	sound reduction index, transmission loss (TL) of a partition
f	frequency (F)
g_n	standard acceleration of free fall = 9.80665 m/s²
P_0	reference sound power, 1 pW
p_0	reference sound pressure for gas, 20 μPa
p_0	reference sound pressure for liquid, 1 μPa
a_0	reference vibratory acceleration, 10 μm/s²
v_0	reference vibratory velocity, 10 nm/s
d_0	reference vibratory displacement, 10 pm
	articulation index (AI)
	community noise equivalent level (CNEL)
	hearing level (HL)
	noise criterion level (NC)
	noise exposure forecast (NEF)
	noise induced permanent threshold shift (NIPTS)
	noise induced temporary threshold shift (NITTS)
	noise level (NL), the A-weighted sound level of airborne sound
	noise reduction (NR), reduction in sound pressure level for a stated frequency or band
	noise level reduction (NLR), reduction in A-weighted sound level
	noise isolation class (NIC) between rooms
	permanent threshold shift (PTS)
	preferred-frequency speech interference level (PSIL)
re	"with reference to" a stated reference quantity, for a level
	single-event noise exposure level (SENEL)
	sound transmission class (STC) of a partition
	speech interference level (SIL)
	temporary threshold shift (TTS)
	threshold shift (TS)

This list is a consolidation, correction, and expansion of the lists that appeared in NOISE/NEWS, 1, 40, 64, (1972). Ed.

Reprinted from NOISE/NEWS 1, 39, 40, 62, 63 (1972)

Glossary of Terms for Navy Noise Measurements, Particularly for the Environmental Protection Data Base

(This material is being published courtesy of Dr. R. W. Young, Naval Undersea Research and Development Center)

acceleration level. In decibels, 20 times the logarithm to the base ten of the ratio of vibratory acceleration to the reference acceleration.

community noise equivalent level. Average noise level over 24 hours, with the noise level existing between 1900 and 2200 hours increased by five decibels and the noise level between 2200 and 0700 hours increased by ten decibels. The average noise level is the mean-square A-weighted sound pressure level. The unit is the decibel (dB).

composite noise rating. A numerical descriptor of aircraft noise exposure, including a different importance of day and night operations. In effect, the composite noise rating is the maximum perceived noise level at a given location due to a typical aircraft operation, minus 12 decibels, plus 10 times the common logarithm of the number of aircraft operations from 0700 hours to 2200 hours (day) plus 17 times the number of operations from 2200 hours to 0700 hours (night). If it is greater, the composite noise rating based on runup noise, and similarly steady sounds, is to be used. This composite noise rating (here with a 20-decibel increase already included to permit direct comparisons) is the typical perceived noise level due to the runup, plus 17 decibels, plus 10 times the common logarithm of the number of minutes of total runup time during the day plus 17 times the total runup time during the night. These are simplified descriptions applicable after 1963. Inasmuch as perceived noise level of an aircraft sound is often 9 to 12 decibels greater than the A-weighted sound level, the composite noise rating at a given location is approximately equal to the typical maximum sound level of an aircraft operation, plus 10 times the common logarithm of the number of daytime operations plus 17 times the number of nighttime operations. For ground runups, the composite noise rating is approximately equal to the typical sound level of a runup, plus 5 decibels, plus 10 times the common logarithm of the number of minutes of total runup time during the day plus 17 times the runup time at night.

cumulative distribution. For time-varying airborne sound, the distribution usually described by a table or graph showing the percentage of a given test sample or a time period during which the varying sound level equals or exceeds stated levels. The levels, such as 50, 60, 70, 80, 90 and 100 decibels are preferably equally spaced at intervals not greater than 10 decibels.

decibel. Unit of a level such as sound power level or sound pressure level. One decibel is the level of the squared sound pressure that is $10^{1/10} = 1.259$ times the squared reference sound pressure, also, one decibel is the level of the sound pressure that is $10^{1/20} = 1.122$ times the reference pressure.

dB A. Composite abbreviation for decibel and A-weighted sound level. The three letters together are not a unit of anything, nor do they stand for a sound pressure level. The decibel is not A-weighted.

dB C. Composite abbreviation for decibel and C-weighted sound level.

displacement level. In decibels, 20 times the logarithm to the base ten of the ratio of the vibratory displacement to the reference vibratory displacement.

effective duration. Duration of a constant sound which, at the maximum sound pressure level of a time-varying sound, would convey the same sound energy in a given sound field as does the varying sound. This effective duration corresponds to an exchange rate between sound pressure level and time, of 3 decibels for a doubling of time, somewhat different effective durations follow from other exchange rates.

effective perceived noise level. Time-integrated perceived noise level calculated with adjustments for irregularities in the sound spectrum, such as caused by discrete-frequency components. The reference time is 10 seconds. The unit of effective perceived noise level is the decibel, but for clarification it is commonly tagged by an abbreviation for effective perceived noise: example, 90 EPNdB. Effective perceived noise level is often derived from tone-corrected perceived noise level calculated at 0.5 second intervals.

equivalent duration. Of a time varying sound, the duration of a constant reference sound of stated sound pressure level that would convey the same sound energy in a given sound field as does the varying sound. The energy equivalence corresponds to an exchange rate, between sound pressure level and time, of 3 decibels for a doubling of time. Other exchange rates may be specified; for example, according to one rule for deafness risk the effective duration of sound at various levels is calculated for the equivalent A-weighted sound level of 90 decibels and an exchange rate of 5 decibels for a doubling of time.

equivalent sound pressure level. The constant sound pressure level equivalent to a varying sound pressure level during a stated sample time. Equivalence is usually based on an exchange between sound pressure level and time at the rate of 3 decibels for a doubling of time; in this case, the equivalent level is the time-mean-square sound pressure level over the sample time. The rate of 5 decibels for doubling of time is employed in some deafness risk tables.

frequency. Number of complete oscillation cycles per unit of time. The unit of frequency often used is the hertz (Hz).

frequency band. Difference in hertz between the upper and lower frequencies that delimit a band, or the interval in octaves between the two frequencies. The band is located frequency-wise by the geometric mean frequency between the two band-edge frequencies. An example is "an octave band centered at 500 Hz."

hearing threshold level, hearing level, hearing loss. For an impaired ear and for a specified signal, the amount in decibels by which the threshold sound pressure level for that ear exceeds a standard threshold of hearing.

hertz. Unit of frequency equal to one cycle per second.

hourly noise level. The average noise level during the hour. More specifically, for airborne sound it is the mean-square A-weighted sound pressure level over the hour. The unit is the decibel (dB).

impulse sound level. The A-weighted sound level measured with the faster detector-indicator characteristic specified in "Additional requirements for the measurement of impulsive sound," 1972 supplement of IEC Publication 179: Precision sound level meters. The unit of impulse sound level is the decibel (dB). Use of the characteristic must be indicated, such as by: the impulse sound level was 78 dB; the limit is 78 dB (AI); L_{AI} = 78 dB.

inverse first power. The variation of squared sound pressure inversely as the first power of distance from a long line or cylindrical source.

inverse square. The variation of squared sound pressure inversely as the square of distance from a point source.

level. For communication and acoustics, the logarithm of the ratio of a given quantity to a reference quantity. The base of the logarithm, the reference quantity, and the kind of level must be indicated. The unit of the level, such as the decibel, serves to identify the base of the logarithm including any constant of proportionality.

loudness. The intensive attribute of an auditory sensation, measured in sones. Calculated loudness of a sound is obtained by a stated empirical rule from the sound spectrum in octave or third-octave bands.

loudness level. Of a sound, numerically equal to the sound pressure level of a 1-kHz, frontally-presented tone subjectively judged equally loud. The calculated loudness level of a sound is the weighted sound pressure level obtained by a stated empirical rule from the spectrum of the sound in octave or third-octave bands; the calculated loudness level is a predictor of the loudness level that would be judged in a psychophysical test. The unit of loudness level, judged or calculated, is the phon which is equal to the decibel.

noise criterion level. The octave-band sound pressure level at 1700 Hz of a noise criterion curve (NC - curve) that at one of its frequencies is equal to the maximum octave band level of a noise.

noise exposure forecast. For aircraft noise, at a given location, the effective perceived noise level there for a typical operation, minus 88 decibels, plus 10 times the common logarithm of number of aircraft operations from 0700 hours to 2200 hours (day) plus 17 times the number of operations between 2200 hours and 0700 hours (night). The unit of noise exposure forecast is the decibel, although it is omitted in usual reporting in the form, for example, NEF-30. For some typical aircraft flying at a distance of a few thousand feet, when 6 percent of operations occur at night and 20 percent in the evening, the noise exposure forecast plus 35 decibels is nearly equal numerically to the community noise equivalent level (CNEL); at greater slant ranges, plus 33 instead of 35 decibels.

noise level. For airborne sound, the same as sound level unless otherwise identified.

noise pollution level. The average sound level of a sufficiently long sample of noise, plus 2.56 times the standard deviation of the sound level. The average sound level is the time-mean-square A-weighted sound pressure level.

noisiness. Subjective magnitude of judged noisiness due to a sound. Calculated noisiness of a sound, in noys, is obtained by a stated empirical rule from the sound spectrum in octave or third-octave bands.

noy. Unit of noisiness either judged or calculated. One noy is the judged noisiness caused by a frontally-presented octave band of pink noise centered on 1 kHz of 40-dB sound pressure level and duration 0.5 second.

octave. Interval between two sounds whose frequency ratio is 2:1.

one-third octave. Interval between two sounds whose frequency ratio is $2^{1/3}$:1, nearly 5:4.

perceived noise level. A frequency-weighted sound pressure level calculated by a stated empirical rule from the spectrum of a sound in octave or third-octave bands for a duration of 0.5 second. The unit of perceived noise level is the decibel, but calculated perceived noise level is usually tagged by an abbreviation for perceived noise: example, 98 PNdB. Judged perceived noise level of a sound is numerically equal to the sound pressure level of a frontally presented octave band of pink noise centered frequency-wise on one kilohertz and duration 0.5 second that is subjectively judged equally noisy in the sense of "unwantedness." Perceived noise level (calculated) is physical predictor of judged perceived noise level.

plotting format. Proportion of sizes of scales used on ordinate and abscissa of a graph. For graphs in which a level in decibels is plotted against frequency on a logarithmic scale, the length for the factor of ten in frequency is preferably 50 millimeters: it must be equal to that for 25 decibels (preferred) or to 50 or 10 decibels.

power level. In decibels, ten times the logarithm to the base ten of the ratio of a sound power to the reference sound power of one picowatt (one-millionth of a watt).

preferred frequency. A frequency whose magnitude is one of the Renard series of preferred numbers that includes 1000, usually a frequency in the 10-series spaced at intervals of nearly one-third octave.

sample time. The total time during which a varying sound pressure level is measured.

signal-to-noise level. The amount, in decibels, by which a given signal level exceeds a related noise level.

sound exposure level, noise exposure level. The level of sound accumulated during a given event. Unless some other exchange rate is indicated, sound-exposure level in decibels is the level of the time-integrated, squared A-weighted sound pressure for a stated time interval or event, based on the reference pressure of 20 micropascals and reference time of one second.

sound level. The quantity in decibels measured by a sound-level meter satisfying requirements of American National Standard Specification for Sound Level Meters S1.4-1971. Sound level is the frequency-weighted sound pressure level obtained with the standardized dynamic characteristic "fast" or "slow" and weighting A, B, or C; unless indicated otherwise, the A-weighting is understood. The unit of any of the sound levels is the decibel. The A-weighting makes the sound-level meter relatively less sensitive to low-frequency sound, somewhat in the way the ear is progressively less sensitive to sounds of frequency below 1 KHz. The C-weighting gives the sound level meter a constant sensitivity in the frequency range 32 to 8000 Hz.

sound pressure level. In decibels, 20 times the logarithm to base ten of the ratio of a sound pressure to the reference sound pressure. The reference pressure for airborne sound is 20 micropascals (20 micronewtons per square meter) (0.0002 microbar). For waterborne sound the reference pressure is one micropascal. In the absence of any modifier, the level is understood to be that of a mean-square pressure. An example otherwise is peak sound pressure level.

speech interference level. For a sound that might interfere with understanding speech, the arithmetic mean of octave-band sound pressure levels, in decibels, centered on 500, 1000, and 2000 Hz. For many sounds it is 7 dB less than the sound level, A weighted. Originally the speech interference level was the mean of the octave-band sound pressure levels in the three octaves from 600 to 4800 Hz, sometimes with the addition of the level for the band 300 to 600 Hz. The presently-used bands are centered on preferred frequencies; hence the name preferred-frequency speech interference level.

spherical spreading. Diminuation of sound pressure level at the rate of six decibels for each doubling of distance from a point source of sound.

TO: Dr. H. E. von Gierke
Chairman, Task Group #3
Aircraft/Airport Noise Study Task Group
Environmental Protection Agency

10 July 1973

SUBJECT: Alternate Method for Considering the Effect of Average Sound Level on Speech Communication

FROM: Daniel L. Johnson
Member, Task Group #3

In the early stages of preparing the Task Group #3 report, I submitted a paper on the "Percentage of Time Speech Interference Will Occur for Various L_{dn} Values". This was incorporated as the appendix on speech interference in the first draft version of the document.

The paper basically recommends some maximum sound pressure levels for various listening conditions, then predicts the amount of time the environmental noise intrusion will be above these sound pressure levels. One of the drawbacks of this method is that no direct accounting is made as to how many dB the intruding noise exceeds such recommended sound pressure levels. Nevertheless, the methods do present a completely different way of analyzing the effect of environmental noise on speech communication. When this method is used as a basis for recommending an environmental L_{dn} limit, the results are not inconsistent with those now obtained by the current methodology of the Task Group #3 report.

Therefore, in the interest of historical and technical completeness, I recommend that this letter with the attached original appendix be incorporated as one of the papers now listed in Annex 2 (Appendix B of June 1 Draft Report) of Task Group #3 report.

Daniel L. Johnson

DANIEL L. JOHNSON, Ph.D.
Member, Task Group #3

Percentage of Time Speech Interference
Will Occur for Various L_{dn} Values

1. *Method of Prediction*

a. In order to investigate the effect of using actual noise profiles with respect to time, the 18 statistical descriptions of daytime noise (pages 18 or 49 of Community Noise[2]) were plotted on probability paper (Fig. A-1). This plot describes the range of PIx when all 18 noise profiles are used. Fig. A-2 shows the range of the possible error that could occur when the 18 noise profiles are approximated by the single profile in which (1) Leq = L_{10}, (2) L_{10} - L_{50} = 10 dB and (3) the statistical distribution of level with respect to time is normal. Note that Fig. A-2 is generalized so that only L_{sc} (the A weighted level for a certain speech criteria) can be evaluated with respect to any outdoor Leq level. The effect inside a house is found by assuming some value for the house noise reduction (NR_h).

b. From Fig. A-2 it is rather apparent that the possible error increases substantially once Leq-NR_h is equal to or greater than the L_{sc} under question. The variability is so large, in fact, that it is questionable that Leq alone can be used as a reliable measure of PIx under this condition. For a Leq-NR_h less than the L_{sc} in question, however, PIx can be estimated with a very reasonable degree of accuracy.

c. Since much of the variability of the predictions is due the noise profiles in which aircraft noise exhibits a strong influence, an analysis was made in which aircraft or other non-typical noise was eliminated. This was accomplished by eliminating four noise profiles where single event noise from aircraft predominated. These were profiles F, K, M, and R (see Attachment #2). The ocean noise (profile E) was also eliminated as non-typical. Fig. A-3 is the result of eliminating these noises. Note that for Leq-NR_h less than the

L_{sc}, there is little difference between the results of Fig. A-2 and Fig. A-3. The range of possible values of PIx is still quite large once Leq-NR_h is greater than the L_{sc}. From the above analysis, it doesn't seem to serve any purpose to separate noise profiles with high aircraft noise from noise profiles in general.

2. Manipulation of the Data in Order to Provide Basis for Selecting a Leq Limit Based on Speech Interference

a. Consolidation of Information of Para. 1. Table A-1 has been constructed in order to summarize the predicted effects previously discussed.

b. Selection of Exposure Situations. Three situations have been selected for discussion. These are exposures that occur (1) outside, (2) inside a standard house with windows open and (3) inside a standard house with windows closed. A house noise reduction value of 15 dB is selected to represent the window open condition and a NR_h value of 25 dB is selected to represent the windows closed condition.

c. Criteria for Speech Interference. Two different measures of speech interference are suggested. The first measure comes from reference 1 (Attachment #1). The breakpoint between good listening conditions and fair listening conditions is 47 dBA. This value was rounded to 45 dBA for the purposes of this report. The breakpoint between fair listening conditions (Attachment #1) and just acceptable speech conditions is 56 dBA (55 dBA will be used).

The second measure comes from Fig. 19 of the Community Noise[2]. Table 4b-1 is a summary of Fig. 19.

d. Table A-3

As the first step in recommending an exposure limit measured in Leq, the data of Table A-1 has been incorporated into Table A-2. This table shows the effect of different exposure limits on PIx. The exposure limits selected to be analyzed were Leq's of 55, 60, 65, and 70 dBA.

e. Selection of Listening or Speech Conditions. The first crucial assumption that must be made is that different listening conditions are appropriate for different living situations. Less speech interference should be acceptable outside a house than inside, for example. For this reason, it is suggested that different listening and speech conditions be allowed the three different living situations. One set of reasonable conditions are listed in Table A-3. There were some interactions among the three living conditions as an attempt was made to make the difference between the recommended levels 10 dB (between windows open and windows closed) and 15 dB (between windows open and outside). This made the outside condition slightly less desirable.

f. Table 4 is another way of looking at the data that is somewhat different than the approach of Table 4b-2. It is obvious that the information in Tables A-2 and 4b-1 can be manipulated in many ways; but in the final analysis the decisions that must be made are (1) what is an acceptable listening condition and (2) what is the maximum percent of the time this listening condition should be exceeded? Once these questions are answered, the Leq limit is determined. The Leq limit can be converted into L_{dn} limit by L_{dn} = Leq + 3 dB.

Figure A-1

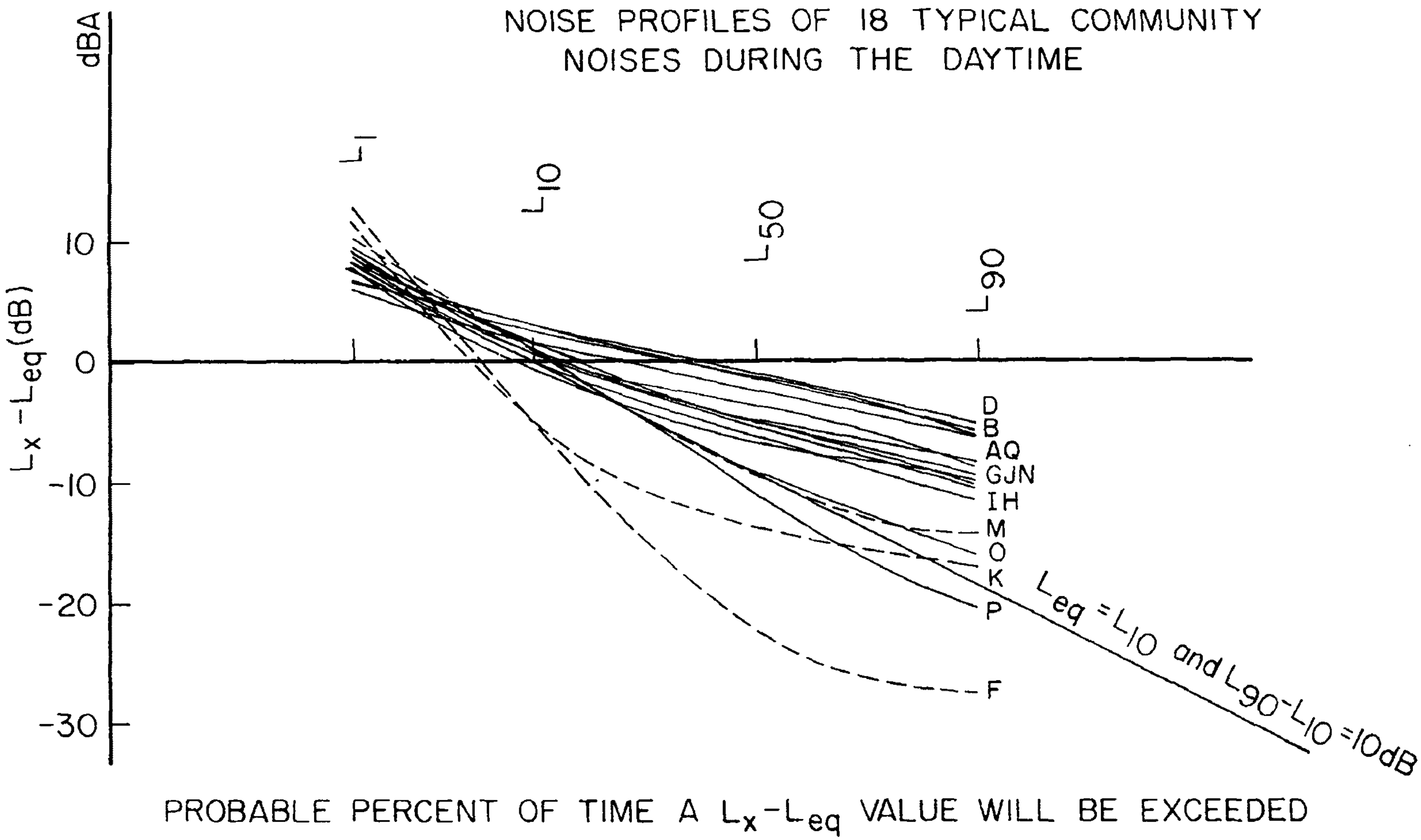
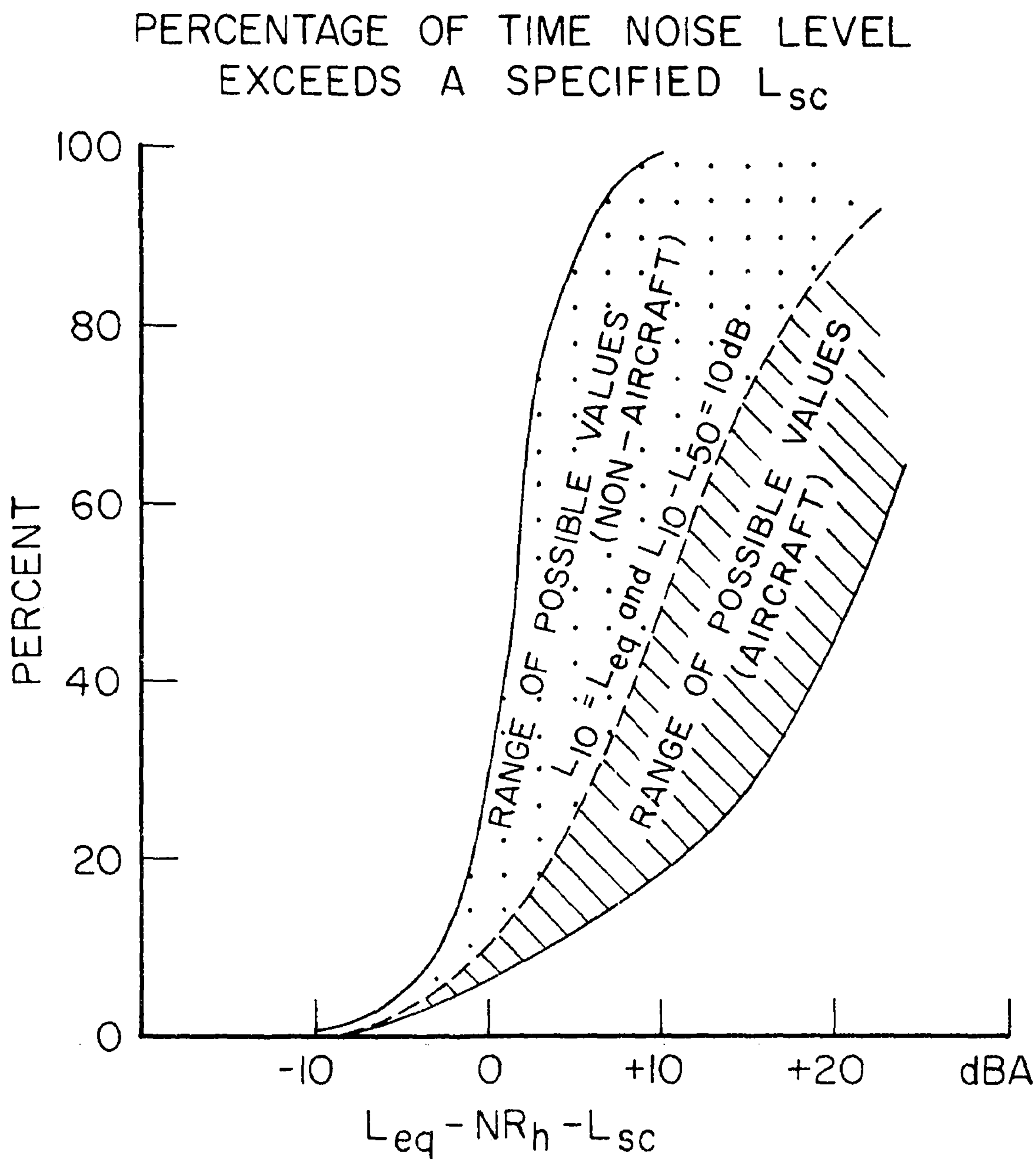

NOISE PROFILES OF 18 TYPICAL COMMUNITY NOISES DURING THE DAYTIME
dBA
$L_x - L_{eq}$ (dB)
10
0
-10
-20
-30
L_1
L_{10}
L_{50}
L_{90}
D
B
AQ
GJN
IH
M
O
K
P
F
$L_{eq} = L_{10}$ and $L_{90} - L_{10} = 10$dB
PROBABLE PERCENT OF TIME A $L_x - L_{eq}$ VALUE WILL BE EXCEEDED

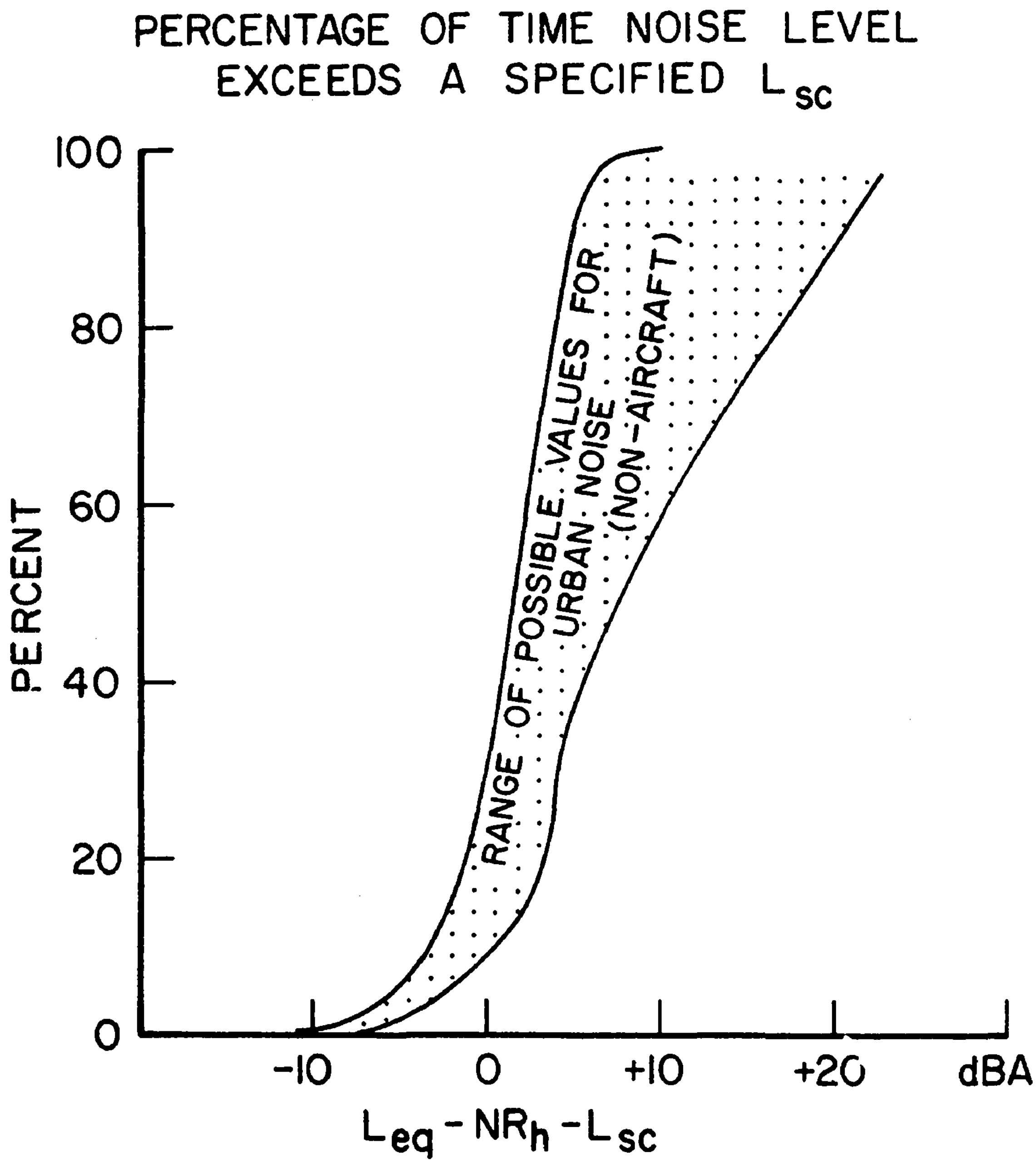
Figure A-2



NR_h = HOUSE NOISE REDUCTION, IF ANY

L_{sc} = SOME SPECIFIED CRITERIA LEVEL OR MAXIMUM BACKGROUND NOISE LEVEL FOR CERTAIN SPEECH OR LISTENING CONDITIONS.

Figure A-3



NR_h = HOUSE NOISE REDUCTION, IF ANY

L_{sc} = SOME SPECIFIED CRITERIA LEVEL OR MAXIMUM BACKGROUND NOISE LEVEL FOR CERTAIN SPEECH OR LISTENING CONDITIONS.

TABLE A-1

$Leq - NR_h - L_{sc}$	
-15 or less	L_{sc} will be exceeded much less than 1% of the time (<< 1%).
-10	L_{sc} will be exceeded less than 1% of the time (< 1%).
- 5	L_{sc} will be exceeded 2 - 5% of the time.
- 0	L_{sc} will be exceeded 8 - 30% of the time (6 - 30% if aircraft noise is also considered).
+ 5	L_{sc} will be exceeded 30 - 90% of the time (11 - 90% if aircraft noise is also considered).
+10 or greater	The variability is so great that more about the noise must be known. Leq is not enough.

TABLE A-2

For General Noise Without Aircraft Noise*

Leq Limit of 55 dBA

L_{sc}	45	50	55	60	65	70	75
Inside - Windows Closed	<< 1%	<< 1%	<< 1%	<< 1%	<< 1%	<< 1%	<< 1%
Inside - Windows Open	2-5%	< 1%	<< 1%	<< 1%	<< 1%	<< 1%	<< 1%
Outside	**	30-90%	8-30%	2-5%	< 1%	<< 1%	<< 1%

Leq Limit of 60 dBA

L_{sc}	45	50	55	60	65	70	75
Inside - Windows Closed	< 1%	<< 1%	<< 1%	<< 1%	<< 1%	<< 1%	<< 1%
Inside - Windows Open	8-30%	2-5%	< 1%	<< 1%	<< 1%	<< 1%	<< 1%
Outside	**	**	30-90%	8-30%	2-5%	< 1%	<< 1%

Leq Limit of 65 dBA

L_{sc}	45	50	55	60	65	70	75
Inside - Windows Closed	2-5%	< 1%	<< 1%	<< 1%	<< 1%	<< 1%	<< 1%
Inside - Windows Open	30-90%	8-30%	2-5%	< 1%	<< 1%	<< 1%	<< 1%
Outside	**	**	**	30-90%	8-30%	2-5%	< 1%

Leq Limit of 70 dBA

L_{sc}	45	50	55	60	65	70	75
Inside - Windows Closed	8-30%	2-5%	< 1%	<< 1%	<< 1%	<< 1%	<< 1%
Inside - Windows Open	**	30-60%	8-30%	2-5%	< 1%	<< 1%	<< 1%
Outside	**	**	**	**	30-90%	8-30%	2-5%

Attenuation assumed - 25 dBA Windows Closed
15 dBA Windows Open

*Aircraft noise can be added changing 8-30% to 6-30% and 30-90% to 11-90%

**Range of variability too great for useful prediction

TABLE A-3

Living Condition	Recommended Listening or Speech Condition
Inside House Windows Closed	(1) The listening conditions should be "good" as defined by reference 1. This good listening condition is at or below 45 dBA. (2) That relaxed conversation can occur up to distances of 12' per Table II. This is also at 45 dBA.
Inside House Windows Open	(1) The listening conditions should be at least "fair" as defined by reference 1. This fair listening condition is defined to be at or below 55 dBA. (2) That conversation can occur up to distances of 12' with a normal voice level. This will occur for levels at or below 55 dBA.
Outside	(1) Conversation with a normal voice level is possible at 2' or conversation with a raised voice is possible at 4'. This will occur for levels at or below 70 dBA.

TABLE A-4

Leq Limit	55 dBA	60 dBA	65 dBA	70 dBA
Percent of Time Conditions of Table A-3 Will Be Exceeded (PIx)	<< 1%	< 1%	2-5%	6-30%

References:

1. Beranek, L. L., W. E. Blazier and J. J. Figwer, "Preferred Noise Criterion (PNC) Curves and Their Application to Rooms," J. Acoust. Soc. Amer., 1223-1228 (1971).

2. "Community Noise". Report prepared by Wyle Laboratories for the U. S. Environmental Protection Agency, Report No. NTID300.3, December 1971.

Attach #1. From Preferred Noise Criterion (PNC) Curves and Their Application to Rooms, Beranek, Blazier and Figwer, JASA, pp. 1227, (1971).

TABLE II. Recommended category classification and suggested noise criteria range for steady background noise as heard in various indoor functional activity areas.

Type of space (and acoustical requirements)	PNC curve	Approximate L_A, dBA
Concert halls, opera houses, and recital halls (for listening to faint musical sounds)	10 to 20	21 to 30
Broadcast and recording studios (distant microphone pickup used)	10 to 20	21 to 30
Large auditoriums, large drama theaters, and churches (for excellent listening conditions)	Not to exceed 20	Not to exceed 30
Broadcast, television, and recording studios (close microphone pickup only)	Not to exceed 25	Not to exceed 34
Small auditoriums, small theaters, small churches, music rehearsal rooms, large meeting and conference rooms (for good listening), or executive offices and conference rooms for 50 people (no amplification)	Not to exceed 35	Not to exceed 42
Bedrooms, sleeping quarters, hospitals, residences, apartments, hotels, motels, etc. (for sleeping, resting, relaxing)	25 to 40	34 to 47
Private or semiprivate offices, small conference rooms, classrooms, libraries, etc. (for good listening conditions)	30 to 40	38 to 47
Living rooms and similar spaces in dwellings (for conversing or listening to radio and TV)	30 to 40	38 to 47
Large offices, reception areas, retail shops and stores, cafeterias, restaurants, etc. (for moderately good listening conditions)	35 to 45	42 to 52
Lobbies, laboratory work spaces, drafting and engineering rooms, general secretarial areas (for fair listening conditions)	40 to 50	47 to 56
Light maintenance shops, office and computer equipment rooms, kitchens, and laundries (for moderately fair listening conditions)	45 to 55	52 to 61
Shops, garages, power-plant control rooms, etc. (for just acceptable speech and telephone communication). Levels above PNC-60 are not recommended for any office or communication situation	50 to 60	56 to 66
For work spaces where speech or telephone communication is not required, but where there must be no risk of hearing damage	60 to 75	66 to 80

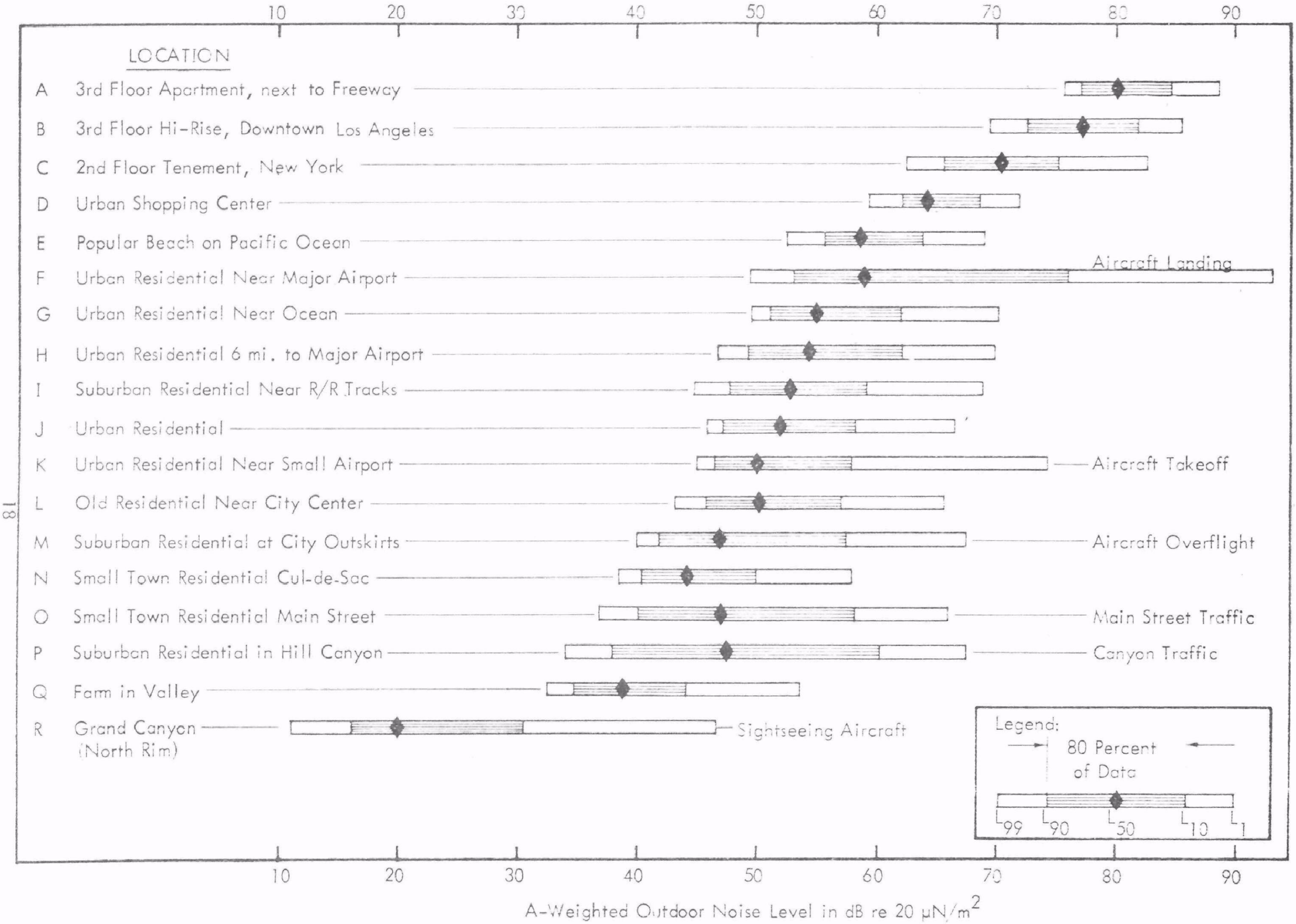


Figure 7. Daytime Outdoor Noise Levels Found in 18 Locations Ranging Between the Wilderness and the Downtown City, with Significant Intruding Sources Noted. Data are Arithmetic Averages of the 12 Hourly Values in the Daytime Period (7:00 a.m. - 7:00 p.m.) of the Levels Which are Exceeded 99, 90, 50, 10 and 1 Percent of the Time

APPENDIX H

POSITION PAPERS SUBMITTED BY TASK GROUP 3 MEMBERS WITH RESPECT TO FINAL DRAFT REPORT OF TASK GROUP 3, DATED 1 JUNE 1973

Summary and Evaluation of Position Papers Submitted By Task Group 3 Members Or Organizations With Respect To The Task Group 3 Report (Draft 1 June 1973) by Dr. H. E. von Gierke, Chairman, Task Group 3.

Letter dated 30 June 1973 from Edgar Shaw, President, Acoustical Society of America.

Letter dated 26 June 1973 from Raelyn Janssen, Environmental Defense Fund.

Letter dated 28 June 1973 from Reginald O. Cook, National Institute of Environmental Health Sciences, Department of Health, Education and Welfare.

Letter dated 2 July 1973 from Gene I. Martin, Aerospace Industries Association of America, Inc.

Letter dated 2 July 1973 from William B. Becker, Air Transport Association of America.

Letter dated 2 July 1973 from J. Donald Reilly with attached comments from the Airport Operators Council International.

Letter dated 26 June 1973 from Clifton A. Moore, City of Los Angeles, Department of Airports.

Letter dated 30 June 1973 from John M. Tyler, National Organization to Insure a Sound-controlled Environment (NOISE).

Letter dated 29 June 1973 (6-7270-1-443) from V. L. Blumenthal, Boeing Commercial Airplane Company.

Letter dated 20 June 1973 from General Aviation Manufacturers Association.

Letter dated 2 July 1973 from K. O. Ingard, Institute of Noise Control Engineering.

Letter dated 2 July 1973 from R. S. Gales, Department of the Navy. Letter written by request of Acoustical Society of America.

Letter dated 29 June 1973 from Clifford W. Graves, Department of Housing and Urban Development.

Letter dated 18 May 1973 from Robert S. Bennin, Director, Bureau of Noise Abatement, City of New York. (Per telecon with Daniel L. Johnson, letter still applies to the 1 June Final Draft Report).

Letter from the Department of Commerce concerning the Aircraft/Airport Noise Task Force.

Letter dated 29 June 1973 for A. L. McPike, Douglas Aircraft Company.

SUMMARY AND EVALUATION OF POSITION PAPERS SUBMITTED BY TASK GROUP 3 MEMBERS OR ORGANIZATIONS WITH RESPECT TO THE TASK GROUP 3 REPORT (Draft 1 June 1973)

by

Dr. H. E. von Gierke, Chairman, Task Group 3

This Appendix contains all official comments and position papers received by 20 July 1973 on the 1 June 1973 draft of the Task Group report. Additional and more detailed comments made by various Task Force members and subsequent Task Force discussions at the 21-22 June 1973 Final Task Force Meeting at Washington, D. C. are a matter of public record at the EPA Aircraft/Airport Noise Study Task Force file. As a result of the comments received up to and at the 21-22 June 1973 meeting minor changes and clarifications were incorporated into this final version of the Task Group report. However none of the conclusions and recommendations of the report were changed. Therefore, although some of the minor comments might have been incorporated or superseded, no changes were made in the final text which could have changed the basic positions or the principal issues as expressed in the letters collected in this appendix.

Most of the basic technical positions addressed by the position papers can be categorized with respect to 4 main points.

(1) The adequacy of the single measure selected (L_{dn}) to measure cumulative noise exposure with respect to public health and welfare as directed by the 1972 Noise Control Act.

(2) The use of A-weighting to account for the importance of some frequencies over others.

(3) The recommended immediate goal of reducing all residential noise exposures to a L_{dn} value below 80 dB.

(4) The suggested long-range goal of reducing the yearly average L_{dn} in residential areas to values below 60 dB.

The following table gives an approximate summary of the responses with respect to these issues, although it is strongly recommended that the reader evaluate the positions for himself by studying this appendix. The positions are summarized only to respond to some of the criticisms and opposing views.

It is important to note that there was hardly any disagreement with respect to the Issues 1 and 2. This is of great significance since this agreement includes concurrence on the important conclusion that aircraft noise exposure must be measured and evaluated by the same yardstick as environmental noise exposure from other noise sources. (The comments by the EDF and NIH with respect to the preference to "D-type weighting" is considered a minor issue at this point and adequately covered in recommendation 1 of the report).

With respect to Issues 3 and 4, the key issues and starting points for the realization of any effective national noise control effort, it is surprising and gratifying that the analysis and approach taken by the Task Group resulted in as much agreement as documented. I fully accept the criticism that the Task Group did not quantitatively analyze the economic impact of achieving the goals recommended for environmental noise levels adequate to protect public health and welfare. However this point is clearly discussed in the report as being beyond the scope of the Task Group and it is for this reason that the Task Group does not recommend a time schedule for achieving the goals. It only states that achievement of the intent of the Noise Control Act of 1972 "to promote an environment for all Americans free from noise that jeopardizes their health or welfare" requires in the Task Group's opinion promotion of the goals listed as Issues 3 and 4 in the Table. The report states that the time schedule for achieving these goals must be based on a detailed analysis of the economic impact.

The technical criticisms dealing with Issues 3 and 4 deal with the inadequacy of the data base for these recommendations, with the alleged disagreement among experts and with the need for additional research prior to formulating such goals. These criticisms are the same ones which have been expressed on these issues over the last two decades and which prevented concerted national efforts, goals and planning for only too long. It is expected that the same criticisms would be heard and could be expressed no matter how much additional research data would be accumulated. I think the difficulties of identifying and selecting maximum noise exposure levels to protect the public health and welfare are clearly discussed in the report, its appendices and references. Decreasing the obviously existing scientific margin of uncertainty between noise exposure and its effects on health and welfare will not solve the main and basic problem which is a social, ethical and economic one: what percentage of the population shall be protected and at what price. In this context it is important to note that the primary criticisms of the goals recommended in Issues 3 and 4 do not come from the organizations with the expertise in the area of the effects of noise on man such as ASA and NIH but from the organizations primarily and rightly concerned with the legal and economic consequences of establishing maximum cumulative noise exposure limits for aircraft. The point is made in ATA's position that the recommendations will affect many other industries such as manufacturing plants, railroads, highway systems, construction industry, etc., and that the Task Group 3 recommendations should not have been made without their representation and input. It is difficult to see what these organizations might have had to contribute to the objectives of this Task Group which were primarily in the domain of acoustics, psychological and physiological acoustics. As Appendix I shows, considerable emphasis was placed on consistency of the Task Group's recommendations with the noise standards of the Federal Highway Administration and of HUD standards of the Federal Highway Administration and of HUD and it is felt that the expertise relevant to environmental/community noise was adequately represented among the Task Group members.

With respect to ATA's statement that neither the appendices nor the opinions of the participants of the recent EPA-sponsored International Congress "On Noise As A Public Health Problem," Dubrovnik, Yugoslavia support the findings and conclusions of the Task Group 3 report, I must state that this does not agree with my interpretation of the data and of the opinions of the international experts in this field. Scientific discussions and differences of expert opinion on details should not be used as arguments that there is no agreement among experts on what approximate noise levels are incompatible with public health and welfare! The technical community represented in the Task Group and those scientific technical organizations which reviewed it supported basically the approach and the recommendations of the Task Group. Several additional qualified organizations, which were invited to submit position papers regarding the Task Group report and did not do so in writing, must be assumed to have no major objections to the Task Group findings; in other words the position papers received are apt to emphasize criticism of the report rather than support.

There was one specific criticism regarding Issue 3 by the AOIC which claimed that a recent HEW sponsored study on hearing of the inhabitants who lived around a major airport was not included because the results would not support the conclusions about expected hearing loss from environmental noises. The report was initially left out because the results were inconclusive with respect to the 80 dB limit recommended. I fully agree with the AOIC that this reference must be included in the Task Group report and consequently a short discussion of the results of this study is now included in Appendix B.

With respect to the recommendation that the Task Group report should be identified as the Chairman's report not representing necessarily the opinions or consensus of the Task Group, I have a mixed response. Certainly the Chairman had the responsibility of assembling the report and making decisions in the deliberations when decisions were needed. These responsibilities were not relinquished to some majority of the Task Group members, which would have had no real validity since any one was invited to join the Task Group activity. Nevertheless, the Task Group meetings gave interested parties a chance to put forth their ideas and complaints. New and novel ideas were thus possible. Appendix H and other documents in the Task Group file document the members' participation. Likewise, ideas which were not supported by members other than the Chairman were eliminated. The report could never have been written without the devoted collaboration of the whole Task Group. In summary, I think the report reflects the opinions and recommendations of the Task Group as summarized by the Chairman; and the Preface indicates the degree of consensus reached on the various issues. I think the final position papers collected in this appendix and their evaluation in the above Table support this interpretation and show that the report reflects indeed the majority opinion.

One final word about the complaints that not enough time was available for the aircraft noise study and the Task Group report: I agree that the report is far from perfect and could be improved with respect to details. On Issue 4 the above mentioned economic study might have shown when and at what price the long-range goal of $L_{dn} < 60$ dB could be realized or if indeed it might be feasible and realistic to lower this goal to $L_{dn} < 55$ or even 50 dB as some organizations well familiar and concerned with the health and welfare aspects suggest (ASA, EDF, NIH). Further studies over much longer time periods and with considerably more resources available as a

Task Group can muster, will have to study this. However, I doubt if the basic conclusions and recommendations of the Task Group report would have changed much if more time had been available and I am confident that the report as submitted is a sound and firm basis for long overdue action: to reduce environmental noise, and aircraft noise in particular, to protect public health and welfare.

SUMMARY OF SELECTED ISSUES RAISED BY THE POSITION PAPERS
ON TASK GROUP #3 REPORT

		ISSUES			
		L_{dn}	A-weighting	Immediate Goal $L_{dn} < 80$ dB	Long-Range Goal $L_{dn} < 60$ dB
1.	Shaw (ASA)	Satisfactory	Satisfactory	Satisfactory	60 dB Satisfactory 50 dB Suggested
2.	Janssen (EDF)	Satisfactory	Satisfactory, Preferred D-weighting	Did Not Disagree	Suggested 55 dB
3.	Cook (NIH)	Satisfactory	Satisfactory, Preferred D-weighting	Satisfactory With Qualifications	Suggested 55 to 60 dB
4.	Martin (AIAA)	Did Not Disagree	Did Not Disagree	Available Data Not Adequate To Support Recommended Goal. No Analysis Of Economic Impact Made.	Available Data Not Adequate To Support Recommended Goal. No Analysis Of Economic Impact Made.
5.	Becker (ATA)	Did Not Disagree	Did Not Disagree	Same as 4.	Same as 4.
6.	Reilly (AOCI)	Satisfactory	Satisfactory	Same as 4.	Same as 4.
7.	Moore (LA Airports)	Did Not Disagree	Did Not Disagree	Same as 4.	Same as 4.
8.	Tyler (NOISE)	Satisfactory	Satisfactory	Did Not Disagree	Satisfactory
9.	Blumenthal (Boeing)	Not Satisfactory, More Research Rqd	Did Not Disagree	No Economic Impact	No Economic Impact

ISSUES

		L_{dn}	A-weighting	Immediate Goal $L_{dn} < 80$ dB	Long-Range Goal $L_{dn} < 60$ dB
10.	GAMA	Satisfactory	Satisfactory	Satisfactory Provided Economic Impact Assessed	Did Not Disagree
11.	Ingard (INCE)	Satisfactory	Satisfactory	Satisfactory	Satisfactory
12.	Gales (ASA)	Satisfactory	Satisfactory	Satisfactory	Satisfactory
13.	Graves (HUD)	Satisfactory	Satisfactory	Satisfactory With Some Qualifications	Satisfactory
14.	Bennin (City of New York)	Satisfactory	Satisfactory	Satisfactory	Satisfactory
15.	Dept. of Commerce	Satisfactory	Satisfactory	Did Not Disagree Economic Impact Must Be Assessed With Respect To Public Welfare	Did Not Disagree Economic Impact Must Be Assessed With Respect To Public Welfare
16.	McPike (Douglas Aircraft Co.)	Satisfactory	Satisfactory	Satisfactory, But Qualifications Both Ways	Did Not Disagree

ACOUSTICAL·SOCIETY·OF·AMERICA

EDGAR A. G. SHAW
PRESIDENT

DIVISION OF PHYSICS
NATIONAL RESEARCH COUNCIL OF CANADA
OTTAWA, ONTARIO, CANADA KIAOSI
(613) 993-2840

June 30, 1973

Dr. Alvin F. Meyer, Jr.
Deputy Assistant Administrator
for Noise Control Programs
United States Environmental Protection Agency
Washington, D. C. 20460
U. S. A.

Dear Dr. Meyer,

Further to my letter of June 29, I have now read the report of Task Group 3 (Aircraft/Airport Noise Study) dated 1st June, 1973. It is, in my opinion, an excellent report for which Dr. Henning von Gierke and the other members of the Group deserve a great deal of credit, particularly in view of the very limited period of time they were given to complete their task.

The decision of the Group to adopt a simple universal measure to characterize human noise exposure is, I believe, a wise one. Moreover, the day-night average sound level Ldn based on average energy seems to be the optimum choice in the light of the available scientific evidence and the practical requirements. As indicated in Conclusion 8 (page III - 4-4), the secondary problems such as the pure tone components of noise can be dealt with separately in emission control standards and land use planning measures.

The key phrase "protection of the public health and welfare" is clearly open to many interpretations. The Task Group has very properly focussed its attention on the issues for which a substantial measure of scientific consensus can be found: the prevention of significant permanent noise induced hearing loss, the limitation of annoyance, and the maintenance of acceptable conditions for speech communication.

"To protect the public against the risk of permanent noise induced hearing loss, with adequate margin of safety", the Task Group recommends that "a yearly outdoor day-night average sound level of 80 dB should, as soon as possible, be promulgated as the permissible limit with respect to health alone" (page III-4-5). This recommended limit is, of course, conservative

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by comparison with the standards which have recently been set for occupational noise exposure. At the same time it implies acceptance of a small but measurable hearing loss in the most sensitive 10% of the population over a 40 year period. The adoption of a limit 5 dB lower (i.e. L_{dn}=75 dB) would provide more complete protection for this sensitive minority. It should also be noted that some recent scientific studies tend to support a more cautious position.

In Recommendation 6(p. III-4-6) a yearly day-night average sound level of 60 dB is proposed as the long range limit of the EPA for environmental noise quality in residential areas with respect to health and welfare. This limit, when reached, will undoubtedly provide a large measure of relief to the several millions of people who are at present subjected to levels 10-20 dB higher than this limit. However, according to Fig. III-IV-3, which is based on large scale surveys in the U.S. and Britain, approximately 23% of the population will remain highly annoyed at L_{dn}=60 dB. The fraction highly annoyed could be reduced to 18% by adopting a limit of 55 dB. In any case L_{dn}= 60dB hardly seems appropriate as a standard for residential areas to be built in the future. So, it would seem appropriate to adopt stronger language in the second part of Recommendation 6. In fact, it might be desirable to recommend that L_{dn} not be allowed to increase beyond 50 dB unless a compelling public interest can be shown to require it.

Finally, it should be noted that a recent Scandinavian study (R. Rylander, S. Sorensen and A. Kajland, J. Sound and Vibration 24, 419-444, 1972) indicates that the percentage of persons highly annoyed by aircraft noise is essentially independent of the number of aircraft take-offs once this number exceeds about 60 per day. For such high exposure areas the percentage of persons highly annoyed varies linearly with the peak level over the range 70-95 dBA. This finding, if it should be confirmed, would strongly reinforce the need to reduce aircraft noise levels.

I trust these comments will prove helpful. You should also be receiving independent comments from another member of the Acoustical Society Special Committee, Dr. Robert S. Gales.

Yours sincerely,

Edgar A. G. Shaw

Edgar A. G. Shaw

SPECIAL

ENVIRONMENTAL
DEFENSE
FUND

1525 18th
XXXXX STREET, N.W., WASHINGTON, D.C. 20036/202 833-1485

June 26, 1973

Mr. Alvin F. Meyer, Director
Office of Noise Abatement and Control
Environmental Protection Agency
1921 Jefferson Davis Highway
Arlington, Virginia

Dear Mr. Meyer:

The Environmental Defense Fund is pleased to have been given the opportunity to participate in the drafting of the report of Task Group 3, "Impact Characterization of Noise Including Implications of Identifying and Achieving Levels of Cumulative Noise Exposure." It was a pleasure to work with so competent and effective a chairman as Dr. von Gierke, whose straightforward direction and open mind account for the productivity of so diverse a representation. We sincerely hope for the implementation of the Report's recommendations, although we wish to voice a few reservations.

EDF fully supports the use of the A-weighted decibel as the basis for the L_{DN}, and the recommendation for future consideration of the D-scale at such time as that has become standardized. We are in complete agreement that, at this time, the A-scale is the only weighting scheme which satisfies the criteria of meaningfulness, in terms of human response, and monitoribility. However, it is also true that the A-scale has certain deficiencies. The text of the Report takes account of these deficiencies, but it is our opinion that they are not adequately spelled out in the "Conclusions and Recommendations" section at the end of the Report. Conclusion No. 8 is addressed to pure-tone components and the lack of penalty for these in the A-weighting system, but there is no mention at this point of either the A-scale's leniency with regard to low frequencies, or of its inadequacy with regard to impulsive noise. Because of the aversiveness of both impulsive noises and of low-frequency emissions from certain sources, such as trucks, it is our feeling that this point needs to be mentioned in the conclusions. It is further suggested that the certification procedures referred to in the text for sources inadequately described by use of the A-scale be made explicit in the form of a recommendation.

A further, and more substantive, comment relates to the stated goal of 60 L_{DN}. We suggest that 60 L_{DN} be an intermediate goal, and that 55 L_{DN} is a more suitable long range goal. We submit that a solution which leaves 23% of the noise-exposed population highly annoyed (which would be the case at a level of 60 L_{DN}) is inadequate. The Report states in the section on "General Health Effects of Noise" that "it does not appear that anything would be gained by setting the goal for day/night average sound level lower than 60 db." Fig. III-3-2, on the other hand, indicates that attainment of a 55 L_{DN} goal would result in a reduction of the numbers of those highly annoyed by about 5%, which is hardly negligible. It appears that unduly heavy reliance may have been placed upon the seemingly low complaint figure of 2%. However, it must be pointed out that complaint figures, while convenient, are inadequate descriptors of the effects of noise on people. Complaint rates are known to be correlated with such irrelevant factors as socio-economic status, and it is quite conceivable that, as the public consciousness about noise rises, complaint rates may rise appreciably. As to the question of economic feasibility, the report declines to indicate a time schedule for implementation, and a time schedule for attainment of an L_{DN} of 55 may as easily be based on the detailed economic and technological feasibility studies referred to in Recommendation No. 7.

Of further concern is the problem of environmental degradation and the probability that the goal, as stated, may constitute a "license to pollute." We feel quite strongly that there is the need for a specific recommendation in the report with regard to this matter, particularly in light of EPA's mandate, under Sec. 5(a)(2) of the Act, to state by next October 27 "the levels of environmental noise...requisite to protect the public health and welfare with an adequate margin of safety." (Emphasis added.) The L_{DN} goal does not provide this margin, and, therefore, where levels of noise exist which are sufficiently low in these terms, they must not be allowed to rise to a point at which this margin no longer exists.

It has been argued by some of the report's detractors that science simply does not know precisely what the effects of noise on human health are and that therefore no permissible dose levels may be recommended at this time. It is the position of the Environmental Defense Fund, as a public law and science organization, that in an area such as this one, where enough evidence has accumulated that some conclusions may be drawn, it is the scientist's responsibility to urge action on the basis of this information. To put off a decision for the years required to eliminate doubts from everyone's mind constitutes an immoral and irresponsible decision not to act in the public interest. This Task Group Report indicates that the time has finally come when scientists specializing in noise effects will use their knowledge for the protection of the public. We sincerely hope that the recommendations of the Task Group will be effectively acted upon and that relief may finally be gained for the noise-exposed segments of our population. Similarly, we hope that modifications in the L_{DN} goals will be made as indicated by future research.

Sincerely yours,

Raelyn Janssen
Staff Scientist

cc: Dr. Henning von Gierke

DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
PUBLIC HEALTH SERVICE
NATIONAL INSTITUTES OF HEALTH

NATIONAL INSTITUTE OF
ENVIRONMENTAL HEALTH SCIENCES
P.O. BOX 12233
RESEARCH TRIANGLE PARK, N.C. 27709

June 28, 1973

Dr. H. E. von Gierke
Chairman, Task Group 3
Aircraft/Airport Noise Impact Characterization
6570 ANRL/BB
Wright Patterson AFB, Ohio 45433

Dear Sir:

It has been a pleasure to serve on Task Group 3---Airport/Aircraft Noise Impact Characterization analysis.

The problems for which the task group was charged with finding practical solutions are very complex, and many areas admit of disagreement between reasonable men, but one thing was clear: reaching a consensus and moving forward on the basis of the best information is so urgent that we must not let less than perfect data or disagreement over part(s) block essential agreement on the whole.

The consequential conclusions of task group 3, which I share, are as follows: Environmental or community noise exposure must be viewed and measured in terms of what reaches an individual's ear, from all sources, summed over a reasonable time period; with a physical descriptor which is simple, economical, practical, applicable to all kinds of noise intrusions, and accurate within the requirements of community noise.

It quickly became apparent that the extraordinary diversity and complexity of community noise precluded its being completely characterized (in terms of human adverse reaction) by methodology which met the tests of simplicity, practicality, and economic feasibility. It is to the task group's credit that it formally recognized that the simple frequency weighting (dBA), energy summing methodology chosen cannot well account for human physiological/psychological response to pure tone components, pulsations, impulses and other deviations from fairly broad, uniform sounds, and as a result, would have to be complemented by more sophisticated source emission characterization methodologies for major contributors to community noise. This methodology already exists for aircraft. Aircraft noise because of its mid-frequency and pure tone sound emission characteristics, has been found to be best related to human adverse response when described by the E PNdB methodology now codified in FAR part 36. (This E PNdB methodology attempts to account for the fact that growth of loudness or adverse reaction is a function of bandwidth as well as the frequency response of the ear and presence or absence of pure tones.) It is the writer's feeling that the degree of success of this dBA community noise descriptor hinges upon the rapid establishment by EPA of more accurate source characterization methods for the other major sources of community noise, specifically but not limited to, truck noise.

A second value judgment of extreme importance made by the task force concerns adoption of the rule of 3 dB for doubling of exposure time (equal energy) to handle the intensity-duration tradeoff. In defense of this rule, proponents pointed out that equal energy is conservative for hearing loss. On the negative side, it appears to put "minimum distance" between exposure lengths relative to annoyance, i.e. 80 dBA for 8 hours would be considered equal to 83 for 4 hours, and 0 for the remaining 4. Given a choice, the great majority of people would opt for the 83 dBA, 4 hour exposure. However, community noise except in rare instances has a fairly continuous character, and no one had any data from the real world saying that a 5dB or 6 dB magnitude tradeoff per doubling of time was any better than 3 dB. Neither was there any data which definitely indicated anything better than a 10 dB nightime tradeoff. So, in general, I fully support the approach of the task force as expressed in the first draft, along with the goal of an L_{dn} of 55-60 dBA, provided EPA follows through with developing and implementing specific source emission descriptors for major sources whose emission characteristics deviate (by containing strong pure tones, pulsations, impulses, etc.) from fairly steady state, broad spectrum character.

Again, the statistics, (page III 3-14), indicating that at an L_{dn} of 60 dBA, 23% of persons find themselves "highly annoyed" with the noise, are disturbing. If these prove to be credible statistics, reflecting real conditions, e.g. real rather than "displaced" annoyance, then the long range goal of the EPA may have to be revised downward.

In connection with these recommended levels, the draft document contains no mention of non degradation of present environmental noise levels. Without attention to this point in the report, the layman might conclude that the 80 dBA L_{dn} to be recommended as an initial limit was "sanctioned" by EPA as not being detrimental to health and welfare, when in fact it was chosen to avoid widespread economic dislocations relative to existing sources and should not be considered acceptable as a limit to which new sources might be permitted to raise community noise levels.

At the combined task force meeting on June 21--22,some speakers from other task forces made statements to the effect that they interpreted the task group 3 report as saying that health effects from chronic noise exposure did not occur below levels sufficient to cause hearing loss. Upon re-reading the relevant pages (III 3-14, III 3-15) carefully, I find that the report does now appear to embrace this view, but gives little attention to an issue of such significance. It quotes and accepts the judgment of the author of a recent critical review who says that, "if noise control sufficient to protect persons from ear damage and hearing loss were instituted, then it is highly unlikely that the noises of lower level and duration resulting from this effort could directly induce non-auditory disease." I would point out that scientific opinion is by no means unanimous on the issue of non-auditory effects at this level and other authors could have been found (or quoted) who would be considerably more cautious in assessing the potential for long term deleterious health effects. With respect to noise induced sleep loss, which is one such non-auditory effect occuring in noise environments incapable of producing hearing loss, it is clear that the medical profession certainly thinks that chronic loss of sleep has deleterious health effects, judging from the number of sleeping pills prescribed. Furthermore, to exonerate noise as a health affector on the basis on non-production of classic disease symptoms is begging the issue by oversimplification. No one has suggested that noise directly (immediately) causes certain diseases. What has been suggested, is that continuing noise exposure may be capable of producing a chronic stress syndrome in some individuals, with consequent elevated endocrine levels leading to deteriorative changes occuring over time. And, for what it's worth, the results of animal experiments conclusively demonstrate the presence of major non-auditory effects. One point is clear, however: more well controlled research is needed to clearly delineate the potential of chronic noise exposure for inducing long range deteriorative health effects.

In the spirit of telling it like it is, we fully realize and are in accord with the fact that the EPA must make some very difficult cost-benefit decisions which must withstand testing in the political arena. We submit that it would be untenable,however, to say or imply, as part of the justification for the level chosen, that no health effects occur below 80 L_{dn} or some figure or that some such level marks the demarcation line between "health effects" and "welfare effects."

Sincerely,

Reginald O. Cook
National Institute of Environmental
Health Sciences

AEROSPACE INDUSTRIES ASSOCIATION OF AMERICA, INC.

1725 DE SALES STREET, N W WASHINGTON, D C. 20036 TEL 347-2315

July 2, 1973

Dr. Alvin F. Meyer
Deputy Assistant Administrator for
Noise Control Program
Environmental Protection Agency
1921 Jefferson Davis Highway
Room 1115
Arlington, Virginia 20460

Dear Dr. Meyer:

At the invitation of the Administrator, Environmental Protection Agency, several AIA member companies participated in your Aircraft/Airport Noise Study. A study task force, divided into six study groups, has assisted in developing respective parts of the report required by the Noise Control Act of 1972. Because of the pace of task group activities and broad scope of information and data being assembled, it was not possible for AIA to develop and submit positions as the study progressed.

We are deeply concerned over the conduct of the study and desire to provide the following comments on this matter:

a. The total subject of aircraft noise control, including standards, retrofit or phaseout of existing aircraft, cumulative noise exposure, operating procedures and definition of health and welfare is exceedingly complex and involved. We are concerned that the five month period available did not allow sufficient time for EPA to assemble a team, let contracts, and accomplish the work necessary to complete the study in a entirely satisfactory manner. Furthermore, this short time made it impossible for the task group members to adequately analyze the findings of the contractors or comment on the work to date in any detail.

b. Because of the diverse backgrounds, expertise and interests of the task group members, little attempt was made to determine consensus or majority opinions on the multitude of questions discussed in the meetings. Many of the conclusions and recommendations developed by Task Group Chairmen were in fact not even covered in the meetings. Consequently, the final reports should not be represented as the conclusions and recommendations of the task groups. They are, more realistically, the opinions and individual views of the Task Group Chairmen which in some impo[illegible] [illegible]stances do not reflect the arguments and facts [illegible]sented by the members.

c. The AIA supports ef[illegible] to review the existing noise standards for new air[illegible]raft designs and to strengthen them. The successful intr[illegible]duction of resulting quieter aircraft into the fleet is critically dependent on Federal action to insure t[illegible]at these aircraft once certificated as complying [illegible]ith the applicable standards shall have the right to op[illegible]rate at all airports, where they meet airworthiness requirements. It is essential that airport operators be preempted from prescribing restrictions which would prevent such certificated aircraft from operating at their airports. The necessity for federal preemptions does not conflict with the use of noise abatement operating procedures. However, it is essential that the operational procedures and required aircraft equipment be FAA prescribed for reasons of safety of operation, pilot training and equipment interchangeability. Any other course which permits individual airport authorities to specify unique requirements will lead to chaos and will be counterproductive to the intent of Public Law 92-574.

d. In general, we find that the cost analysis approach taken by EPA was inadequate. For example, the cost analysis on curfews would suggest that night time curfews offer a very efficient means of reducing noise exposure areas on per dollar cost basis. In fact, the adverse economic impact resulting from disruption to overseas travel and from aircraft being other than where needed for the following day's flights would be severe and was not properly considered. Another example is in the case of land use studies where more factual data is needed in place of oversimplified extrapolations. We are convinced that the economic analyses must be completely re-examined before any meaningful conclusions can be drawn.

e. While AIA is not in a position to disagree with the general approach taken to rate noise exposure using the dBA unit, we strongly question the selection of the specific values of 80 for hearing damage and 60 as the ultimate goal for annoyance or disturbance criteria in the L_{dn} scale. The data presented does not adequately substantiate the selection of these levels. The implication and impact of these limits is far reaching. Such limits require substantiation prior to their selection.

f. The FAA noise regulatory actions recommended by the Task Group Chairmen contain a number of elements with which AIA is not in agreement. These disagreements will be discussed at the time issue of subsequent regulatory notices.

The AIA recognizes the extent of the noise problem and the need for progress in alleviating its impact on the environment. We agree that regulations and procedures relating to operations and compatible land use are necessary to assist in reducing noise exposure. We also agree with the need for continued research to reduce noise at the source and provide operating procedures to reduce noise exposure for airport neighbors. We concur with the need to provide financing for research, equipment development, implementation of noise control measures, and land acquisition.

In closing, we do want to commend the EPA Task Group Chairmen for their diligent efforts under difficult circumstances. We urge your consideration of our concerns discussed above.

This letter revises AIA letter of May 25, 1973 to you. It is submitted in request to your appeal at the EPA hearings on June 20, 1973 at the Department of Commerce Auditorium, Washington, D. C. for all previous submittals made to EPA on the study subject be reviewed and revised not later than July 2, 1973. As reflected in our statement at the hearing on June 20, 1973, it is requested that this statement be included in the record of all study groups.

Very truly yours,

AEROSPACE TECHNICAL COUNCIL

Gene I. Martin
Associate Director
Civil Aircraft Technical Requirements

GIM:ssf

cc: John Schettino - EPA
EPA Task Group Chairmen (6)

Air Transport Association OF AMERICA

1709 New York Avenue, N.W.
Washington, D. C. 20006
Phone (202) 872-4000

July 2, 1973

Mr. John Schettino
Director - Aircraft/Airport Noise Study
Environmental Protection Agency
Crystal Mall Building No. 2, Rm. 1107
1921 Jefferson Davis Highway
Arlington, Virginia

Dear Mr. Schettino:

In line with Dr. Meyer's announcement at the EPA Conference on June 21 and 22, regarding the draft reports of the six Task Groups established to make the study required under Section 7(a) of the Noise Control Act of 1972, I hereby am forwarding my comments on the draft report of EPA Task Group 3. I request that this letter, and the attachments thereto, be included in the final report of the chairman of Task Group 3. My previous letters of May 10 and June 1 to Dr. von Gierke on the earlier draft can be disregarded for the purposes of the final report, as I recognize there have been a substantial number of minor as well as major changes in the second draft.

The comments contained in this letter, and the attachments to it, refer to the "Draft Report on Impact Characterization of Noise Including Implications of Identifying and Achieving Levels of Cumulative Noise Exposure," dated 1 June 1973.

I recommend that your final report indicate that this is the report of you, as chairman, and not a report of the Task Group, or even a consensus of the Task Group as there is still obvious large disagreements as to the contents of much of the report. In addition, particularly during the last committee meeting on May 11 it developed that there was little, if any, scientific support for the recommendations and conclusions of the draft report as much of the justifications cited throughout the report is based on hypotheses and theories, from which time has not permitted conclusions to be drawn. For example, I do not see agreement, supported by facts, regarding the cumulative noise exposure formula set forth in the report, or that an L_{dn} of 80 dBA is the appropriate limit to be prescribed. Certainly the Appendices A through D to the report do not support the conclusions. In addition, the recent International Congress on Noise as a Public Health Problem held in Dubrovnik, Yugoslavia verifies to me this same point, i.e., there is no agreement on the basis for the findings in the report. In other words, and it was pointed out time and time again at the Dubrovnik meeting, (a) there are great differences in opinion as to how cumulative noise exposure should be measured, if it should be used at all as a means of determining the effects of noise on the public health and welfare, (b) there is no conclusive knowledge as to the effect of noise exposure on humans, and (c) no agreement as to the actual level of peak noise or continuous noise which may or may not affect the public health and welfare. There is no agreement even as to what is "normal hearing," much less what hearing loss is normal, as opposed to induced hearing loss. I gather that the experts in the field, such as yourself, have been trying for 15 years or more to arrive at an agreement on cumulative noise exposure without success, and just because the U. S. Congress says that this must be done within a year's time, we must have such an agreed on formula. Whether that formula, or the noise exposure limits recommended, is possible or correct seems to be of secondary or little importance, notwithstanding the effect such limits would have on the industry of the country and the "health and welfare" of the nation.

Following along with the thought expressed in the previous paragraph, I specifically cannot see how we can establish firm noise level limits for "health and welfare" purposes when the great majority of studies referred to as the basis for the determination reached are full of assumptions, expectations, predictions, small statistical basis, approximations, estimations, probabilities, conceptions, proposals, etc. This too was verified for me by the presentations at Dubrovnik. As Mr. Robert D. Moran, Chairman of the U. S. Occupational Safety and Health Review Commission indicated at Dubrovnik, noise theories and hypotheses based on assumptions, etc., cannot be the basis for rules or regulations and enforcement proceedings that are expected to stand up before challenges in the courts. You may recall that, generally speaking, Mr. R. F. Higginson of the U.K. supported Mr. Moran's viewpoint. Enclosed is a copy of the paper Mr. Moran submitted at the Dubrovnik Conference. (Attachment I). It is requested that it be included in your final report.

I think it is necessary that whatever noise measurement standard is used, or whatever cumulative noise exposure formula is determined to be appropriate, must be workable for regulatory and enforcement purposes. The proposals set forth in the draft report do not fit these requirements. As one who has been associated with federal regulations in the aircraft safety field for a number of years, I see no possible way by which the recommendations in the draft report can be reflected in regulations or enforced in an environment where many noise sources (both peak and continuous) are creating the total noise exposure problem. Many industrial, residential, transportation, recreational, etc., noise sources would be governed by the proposal set forth in the draft report, because if the formula and the levels included in this report are to be effective they would have to apply to all noise sources. In many cases no single noise source would be prominent enough to create the noise exposure to be regulated.

This is particularly true when one takes into consideration that the report recommends that the noise exposure dose is to be related to each individual. Most individuals are moving from a residence noise level, via a transportation system (noisy), to a workday noise environment, and back to his residential noise level by, again, a noisy means of transportation. It is impossible to control the noise dosage without controlling (a) the kind of work the individual will do as related to the noise levels to which he is exposed, (b) how, and how long, he would be exposed to transportation noise while to and from work, (c) the noise exposure at his residence and (d) the noise level associated with his recreation activities.

Associated with this last comment must be the fact that EPA Task Group 3 is, in effect, establishing cumulative noise exposure levels with respect to the health and welfare of the public from all the noise sources of many industries, such as manufacturing plants (of all kinds), the railroads, the highway system, the automobile industry, the building construction industry, etc., and yet no representatives of these various industries and systems have been present in the discussions of the working group. In fact, I doubt that the various industries who will be concerned with Task Group 3's report are aware that the task group is working in an area that will radically affect the economic and technical well-being of their industry, and the nation at large.

In each of the five meetings of Task Group 3, the point has been brought up, in one form or another, that it was not possible in the time available to analyze the overall economic impact of reducing most human noise exposures in the U.S. to the maximum permissible levels indicated in the report. The report points out on page III-3-1 that the decision on maximum permissible noise levels involves "value judgements in the political, social, ethical and economic domain, beyond the responsibility of the Task Group." (Underlining supplied.) I feel it is quite wrong to attempt to prescribe noise level exposure limitations which will have great economic, technical and legal effect on the well-being of the industries throughout the nation and thus the well-being of the general public without knowing within a fair degree of certainty what the economic effects of such proposed exposure limits will be. I can assure you that the recommendations contained in the draft report, if they are adopted, could and will have disastrous effects on the aviation industry and the air transportation of the U. S.

One other general point, the draft report uses the term public health and welfare, to mean the health and welfare of people living near a noisy facility such as an airport, railway, highway interchange, manufacturing plant, etc. The point was developed by several members of the Task Group, including myself, that "public health and welfare" refers not only to such people. The health and welfare of the entire nation and the whole community served by an airport, a railway, a highway, etc. should be included by EPA in determining "what is necessary to protect the public health and welfare." You will recall that it was agreed that the Task Group could not possibly study the complete welfare question, or for that matter the public health question, adequately on the broad base that is necessary under the provisions of Section 611(c)(1) of the Federal Aviation Act of 1958, as amended by the Noise Control Act of 1972. There are several places throughout the paper where this omission is not recognized. In addition, EPA cannot disregard the need of transportation, be it airplane, bus, train, etc. or the need for the construction of buildings, subways, highways, etc. (during which excessive noise is produced), all of which is necessary for the public welfare and health of the whole population and the nation. We feel that it is very necessary that this report include the fact that the kind of study needed and referred to above, could not be accomplished because of lack of time.

I hope these points will be of some assistance to you. My detailed comments on the draft report dated June 1, 1973 are included as Attachment II.

Sincerely,

William B. Becker

William B. Becker
Asst. Vice President - Operations

Attachments

Copy to:
Dr. H. E. von Gierke - EPA Task Group 3 Chairman
Dr. A. F. Meyer, Jr. - EPA

WBB:lbh

The paper referenced by Mr. Becker as Attachment I, "Some Practical Aspects of Controlling Excessive Noise by Government Regulation", by Robert O. Moran, was not included in this report, but is being published in the proceedings of the EPA sponsored International Conference on "Public Health Aspects of Noise at Dubrovnik, Yugoslavia, May 1973.

Attachment II

July 2, 1973

Detailed Comments on Draft Report on "Impact Characterization of Noise Including Implications of Identifying and Achieving Levels of Cumulative Noise Exposure" - June 1, 1973 - EPA Task Group 3.

1. Page III-v, paragraph number 3 at the top of the page. I wish to point out as I did at the EPA Conference on June 21, 1973, that neither Task Group 3, or any of the other five Task Groups, conducting the studies determined "the implications of issuing Federal regulations establishing a standard method for characterizing the noise from aircraft/airport operations and of specifying maximum permissible levels for the protection of the public health and welfare."

2. Page III-v, first paragraph under APPROACH. As pointed out in my covering letter, this report in its final form should be that of the chairman of Task Group 3, as it does not represent conclusions and recommendations of the Task Group, or consensus of the members thereof.

3. Page III-v, paragraph number 2 at the bottom of the page. It is absolutely impossible to regulate a noise exposure dose for individuals and such a rule enforced. For example, the level received during an eight-hour working day by a foundry worker is far from that received by a salesman in a clothing store. In addition, the noise to which each is exposed during transportation to and from work will vary widely, even though their homes were next door to each other in a neighborhood where the noise level is acceptable. Unless we are to put restrictions on (a) the kind of work an individual will do, as related to the noise levels to which he is exposed, and (b) at the same time govern how he is transported to and from work, as well as (c) where he lives; there is simply no way to follow through with the concept outlined in this paragraph.

4. Page III-vi, paragraph 3. Same comment as in comment 3 above.

5. Page III-vi, paragraph 4. I certainly cannot agree that the urgency to characterize a cumulative noise exposure is such that substantiating research data and refinement should not be waited for. Premature cumulative measuring methods, and the establishing of unrealistic cumulative noise levels, will have a devastating effect on industry and the nation.

6. Page III-vi, paragraph 5. Strike the phrase "and need not" in the first line. We feel that the cumulative environmental noise exposure should be taken into account, even though practically we must recognize that it cannot be done. Taking these three words out will not reduce the effectiveness of the paragraph. With respect to the second and third sentences of this paragraph, I feel that the cumulative noise exposure should take into account one-time noise events, high instantaneous peak values, etc. I know that it makes it more difficult to establish an acceptable cumulative noise exposure standard, but we cannot disregard these noises, and the regulation of the noise source will not otherwise be effective many times. As to the rest of the paragraph, I feel that there should be one measurement standard for the purpose of rulemaking, and enforcement, etc. There can and should be only one unit of measurement for all noise sources, be it aircraft noise, chain-saws, air-conditioners, etc. At least in the airline industry we cannot be regulated for emission purposes by one measurement unit and have operating regulations and enforcement thereof under another unit.

Regarding the last two paragraphs of Paragraph 5, I don't think either is a true statement. I don't recall any consensus of agreement on the approach and contents of Sections II or III.

7. Page III-vii. Last paragraph on the page. I do not concur that the overall economic impact of achieving the noise levels prescribed in the report was gone into in any depth whatsoever. Nor do the reportsof Task Groups 1, 2, 4 and 5 provide any clues as to the economic impact of the cumulative noise level methodology and the levels prescribed, particularly with respect to aviation, and even more particularly with respect to other noise sources. The last sentence starting on the bottom of this page indicates that a vote was taken as to the need for a goal for a maximum permissible exposure. There was no such vote, nor as far as I can recall agreement, particularly with respect to the L_{dn} levels prescribed further on in the report.

8. Page III-1-1, first paragraph. As noted in comment 1 above, the "implications of identifying and achieving levels of cumulative noise exposure around airports" are not provided by this report or the other five Task Group Reports.

9. Page III-1-1, paragraph 1. Do not believe that as of this point in time there is sufficient information available to provide the correlation needed.

10. Page III-1-1, paragraph 5. Suggest that this sentence be changed to read as follows: "The measure for airport noise should be the same as that currently used for noise from other sources." Again, I point out the necessity to use one unit of noise measurement for all purposes, i.e., noise source regulation, operating regulations, cumulative noise measurement, enforcement, etc. There should be no special application measure for aviation noise regulation or enforcement.

11. Page III-1-1, paragraph 6. Considering all sources of the various noises be taken into consideration, predictability measurement of cumulative noise exposure is impossible because of the lack of knowledge of all noise causes and sources. This is particularly true insofar as aircraft engine noise is concerned. Very frankly we know comparatively little of the "physical events producing the noise" from aircraft engines. Aviation noise experts are just beginning a learning curve.

12. Page III-1-3, second full paragraph, last sentence. As mentioned earlier dBA should be used from an engineering noise control aspect. dBA should be used across the board.

13. Page III-1-4, third full paragraph. As stated earlier, FAR Part 36 which regulates noise emissions from aircraft engines should also use dBA.

14. Page III-1-6. Under the heading AVERAGE SOUND Level, last sentence, it is suggested that the daytime be defined as 0701 to 2300, and nighttime be defined as 2301 to 0700.

15. Page III-1-7 and III-1-8. Notwithstanding the explanation set forth in the appendices, the 10 db differences between night and day certainly hasn't been proven scientifically, or accepted internationally. In other words, to my unscientific mind, the 10 db penalty urged for application to the nighttime period is really based on opinion, not proven, and seems to be continually proposed on the basis that "if we say it often enough, it will become fact."

16. Page III-1-9. First five lines at the top of the page and the following paragraph. After the word "indoors" where it appears three times in these two paragraphs, insert the phrase "and in vehicles" and at the end of the fifth line at the top of the page add

the phrase "and vehicles." The point is, much time is spent by individuals throughout the United States inside vehicles such as buses, trains, automobiles, etc. going to and from their work and recreation, and noise is attenuated by these vehicles.

17. Page III-1-9. First full paragraph. Do not concur with the conclusion set forth in this paragraph, although it is an easy way around a difficult problem. We believe the application of these considerations should be included in L_{dn}.

18. Page III-1-9, second full paragraph. For the first time I notice the use of the word "estimated." Perhaps there have been other usages of this and similar words prior to this page, but this is the first I have noticed it. Frequently and entirely too frequently, throughout this draft paper, estimations, assumptions, approximations, and words of that order, are used, which give added credence to the concern expressed earlier that the basis upon which most of this report stands, including the resulting recommendations and conclusions; are not sound, and will not stand up against challenges which are bound to be made by various interested groups throughout the United States, both within and without the EPA, other government agencies, and surely by the Congress and the courts.

Approximations and assumptions cannot be the viable basis for the kinds of recommendations and conclusions set forth in Section V of this report.

19. Page III-1-9, third full paragraph, and chart at bottom of page. The word "approximately" appears in the paragraph as well as the abbreviated form in the chart. Also the word "typical" appears in the sentence immediately preceding the chart. The use of these words heightens the concern expressed in item 18 above.

20. Page III-1-10, paragraph 2. The sentence here contains a double negative and makes the thought which I believe to be expressed in the sentence quite erroneous. In addition, we do not believe the factors set forth here, or in paragraph 1, immediately preceding should be used by local jurisdications. Decisions of this nature have to be done on a national basis if we are to have a safe and effective national air transportation system.

21. Page III-1-10, last paragraph. Again the 10 decibel difference between daytime and nighttime is challenged and we recommend that "2200" in both places where it appears in the second sentence be changed to "2300"

22. Page III-1-11. Large paragraph in the middle of the page. I gather from several of the rather heated discussions at Dubrovnik that there is far from complete agreement on the method outlines here for measuring the accumulation of sound as it does not recognize appropriately temporary peak noises and the recovery from the effect of such peak noises on man. I gather, and I am not really qualified to discuss this point at all, that there is still much disagreement among experts in the field on the conclusions set forth in this paragraph.

23. Page III-2-1. Second full paragraph. At the end of this paragraph the point is made that there are "more elaborate computerized monitoring systems now coming in use at major airports." Though I am not too familiar with these systems, what knowledge I do have with respect to one system, i. e., that being installed at Los Angeles International Airport (and it is not yet usable after nearly two years of evaluation) does not record noise exposure from all sources. Because of the purpose of the LAX monitoring system, it only records noise above a certain specified level which is pre-set in the instrumentation. In other words, the LAX system does not record total cumulative levels from all sources.

24. Page III-2-4. Item 3. The phrase "aircraft acceleration effects" is not understood by me. Thus, it needs further explanation in the text.

25. Page III-2-4. Paragraph 6. Strike the phrase "busy-day" and insert the phrase "average-day." Why should the <u>worst</u> day be used in computing aircraft noise exposure.

26. Page III-2-4. Add the following paragraphs as 9, 10, 11, 12 and 13:

"9. Wind-rose data for runway involved.

"10. Aircraft operating weights on takeoff.

"11. From aircraft operator - the variations in flap, power setting and airspeed used in takeoff and landing.

"12. Runway gradient and runway surface, as related to aircraft model acceleration.

"13. Terrain (rise or fall) from airport surface level."

27. Page III-2-4. Second last line on page. Change the word "Differences" to "Major differences".

28. Page III-2-5. Eighth line from the top. I believe the phrase "$\pm$ 1 dB" will be quarreled with by experts in the field. It is suggested that the following phrase be substituted, "a few dB"

29. Page III-2-5. Paragraph in the middle of the page. I have difficulty with this paragraph because it deals with measuring L_{dn} levels and indicates that such measurements are preferable to predicted values. However, the first paragraph of this section indicates that we are only talking about predicted values as opposed to measured values. In other words, this paragraph does not "track" with the first paragraph in this section appearing at bottom of Page III-2-2.

30. Page III-2-6. First paragraph after the heading, add after the phrase "motor vehicle traffic", the following "factories, construction, etc."

31. Page III-2-6. First sentence last paragraph is not necessarily true. There are many cases where though an airport noise situation is "of interest", the dominant noise near the airport is not that of aircraft. Measurement of such noises as in the Georgetown area near Washington National Airport has proven this to be a fact. There are other cases as well.

32. Page III-3-1. First paragraph. The second sentence indicates that this section of the report is based on recent surveys of "scientific data" that will support EPA's criteria document. The scientific data that is alleged to support EPA's criteria cannot be found in the pages following in Section III-3. Several so-called studies which follow in Section III-3, are not based on factual provable information and are full of assumptions, expectations, predictions, small statistical basis, approximations, estimates, probabilities, hypothesis, and theories. The information is not specific enough to be interpretable for the purpose at arriving at a maximum permissible average level with respect to cumulative environmental noise exposure.

33. Page III-3-1. Second paragraph. After the word "responsibility" in the fourth line, add the phrase "and capability". In the last sentence of this paragraph it is indicated that the options available for setting the maximum permissible average sound level are restricted to a range of not more than 20 db, no matter how to challenge to avoid significant effects on health and welfare is interpreted. As stated in comment 32 above, the conclusion reached here is far from provable.

34. Page III-3-1. In the sentence starting at the bottom of this page and continuing on to the next, it is concluded that annoyance due to noise and interference with speech communication, should be interpreted as interference of the noise environment of public welfare according to the intent of the Noise Control Act. I assume this is a conclusion of the chairman, as it is not supported in the draft report. In addition I suggest places the definition of "health"set forth by the World Health Organization in the paper for ready reference.

35 Page III-3-2. First full paragraph. The phrase "reasonable to require" in the fourth line when associated with the phrase "these assumptions" in the third last line indicates the unscientific approach being used here. In addition, the second criteria referred to, i.e., "Economically feasible" is not supported by the study - see the second paragraph on the preceding page, i.e., III-3-1. In addition, the statement in paragraph number 2 which states "These levels can be enforced by relatively simple environmental noise monitoring systems" is not true. The Los Angeles noise monitoring system has been worked on for two years and it still is not functioning properly.

36. Page III-3-3. The sentence at the top of the page, and which commences on the preceding page, is one that contains the type of conclusion which we have commented on before. See comments 6, 10, 12 and 13.

37. Page III-3-3. First full paragraph. "Local authorities" should not have this authority, if we are to have a safe and efficient national air transportation system. Add to the end of the sentence ending this paragraph the following, "construction, manufacturing, etc."

38. Page III-3-3, Paragraph under "HEARING LOSS". The word "potential" as used here certainly indicates there has not been any proven permanent hearing loss documentation.

39. Page III-3-3. The word "assume" in the third line of the last paragraph is prominent and the word "generally" in the last line also is prominent.

40. Page III-3-4. Second full paragraph. No where do I see the conclusions reached and set forth in this paragraph, supported or justified.

A similar comment is made with respect to the paragraph under "INDIRECT EFFECT". Again, note the word "assuming" in the second sentence of this paragraph.

41. Page III-3-5. In the chart at the top of the page the "double asterisk" note indicates that one should "add 5 dB to the average sound level for intermittent noise such as that produced by aircraft operations." Who says so? Where is the justification?

42. Page III-3-5. Bottom of the page. The conclusion indicated by this paragraph does not relate properly or agree at all, as I see it, with the existing OSHA standards of a continuous 90 dBA limit for an 8-hour period.

43. Page III-3-6. The contents of Table III-3-2 at the top of the page lacks justification. The phrase "most likely" in the note is disturbingly prominent.

44. Page III-3-7. First full paragraph. Note the word "assumptions" and the phrase "might lead" in the second last sentence of this paragraph. In addition, the phrase "it is judged reasonable to recommend an L_{dn} of 55 dB as the maximum permissible yearly outdoor average sound level" (underscoring supplied), points up the fact that this recommendation is based on assumptions, expectations, and conjecture. In fact the whole paragraph is a hypothesis and not based on proven scientific data.

45. Page III-3-8. The first paragraph indicates that in "choosing suitable limits . . . it appears reasonable to limit . . ." Certainly such a choice is not based on scientific proven data.

46. Page III-3-8. Last paragraph. In the middle of the paragraph it is stated that "a reasonable criterion value . . . is 45 dB." The basis for choosing this level is highly questionable because of the lack of sufficient scientific supporting data. Also the word "assuming" at the beginning of the last sentence is prominent.

47. Page III-3-11. The first two sentences at the top of the page. I am disturbed by these two sentences because it indicates that the survey of respondents to questionnaires can result in correlation between annoyance and noise exposure. This might be true, but only if the survey questionnaires on the noise subject are appropriately worded and the subject properly approached and presented by the questionnaire. This certainly was not true in the Tracor Study. The questionnaire was 90 to 95 percent strictly "noise" oriented. Obviously this kind of questionnaire leaves the respondent to focus entirely on noise and be lead to focus entirely on the noise problem. The result can often be warped replies. Thus, correlation between annoyance and noise exposure cannot be made on the basis of such questionnaires. For the same reason I quarrel with the last sentence of the last paragraph on this page.

For the same reasons I am concerned with the last sentence of the first full paragraph on the page.

48. Page III-3-11, second full paragraph, second sentence. The phrase "seems reasonable" is prominent.

49. Page III-3-11. Regarding the third and fourth paragraphs, refer to comment 47 above. We are not familiar with the Heathrow Survey, but we are with the Tracor questionnaire. We, therefore, question the relationship between the number of complaints and the number of persons highly annoyed. If the Heathrow Survey questionnaires were anything like that used in the Tracor Study, the result of those two surveys are equally questionable.

50. Page III-3-13, second full paragraph. Reference is made to a "55-case study described in Appendix III-IV." I would submit that a 55-case study does not give a very sound statistical base from which sound conclusions can be reached.

51. Page III-3-14. In the last sentence starting on this page, it is recommended that exposures to levels below 80dB is considered acceptable. Apparently it gives 5 dB more protection then provided by the Occupational Safety and Health Administration Act of 1970. Why should the recommendation be more conservative than the OSHA standards, particularly, as there is lack of knowledge as to the acceptable levels at this time.

52. Page III-3-15, second full paragraph. Note the word "potential" in the first line of this paragraph.

53. Page III-3-15. The general tenor of this page leaves the impression that there is no clearly established noise levels which distrub sleep, yet a most conservative level is proposed without the benefit of real proof.

We are particularly distrubed by the fact that the recommendation that peak sound levels during nights be controlled by separate local noise ordinances. This would mean that every jurisdiction into which an airplane operated would be permitted to establish a peak sound level for night operations. It would be impossible for a national air transportation system to be operated under such conditions.

54. Page III-3-16. The 10 dB figure and 60 dBA figure set forth in this paragraph are questioned as not being based on provable facts. The phrase "will most likely cause no adverse effects" is prominent.

55. Page III-3-16. Second paragraph under "NATURAL INDOOR NOISE 'FLOOR'". Note the phrase "are considered representative." My question "Considered representative" by whom and on what basis?

56. Page III-3-17. Second paragraph. First line please note the phrase "it is reasonable to conclude". Where is the proof for such a conclusion.

57. Page III-3-17. Third paragraph. The phrases "a typical house" in the third line as related to the noise level "15 dB" in the fourth line, indicates the kind of non-specificity upon which sound rules cannot be based. In the second last sentence "expected to produce" appears. This again shows lack of a sound data upon which a rule must be written.

58. Page III-3-17. Fourth full paragraph. The phrase "It is concluded that" appears in the first line. Again where is the real proof for such a conclusion.

59. Page III-3-17. The phrase "preliminary estimate" in the fourth line is prominent.

60. Page III-3-18. Table III-3-6. In the first sentence of the table the words "Estimated Number of People" is prominent.

61. Page III-3-18. First full paragraph. Note the word "estimates" in the first line, third line, and fifth line.

62. Page III-3-19. Note the word "estimated" on the first line of the page and the phrase "may be the subject to risk of hearing damage' in the third line.

63. Page III-3-19. The last full paragraph on this page is full of questionable facts, estimations, and apparent conjecture. The information set forth here should not be used as a basis for recommendations to the Congress.

64. Page III-3-21. This page consists of Table III-3-7, and is a summary of many of the conclusions, estimates etc. previously discussed. We, therefore, question the validity of the information contained in this Table.

65. Page III-4-1. Paragraph 2. In line with previous comments, it is suggested that the following part of line 4 and 5 be eliminated: "it can be related to other more complicated methods in use for special applications as discussed in Appendix III-I."

66. Page III-4-2. In the fourth last line, it is suggested that the phrase "have a definite" be replaced with the word "may" and the word "on" be deleted.

    It is also recommended that the last full sentence in this paragraph be deleted for the reasons stated earlier, i. e., we need one and only one measure of aircraft noise for emissions, certification, enforcement, et al.

67. Page III-4-2. Paragraph 3. As mentioned in comment 2 above, it will be impossible to establish an average cumulative noise exposure for individuals. There is no regulatory method to apply a cumulative noise exposure limit to individuals and enforce the regulation.

68. Page III-4-2. Paragraph 4. As mentioned earlier we do not believe that this conclusion is based on sufficient facts to be viable. The same is true for conclusion No. 5 which follows.

69. Page III-4-3. The same is true of conclusion No. 6 on this page, and that of conclusion No. 7 which follows.

Continuing on top of Page III-4-4. Again, we point out the impossibility of continuing a national air transportation system with noise levels being controlled by local authorities.

70. Page III-4-4. Paragraph 8. As stated in previous comments, it is necessary to use one measure of noise. That should be dBA, and apply to all noise sources, emission rules, certification standards, enforcement procedures, etc.

71. Page III-4-4. Paragraph 9. This conclusion is not supported by scientific evidence, and certainly not by this draft report.

72. Page III-4-5. Paragraph 2. As stated in several comments above, the aircraft noise descriptor should be used for certification, emission rules, et al, in addition to those purposes set forth in this paragraph.

73. Page III-4-5. Paragraph 4. Again, we feel that the outside cumulative noise exposure level L_{dn} of 80 dBA, recommended here, is not supported by the facts available at this time. Therefore, we do not concur with this proposal.

74. Page III-4-5. Paragraph 5. For the reasons set forth in comments above, we do not concur with this recommendation. It is not based on scientifically supportable facts.

75. Page III-4-6. Paragraph 6. Again, for the reasons set forth in earlier comments, we do not concur with this recommendation. It is not based on scientifically supportable facts.

76. With respect to Appendices III-I, III-II, III-III and III-IV, our previous comments have effectively questioned the validity of these appendices as not being sufficiently based on scientifically provable facts, but on assumptions, approximations, etc.

July 2, 1973

Mr. Henning Von Gierke, Chairman
Task Group III
Aircraft/Airport Noise Report Study
Environmental Protection Agency
Room 1107
1921 Jefferson Davis Highway
Crystal Mall Building, No. 2
Arlington, Virginia

Dear Mr. Von Gierke:

Enclosed you will find a copy of the Airport Operators Council International's comments on the draft report of Task Group III of the Aircraft/Airport Noise Report Study.

Sincerely,

J. Donald Reilly
Executive Vice President

Enclosure

[illegible] 1700 K Street, Northwest Washington, D.C. 20006 Phone: (202) [illegible] 3270 [illegible]

TASK GROUP III

AOCI Comments On

Impact Characterization of Noise Including Implications of Identifying and Achieving Levels of Cumulative Noise Exposure

For

Environmental Protection Agency
Aircraft/Airport Noise Report Survey

There is no objection to the use of a time integrated dBA for single event measurement. There is also no objection to the L_{DN} methodology to quantify cumulative noise exposure. In the final analysis, it is a simplified CNEL measurement and is similar to the many other systems now in use.

Our quarrel is with the interpretations of the impact of the numbered contours generated by the methodology. There is a major objection to the use of the 80 L_{DN} level as a limit for health and the 60 L_{DN} level as a long range limit for health and welfare. These levels appear to have been selected as a judgement by the Task Group Chairman and the acoustical consultant to this group without sufficient back-up data or studies to support the recommendation. It also appears that studies such as the HEW Study of hearing around Los Angeles International Airport have been left out as they do not support these conclusions. There is also evidence in the Report that the levels were selected on the basis of data on an eight (8) hour steady work environment exposure rather than the peaking type of exposure from aircraft overflight. Abundant evidence exists that the effects of these two types of exposure on people are drastically different in toleration and auditory recovery capability. Presentations at the recent Dubrovnik conference clearly indicated that at this time there is insufficient data to establish limits for health and welfare purposes, therefore additional work is needed.

The impact of many recent court decisions regarding noise have also been ignored. These decisions are beginning to define a specific pattern that cannot be ignored if any proposed regulation is to stand up before court challenge.

While we have been told that EPA will not try to set tolerance levels at this time, nevertheless, the levels are in a published draft report. We state again that the levels are without adequate scientific foundation and before any levels are set, greater in-depth studies are required. Therefore, we recommend that any figures utilized by EPA in its final report to Congress be submitted with a caveat that no clear scientific data exists to substantiate use of the figures themselves or the application of the methodology for purposes proposed by the report.

VAN NUYS
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CLIFTON A. MOORE
GENERAL MANAGER

CITY OF LOS ANGELES
DEPARTMENT OF AIRPORTS
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TELEPHONE (213) 646-5252 · TELEX 65-3413

June 29, 1973

Mr. John C. Schettino
Aircraft/Airport Noise Study Task Force
Environmental Protection Agency
1921 Jefferson Davis Highway
Crystal Mall, Building No. 2
Alexandria, Virginia 20640

Dear John:

This is the final version of my letter to Dr. Alvin F. Meyer, Jr. I believe you had an earlier draft which was incorrect.

Cordially,

Clifton A. Moore
General Manager

CAM:ls

Enc.

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June 26, 1973

MEMORANDUM

TO: Dr. Alvin F. Meyer, Jr.
Deputy Assistant Administrator
for Noise Control Programs
Environmental Protection Agency

FROM: Clifton A. Moore
General Manager

SUBJECT: Comments -- Draft Reports, Task Groups -- Airport Noise

We have carefully reviewed the draft chapters of the task group reports on airport noise. These reports are to be used as inputs into EPA to aid in the preparation of the report to Congress required by Public Law 92-574.

In general, I do not have major problems with the recommendations as a whole; however, great care must be taken in the wording for feasibility, safety, timing and financing to be sure that the requirements of the Public Law for maximum safety and economic and technical feasibility are met. When consideration is given to L_{DN} limits for health and the L_{DN} limits as long range goals for health and welfare, great care must be taken in the language of the report that interprets the standard so as not to draw definite conclusions on health and welfare effects until many more studies are completed and more definitive data is compiled. The Environmental Acoustics--HEW study at LAX, as well as other studies around the country, cast considerable doubt as to the recommendations in the Draft No. 3 report of an L_{DN} 80 limit for health and the L_{DN} 60 limit for health and welfare. The Dubrovnik meeting papers for 1973 further support the need for more data.

Recommendation No. 1a of Task Group No. 1 (Legal) that the FAA would make the California State Standards of CNEL effective in California only is patently unfair to this state, is unacceptable, and in our opinion probably illegal. As with the L_{DN} numbers mentioned in the previous paragraph, more supporting data is needed for the impact numbers used in the California Standards. As you know, these standards are under attack in the courts with the ATA lawsuit and from all indications will probably be overturned. In lieu of this recommendation, I would like to suggest the following alternative: The LAX sound monitoring system is capable of being programmed to compute CNEL or L_{DN} measurements. As an experiment and in order to establish the effects of proposed national regulations on a major airport and the country, we would supply the data to EPA from the monitors in either impact system that is desired. This would give a comparison of the measured versus the calculated impacts and would permit an evaluation to be made of the overall land areas within the various impact contours. This would give valuable data that could be used along with other data in the selection of final numbers for health and welfare.

We strongly support a retrofit program for all non-Part 36 types of aircraft operating into our airport both foreign and domestic. The program must be programmed to be completed by the year 1980 or before. The Fleet Noise Rule (FNL) staging of the program is acceptable for managing the program and setting the timing of compliance. In this manner, all aircraft will meet or better the Part 36 noise limits by 1980.

Financing of the retrofit program must become a part of the rule-making procedure. We have long advocated a one to two dollar charge per airline ticket and a small percentage to be added to each airfreight waybill as a means of financing the program. The charge is the least expensive way (insofar as the user is concerned) of paying the cost and should be dropped when retrofit is complete. This grant to the airlines should not be taken into the airline accounting system and should not be capitalized.

In line with financing noise costs, the ADAP funding to airports should be changed to permit the acquisition of land and/or easements for noise purposes under the program. Land acquired for noise is just as important to the airport as land acquired for approach lights or other facilities.

We strongly support changes in flight procedures that reduce flight sound levels provided there is no reduction in safety or operational minimums for the airport. The two segment approach, the flap managed approach, and the development of two departure profiles seems to be approaching acceptability under this criteria as a result of flight tests. When proven they should be mandated. However, such regulations must be issued by the FAA.

In the matter of flight procedures, it should be made very clear that this is an area where the airport owner cannot dictate policy. There are safety, liability and expertise reasons why the airport cannot become involved in the flight techniques of aircraft. While we obviously will coordinate completely with the FAA and the airlines in developing flight procedures and pointing out problem areas around our airports, the procedures must be flight tested and specified by the FAA.

The Task No. 3 effort to develop a single event measurement system and a cumulative noise exposure impact methodology is generally acceptable. Obviously, more detailed study is needed. We would suggest that there be only one health and welfare number and that this number be selected only on a preliminary basis subject to evaluation and confirmation pending definitive field studies around noise sources to determine areas involved and additional scientific studies of the effects of various cumulative levels.

Airport certification for noise would be a problem with present procedures. Noise certification can only be contingent upon the full completion of the retrofit program to Part 36 or better standards. A staged approach to certification could be acceptable if full compliance is not required until after the tools are available to meet certification requirements such as retrofit, flight procedures, funding of programs, and also rights and obligations of both FAA, as well as proprietor are more clearly defined.

I trust that these comments will be helpful to you. If I can be of further assistance, please call me.

Clifton A. Moore
General Manager

CAM:BJL:sm

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National Organization to Insure a Sound-controlled Environment

Dr. Henning Von Gierke, Chairman
Task Group 3
Aircraft/Airport Noise Study Report
U.S. Environmental Protection Agency
Building 2, Crystal Mall
Arlington, Virginia 20460

June 30, 1973

Dear Dr. Von Gierke:

I have attended all of the meetings of Task Group 3 and have reviewed the Draft Report on "Impact Characterization of Noise Including Implications of Identifying and Achieving Levels of Cumulative Noise Exposure". I have been familiar with and participated in the reasearch in this field for many years. Our organization presents the following as our position on this subject:

1. Since the research in the field of human reaction to noise overwhelmingly indicates that humans react to cumulative noise exposure we support the use of a cumulative noise scale.
2. We support the use of noise energy as the basis for cumulative noise exposure.
3. We support the use of a 10 dB higher weighting of noise during the sleeping period (2200 to 0700) than during the daytime.
4. We support the use of L_{dn} = 60 as the criterion for outdoor noise in single family residential areas.

While we recognize that the setting of a criterion or standard of L_{dn} = 60 will not mean that the noise in all residential areas will be reduced to this level immediately we believe that it is well to have this criterion established now and to start work to bring noise in residential areas down to this level as soon as possible.

Sincerely,

John M Tyler

John M. Tyler, Executive Director

COMMERCIAL AIRPLANE COMPANY
P.O. Box 3707 Seattle, Washington 98124

June 29, 1973
6-7270-1-443

Dr. Henning E. von Gierke
Office of Noise Abatement and Control
Environmental Protection Agency
Washington, D. C. 20460

Subject: Boeing Commercial Airplane Company Position on Task Group 3, "Impact Characterization of Noise Including Implications of Identifying and Achieving Levels of Cumulative Noise Exposure."

References:

1) Boeing Letter 6-7270-1-442, V. L. Blumenthal to R. L. Hurlburt.

2) Boeing Letter 6-7270-1-444, V. L. Blumenthal to W. C. Sperry.

3) Boeing Letter 6-7270-1-445, V. L. Blumenthal to W. C. Sperry.

Dear Dr. von Gierke:

In response to the request made by Mr. John C. Schettino in his letter of June 25, 1973, the Boeing Commercial Airplane Company wishes to include only this letter in the final report of Task Group 3. Therefore our Task Group 3 letters of April 2, 1973, and May 24, 1973, should not be included. References 1, 2 and 3 contain our position letters for Task Groups 2, 4 and 5.

In some of the Task Group draft reports it clearly states that the conclusions and recommendations are the responsibility of the chairman. We endorse this position and agree with it completely as being the only reasonable and fair manner in which such reports could be written. Because of the variety of opinions espoused in the Group discussions, and because generally no formal attempt was made to obtain a consensus, we would suggest that any inference of unanimity of opinion be expurgated.

A DIVISION OF THE BOEING COMPANY

Dr. Henning E. von Gierke 6-7270-1-443

We are deeply concerned about airport noise exposure and Group Three's objective of characterizing airport noise. We recognize the need for, and support the goal of, reducing aircraft noise exposure within airport communities. However, as discussed in our reference 2 letter, all recommendations leading to the formulation of noise standards must consider both the cost and the end result for which they are created.

The Boeing Company has encouraged and participated in the development of methods for rating human response to noise. Several noise rating scales have been developed in an effort to account for both the variability in individual response to a given noise, and the multitude of different sounds to which people are exposed. Community surveys have shown that noise alone is a poor indicator of annoyance. At present no subjective scale, including the new L_{dn} unit used in this report, can provide more than a crude estimate of community response to a complex sound. Such deficient scales are not suitable for making major decisions and could result in costly mistakes.

We believe that the method and responsibility for allocating noise reduction burdens or design objectives among various noise sources (autos, trucks, airplanes, construction, playgrounds, trains, etc.) which contribute to the cumulative noise level must be defined. Only in this way can a manufacturer determine the exact criterion by which his product should be designed in order to satisfy the established noise exposure limit.

Sufficient data are not available to provide definitive maximum values of noise exposure. The potential impact from the establishment of a maximum acceptable noise level that will protect the public health and welfare is so great that all facets must be understood. We suggest that a national research program to produce criteria which reflect the complex relationship between noise, the people's health and welfare, and the economic ramifications be vigorously pursued.

It has been our pleasure to participate in the Task Force effort and we feel these comments will be of value to the EPA.

Very truly yours,

BOEING COMMERCIAL
AIRPLANE COMPANY

Vaughn Blumenthal

V. L. Blumenthal
Director, Noise and Emission
Abatement Programs

General Aviation
Manufacturers Association

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GENERAL AVIATION MANUFACTURERS ASSOCIATION

COMMENTS ON THE

DRAFT REPORT
ON

IMPACT CHARACTERIZATION OF NOISE
INCLUDING IMPLICATIONS OF IDENTIFYING AND
ACHIEVING LEVLES OF CUMULATIVE NOISE EXPOSURE

FOR

ENVIRONMENTAL PROTECTION AGENCY
AIRCRAFT/AIRPORT NOISE REPORT STUDY

TASK GROUP 3

June 20, 1973

The General Aviation Manufacturers Association has been pleased to contribute to the work of Task Group 3. Specific comments on this report are as follows:

1. The unit L_{dn} appears to be reasonable and justifiable from a public health and welfare viewpoint. However, it is not clear how the unit would be used for establishing regulations. Indeed, an L_{dn} of 80 must be related to existing or pending aircraft noise regulations before the impact on the aviation industry is properly understood. In addition, as other noise sources exist around an airport, what preferences would be adopted in controlling the L_{dn} to a specific number? It would appear that a responsibility of Task Group 3 in characterizing a unit and an allowable magnitude would be to delineate how these recommendations could be used in a practical sense. GAMA expresses its concern in this regard and respectfully requests clarification from the EPA.

2. A considerable amount of work has been expended by GAMA, other industry associations, and U.S. and foreign governments, to formulate new ICAO/FAA regulations for general aviation aircraft. These pending regulations represent a sincere challenge in noise reduction and, indeed, tax the capabilities of the general aviation industry. GAMA requests clarification from the EPA on the specific relationship between its recommendations and the pending ICAO/FAA regulations.

3. If it is assumed that explicit answers to items (1) and (2) above are forthcoming, the questions arises as to the economic impact on the aviation industry, as a whole, resulting from the Task Group's recommendations. The economic impact has not been addressed, even superficially. GAMA recognizes that, in the time available to the task group, it would have been difficult to obtain the necessary information. However, GAMA believes it would be irresponsible to endorse recommendations without prior knowledge of the economic impact on the general aviation industry. Consequently, GAMA requests that the EPA furnish a clear picture of the economic impact resulting from the recommendations.

GAMA endorses the goals to control noise for the benefit of public health and welfare, and will cooperate fully in establishing responsible recommendations, consistent with the health of the general aviation industry.

INCE INSTITUTE OF NOISE CONTROL ENGINEERING

K. Uno Ingard, 1973 President
Room 20F-104
Mass. Inst. of Technology
Cambridge, MA 02139

2 July 1973

Mr. John Schettino
Environmental Protection Agency
Room 1107 - Bldg. 2
1921 Jefferson Davis Highway
Arlington, Virginia

Subject: Draft Report on "Impact Characterization of Noise Including Implications of Identifying and Achieving Levels of Cumulative Noise Exposure"

Dear Mr. Schettino:

On behalf of the Board of Directors of the Institute of Noise Control Engineering (INCE), I would like to extend our hearty endorsement of the principal accomplishments of Task Group 3 which are embodied in their report.

We find that the report contains an excellent and balanced summary of the principal human effects of noise.

We concur in the urgent national need for a single noise scale for cumulative noise exposure which can be applicable to noise from all origins, and we endorse the Task Group's selection of the Day-Night Average Sound Level for this purpose. This proposed measure of noise combines the best features of the several complex measures developed during the past two decades for assessing cumulative exposure to aircraft noise with the simplicity of the A-weighting which is utilized in the basic sound level meter to account for the frequency characteristics of a noise. We feel that the A-weighting is sufficient for cumulative outdoor environmental noise although more complex measures may be appropriate for source noise standards and engineering purposes. Furthermore, since A-weighting has been in common use over three decades, A-weighted sound level data are available for almost all noises; see, for example, the "Report to the President and Congress on Noise," Senate Document No. 92-63, 92d Congress, 2d Session, dated February 1972, Report of the Administrator of the Environmental Protection Agency in Compliance with Title IV of Public Law 91-604, The Clean Air Act Amendments of 1970.

We agree that it is essential to state a national goal for cumulative noise exposure to enable systematic progress toward necessary improvement of the noise environment. We endorse the report's recommendation that "... a yearly outdoor day-night average sound level of 80 decibels in residential areas should, as soon as possible, be promulgated as the permissible limit with respect to health alone." In addition, we concur with the recommendation that "A yearly outdoor day-night average sound level of 60 dB should be the long range limit of the EPA for environmental noise quality in residential areas with respect to health and welfare. ..." This recommended long-range limit is consistent with current knowledge.

Sincerely yours,

Uno Ingard

Uno Ingard
President, INCE

UI:CFS

DEPARTMENT OF THE NAVY
NAVAL UNDERSEA CENTER
SAN DIEGO, CALIFORNIA 92132

IN REPLY REFER TO:
401/RSG:mvg
2 July 1973

Dr. Alvin S. Meyer, Jr.
Deputy Ass't Administrator
for Noise Control Program
US Environmental Protection Agency
Washington, DC 20460

Dear Dr. Meyer:

I have been requested by Dr. Edgar Shaw, President of the Acoustical Society of America, to review and provide comments to you on the Draft Report of 1 June 1973 of Task Group 3 on "Impact Characterization of Noise Including Implications of Identifying and Achieving Levels of Cumulative Noise Exposure".

The short time available for review of the report precluded an in-depth study. I am, therefore, constrained to make my comments an overview of the general aspects and basic philosophies embodied in the report with particular emphasis on the conclusions and recommendations. My comments follow.

1. The basic requirement stated in Conclusion 1, the adoption of a common measure applicable to environmental noise from all types of sources is of critical importance, and the selection of Sound Level A for this measure is in accord with recommendations of Working Group S3-47 (S1) of the American National Standards Institute (ANSI). This group is assigned "Evaluation of Noise with Respect to Human Response", and its membership consists of the chairmen of all ANSI Working Groups dealing with noise which have a relationship to human response.

2. The use of L_{dn}, employing an energy-type integration of sound pressure squared and time is fundamentally sound, and is also in accord with recommendations of ANSI S3-47 (S1).

3. It must be recognized, as pointed out in the report, that the basic measures recommended have been shown to be useful predictors of first order effects on man. These primary effects are the ones which I believe are capable of being treated in the current time frame, and it is clear that timeliness of action is an essential part of the Noise Control Act of 1972. The report under discussion properly utilizes state of the art, and very appropriately identifies as secondary, such issues as tone corrections, improved weightings, etc. These are subjects worthy of research which may lead in the future to possible minor revisions of sound ratings, but are not of such importance as to warrant postponement of action.

01/RSG:mvg
2 July 1973

4. In adopting L_{dn} as the primary measure of exposure the information as to the time pattern of the sound is eliminated. The report properly notes that the time structure of a sound is often an important element in the human response (hearing loss, speech interference, annoyance, etc.). Research should be continued on this. In general, at least for speech interference and hearing loss the element of variance in the time pattern is probably such as to make L_{dn} a conservative measure as applied to aircraft noise. The areas of annoyance, sleep interference, and physiological effects (all of which are difficult to quantify) may be more critically dependent on specific time patterns of variability. The report quite properly points out that control of the intermittent and occasional noise of short duration may require measures other than L_{dn}. These might be maximum sound level, single event noise exposure level, etc. It is quite appropriate that these be embodied in local ordinances as stated on page III-3-15, particularly for comfort and sleep. This will need additional attention in the future.

5. I believe it is important that where the report speaks of "health" in the sense of dealing with hearing conservation, attention should also be given to the lesser known effects of noise on health, mediated through such physiological effects as heart rate, blood pressure, etc. This is dealt with briefly in the section <u>General Health Effects of Noise</u> on page III-3-14. The implication that if noise is held down to levels which protect hearing it is <u>unlikely</u> that other health effects will occur appears to be an over generalization. Although I know of no data to the contrary, it seems possible that patterns of fluctuating noise may exist which at L_{dn} not exceeding 80 dB might possibly produce adverse effects on the nervous and vascular systems. Again, I believe that this should not be used as an excuse to postpone action, but as a reminder to remain alert to future findings.

6. The limits proposed--L_{dn} 80 dB and 60 dB appear to be well-chosen compromises between ideal and practicable goals.

In summary, I believe the Task Force is to be commended for a timely document, well-conceived toward the objectives of the Noise Control Act of 1972.

Yours very truly,

R. S. Gales

R. S. GALES
HEAD, ACOUSTICS, BEHAVIOR &
COMMUNICATIONS DIVISION

Copy to:
John Schettino

DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT
WASHINGTON, D.C. 20410

ASSISTANT SECRETARY FOR
COMMUNITY PLANNING AND MANAGEMENT

JUN 29 1973

Mr. John C. Schettino
Director, Aircraft/Airport Noise Study
Office of Noise Abatement and Control
Environmental Protection Agency
Washington, D. C. 20460

Dear Mr. Schettino:

We would like to take this opportunity to express our general satisfaction with the work of EPA Task Force which was organized to provide recommendations for dealing with the aircraft/airport noise problems. Unfortunately, we were able to provide only limited assistance to three of the Task Groups due to staff shortages and other pressing assignments; however, I am enclosing our general observations and position on many of the preliminary recommendations of the Task Force.

We will continue to support the activities of the Environmental Protection Agency in the aircraft/airport noise program, and will be happy to provide whatever assistance we can to the EPA in this effort.

Sincerely,

Clifford W. Graves
Acting Assistant Secretary

Enclosure

Department of Housing and Urban Development

Comments on

RECOMMENDATIONS ON THE EPA TASK FORCE ON AIRCRAFT/AIRPORT NOISE PROBLEMS

A. HUD's ROLE IN NOISE ABATEMENT

It has long been HUD's policy to encourage the creation and maintenance of a quiet environment. To further this goal, HUD issued, on August 4, 1971, a policy Circular on "Noise Abatement and Control: Departmental Policy, Implementation Responsibilities and Standards." This policy was promulgated after several years of development, in an effort to fulfill the Department's mandate to "provide a decent home and a suitable living environment for every American family". With the issuance of this policy, HUD stated its conviction that "noise is a major source of environmental pollution which represents a threat to the serenity and quality of life in population centers." The policy formalized and expanded existing FHA noise regulations which had been in effect for many years, and drew upon the work of several other agencies and groups and on a long standing and developing body of knowledge in the area.

The policy establishes noise exposure policies and standards to be observed in the approval or disapproval of all HUD projects; it supersedes those portions of existing program regulations and guidance documents which have less demanding noise exposure requirements. Further, it is HUD's general policy to foster the creation of controls and standards for community noise abatement and control by general purpose agencies of State and local governments. HUD also requires that noise exposures and sources of noise be given adequate consideration as an integral part of urban environments in connection with all HUD programs which provide financial support to planning. The policy emphasizes the importance of compatible land use planning in relation to airports, other general modes of transportation, and other sources of high noise, and supports the use of planning funds to explore ways of reducing environmental noise to acceptable exposures by use of appropriate methods. Reconnaissance studies, and, where justifiable, studies in depth for noise control and abatement will be considered allowable costs.

Because HUD's noise standards are technically specific in nature, the Department has published "Noise Assessment Guidelines", a manual to provide HUD's personnel and the general public with a practical methodology for preliminary evaluation of noise levels at given project sites. An important facet of the Department's noise control activities is a continuing program of sponsored research into various aspects of the cause and effects of environmental noise. Typical of these is a series of Metropolitan Aircraft Noise Abatement Policy Studies, funded jointly by HUD and the Department of Transportation. This work was summarized and extended in the form of a guideline manual, to help localities plan community growth in the vicinity of airports. The manual discusses the costs, benefits and limitations of alternative methods of noise alleviation such as compatible land use development, zoning, and noise attenuation measures in building construction. Applicable to all type of airports, it will be used to develop procedures for dealing with a variety of local airport noise situations. It also contains relevant information on Federal and State programs to assist in achieving compatible airport-community development. The manual entitled "Aircraft Noise Impact: Planning Guidelines for Local Agencies," is now in printing by the Government Printing Office and will be given wide distribution.

B. HUD's POSITION ON ISSUES RELATED TO THE WORK OF THE TASK FORCE

1. Cumulative Noise Exposure

We believe that there is an urgent need to standardize a measure of noise exposure as a prerequisite to promulgating a national set of noise exposure standards and implementing procedures. We, therefore, strongly support the activities of Task Group 3. The lack of what might be called a "perfect" index of measure is no excuse for inaction on the growing problems of noise abatement and control. Our major concern is that any proposed aircraft noise assessment method be compatible with those now in use by this Department in implementing the HUD noise policy, i.e., Composite Noise Rating (CNR) or Noise Exposure Forecast (NEF).

We are in agreement with the long term goal of Ldn of 60 (NEF 25) recommended in the Task Group report, though we feel that further clarification is needed. Current HUD policy is to discourage residential development beyond 30 NEF (though some discretion is applied in certain cases where noise exposures lie between NEF 30 and 40). The NEF 30 value corresponds roughly to an Ldn of 65. Thus, the current allowable noise exposure for HUD assisted new residential construction is marginally higher than the long term goal recommended by the Task Group. However, we fully hope and anticipate that the EPA, with the cooperation of other Federal agencies and industry groups, will be successful in reducing noise through source and operational controls, so that noise reduction from these activities will bring current residential construction satisfying existing HUD criteria well within the long term objective (Ldn of 60). It is important to emphasize that since new construction represents the long term establishment of a given land use to a particular area, implementation of long term goals requires immediate action of the type HUD has been actively pursuing in the last two years.

We assume that the immediate goal of Ldn (45 NEF) of 80 is to be implemented through source and operations controls, building modifications, and where necessary, condemnation and relocation, and is to be applied to existing residential units. We fully support such a recommendation providing adequate relocation resources are available at a price the displacees can afford (pursuant to provisions of the Uniform Relocation Act).

We are concerned, however, that noise levels less than Ldn 80 may also constitute risks to health resulting from sleep interference, unless airports have stringent restrictions on night-time operations. The problem is exacerbated with windows open, as they must be in the summer months in many areas when adequate alternative ventilation is not available.

We support recommendation concerning a standardized computer program for calculating cumulative noise exposure. Further, there should be a standardized definition of data input requirements and a central data center which can generate contours of cumulative noise exposure for use by Federal, State and local agencies in making land use decisions.

2. Airport Noise Regulation

We would endorse the recommendations that airport operators exercise their authority to regulate aircraft operations to reduce noise in residential areas. The requirement that airport operators predict operations and noise exposure to determine compatibility of airport operations with the adjacent land uses and then take actions to achieve a larger measure of compatibility through reduction in the noise effective size of the airport is an important element in the total program to reduce airport-community conflicts. Decisions on runway alignment, airport expansion and volume and type of aircraft use are as essential to ameliorating and preventing noise conflicts as are the control of noise at the source and the control and guidance of land use development in the airport environs.

It is understood that the FAA has the authority for requiring airport certification under existing legislation. That agency should therefore be encouraged to take the necessary action to meet the EPA compliance schedule.

3. Continuing Program for Noise Abatement

We would concur in the need for a continuing Federal Program to assist in implementing a comprehensive national aircraft/airport noise abatement program. We would be happy to participate in those aspects of the program which are of interest and concern to the Department.

C. OTHER RELATED ISSUES

There are other problems that need to addressed to further goals of the air craft/airport noise abatement program; some of these are:

1. National Airport System Planning

A National Airport System Plan appears to offer a key to the problem of location and expansion of airports in the Nation, and a meaningful document can lessen the potentially adverse impacts of such development. The long range plan could identify the projected kinds and volume of operations at specific classes of airports so that there would not continue to be the many surprises which appear to develop fairly regularly following the creation of an airport or changes in operations at existing airports. Communities in the airport environs would then have an explicit idea of the kinds of airport development expected and could plan accordingly. The National Airports System Plan should have a rational national focus and not be only a compilation of airport projects conceived solely by state and local authorities.

2. Modification of Airport and Airway Development Act (AADA)

We believe that the AADA can be strengthened to insure a greater measure of compatibility between airports and their surrounding areas, as follows:

a) Aircraft noise is not specifically addressed in the law. In view of the growing concern with environmental quality and the impact of the airport development program, noise merits specific recognition. The law does not now support the acquisition of land to be exposed to severe levels of noise;consideration should therefore be given to modifying the statute to allow the acquisition of such land, by easement or fee simple, as part of the airport development project costs. Inclusion of such a provision to cover areas of very severe noise exposure is both desirable and necessary to any meaningful solution to the noise problem.

b) The rules promulgated by the FAA for implementing the Planning Grant Program under the AADA are not consistent with Section II of the Act. Airport systems planning should be an integral part of multi-modal transportation planning for the metropolitan area, and should be handled by the appropriate public comprehensive planning agency. Environmental considerations and airport location should be a significant part of the systems planning process rather than a token after-the-fact issue in airport master planning.

MCE
6/21/73

May 18, 1973

Dr. Henning Von Gierke
Chairman, Task Group 3
6570 AMRL (BB)
Wright Pattersen AFB
Ohio 45433

Dear Henning:

I have reviewed the Task Group 3 report and endorsed it fully. It was a rewarding experience to serve on your task group, and I feel confident that this effort will be a vital part of the program to control airport/aircraft noise.

To help with the final chapter report, I have annotated the pages of the draft report with specific comments. I regret that time did not permit me to go through the appendices in greater detail and make comments.

In addition to the comments made during the May 11 meeting with the other members of the Task Group, I am listing below some general points dealing with the report and the overall conclusions and recommendations.

1. The overall approach taken in the report to develop the cumulative noise exposure descriptor is good, and Ldn is an excellent method for characterizing this.

2. I fully support the maximum exposure level of 80 and the future goal level of 60. The report contains sufficient data to support these exposure levels.

3. While the conclusions are clearly spelled out and appropriate, they are long. Many of the supporting details are contained in the body of the report and need not be presented in the conclusions.

4. Conclusions should state that the Ldn lends itself to contouring in the same way that NEF does.

5. Establish a simple basis for comparison between Ldn and CNR, CNEL, NEf etc. This could be in the form of a table, graph, or nomograph.

I trust that my comments will be of help to you and I look forward to working with you further.

Best regards,

Robert S. Bennin
Director, Bureau of
Noise Abatement
City of New York

Enclosure

GENERAL COUNSEL OF THE DEPARTMENT OF COMMERCE
Washington, D.C. 20230

JUL 19 1973

Mr. John C. Schettino
Director, Aircraft/Airport Noise Study
Office of Noise Control Programs
United States Environmental Protection Agency
Washington, D. C. 20460

Dear Mr. Schettino:

This is in reply to your request for the views of this Department concerning the Environmental Protection Agency Aircraft/Airport Noise Report Study, 1 June 1973.

This study has been submitted for interagency review in draft form and organized into six Task Group reports. The study was undertaken pursuant to the legislative directive in section 7(a) of the Noise Control Act of 1972 (Public Law 92-574). The Act directs the Administrator to conduct a study of the

(1) adequacy of Federal Aviation Administration flight and operational noise controls;

(2) adequacy of noise emission standards on new and existing aircraft, together with recommendations on the retrofitting and phaseout of existing aircraft;

(3) implications of identifying and achieving levels of cumulative noise exposure around airports; and

(4) additional measures available to airport operators and local governments to control aircraft noise.

The functions of the six task groups were as follows:

(1) Consider legal and institutional aspects of aircraft and airport noise and the apportionment of authority between Federal, state and local governments.

(2) Consider aircraft and airport operations including, monitoring, enforcement, safety, and costs.

(3) Consider the characterization of the impact of airport community noise and to develop a cumulative noise exposure measure.

(4) Identify noise source abatement technology, including retrofit, and to conduct cost analyses.

(5) Review and analyze present and planned FAA noise regulatory actions and their consequences regarding aircraft and airport operations.

(6) Consider military aircraft and airport noise and opportunities for reduction of such noise without inhibition of military missions.

In order to assure that each task group report received the technical review appropriate, the reports were distributed throughout the Department for comment. The comments which follow are therefore prepared separately and in relation to individual reports.

Departmental Comment

The Department of Commerce has serious reservations about the adequacy of this study as a basis for aircraft/airport noise regulations.

In general, we would stress that as these reports will be used as the basis for EPA's initial proposed regulations of aircraft noise and sonic boom which proposed regulations EPA will submit to the FAA, we find the economic cost/benefit analysis extremely inadequate and strongly urge that a more detailed and technical analysis be undertaken prior to the development of the initial regulations. Specifically, we question whether the costs of compliance have been adequately weighed and whether the technological feasibility has been accurately measured, taking into account adequate safety factors.

We note also that section 7(b) of the Noise Control Act of 1972 requires EPA to submit such regulations "as EPA determines is necessary to protect the public health and welfare" (Emphasis added). This study does not deal directly with the subject of public health and welfare. Therefore, EPA still must establish that there is a need to protect public health and welfare from aircraft/airport noise. Only after having established that need, can EPA begin quantifying the amounts of noise reduction necessary to meet the health and welfare requirements.

Task Group I - Legal and Institutional Analysis of Aircraft and Airport Noise and Apportionment of Authority Between Federal, State and Local Governments

General Comments

The Task Group was charged with the following tasks:

1. Clearly setting forth the existing legal/institutional framework for aircraft/airport noise control, including all levels of government.

2. Identifying constraints and shortcomings of the existing legal/institutional system that may be impeding the implementation of available solutions.

3. Making recommendations for structuring of legal/institutional changes that would facilitate an accelerated and comprehensive solution of the aircraft/airport noise problem, both by actions within existing authorities and through legislative changes.

It would appear that the Task Group did a commendable and thorough job in tasks 1 and 2 above. It is obvious that in an area which impacts a major industry in several different ways, any recommendations tendered, i.e., task 3 above, will be controversial, however, the approach of the Task Group appears to be both workmanlike and well reasoned.

Specific Comments

1. Criterion I: Promote Adequate Consideration of All Relevant Factors; Factors to be Considered, #1 Effects of Noise on Public Health and Welfare, p. I-3-2

All the factors listed in subpoint (a) - direct health and welfare effects of noise - and subpoint (b) - economic and social impacts of noise - are negative ones. If the only effects to be considered are detrimental ones then obviously any conclusions reached will be negative.

It is our contention, and it has been generally recognized, that "public health" is limited to physical and mental well-being, while "public welfare" encompasses an extremely broad range of factors.

In relation to aircraft/airport noise, consideration of "public welfare" should include such factors as the economic benefits to our nation, its individuals, and business, of air transport and of aircraft manufacture. It should also include the convenience to individuals of air transport and local airports, and the economic advantage that location near an airport provides a town in attracting industry.

Factors such as those listed above should be included in the list of examples parenthesized in 1(b) so that a valid consideration and balancing of the effects of noise on "public welfare" can be reached.

2. <u>Comparison of the Present Legal/Institutional Scheme With Identified Criteria, p. I-4-2</u>

In its discussion of this matter, the Task Group points out that prior to the adoption of the Noise Control Act of 1972 amendment, §611 of the Federal Aviation Act did not contain the words "public health and welfare", but rather was aimed at providing relief from "unnecessary noise", which according to the Task Group, suggests "a focus on the issue of what level of noise can be abated in an economically reasonable and technologically practicable manner." The Task Group Report continues "/T/he 1968 Act did not explicitly require a consideration or balancing of the demands of public health and welfare for a quieter environment on the one hand <u>versus</u> the economic and technological feasibility of instituting abatement measures on the other."

The implication of this language, coupled with material which follows it on the next few pages of the Report, is that the Noise Control Act does require such a balancing of demands. We would vigorously disagree with the underlying assumption that "public welfare" is something separate and apart from economic and technological factors. We refer to our previous discussion (point 1) of "public welfare" and strongly urge this portion of the Report and any others wherein this inaccurate assumption appears, be redrafted. The concept of public welfare is in itself a balanced concept - to arrive at a definition of public welfare it is necessary to balance both beneficial and detrimental factors of the subject matter under consideration.

3. <u>Application of Noise Regulations to Foreign Aircraft Recommendation #5, p. I-6-12</u>

The Recommendation provides that:

". . . it is recommended that all U.S. regulations regarding aircraft noise be applied equally to all aircraft operating into U.S. airports. This includes rules of airport proprietors adopted pursuant to achievement of their implementation plans under the proposed airport noise regulation.

"Regarding the design of aircraft hardware, when adequate international standards are established (e.g., for retrofit, fleet noise levels or type certification) which are similar to or which have substantially equivalent effect to U.S. regulations, <u>it is recommended that the United States waive compliance with its rule to the extent foreign-owned aircraft comply with the international standard.</u> This is provided foreign governments similarly waive compliance with their noise standards for U.S. owned aircraft that comply with an equivalent American regulation. The purpose is to provide for [illegible] of equivalent measurement procedures, in which the result is substantially unchanged thereby."

We strongly endorse this recommendation.

Any exemption for foreign aircraft would have the effect of imposing a cost penalty upon United States air carriers engaged in international traffic. This would seriously affect the nation's carriers' ability to compete with their foreign competition carriers and impose a non-tariff trade barrier on this important industry which is already in an extremely precarious financial state.

Furthermore, any aircraft/airport noise regulations which are eventually promulgated would be effectively impeded in their ability to protect public health and welfare if foreign aircraft need not comply with those or equivalent noise standards.

Task Group II - Operations Analysis Including Monitoring, Enforcement, Safety, and Costs

Major Comments

1. The report is written clearly and is organized well. Its conclusions are explicitly attributed (p. II-v) to the EPA rather than to the task group per se, though the title page could make this clearer.

2. The text gives both sides of points in dispute. This is not quite as true in the sections on Conclusions (II-5) and Recommendations (II-6), which may be the only sections that people will examine. These sections should therefore refer the reader to the balanced discussion on II-4.

3. The Cost-Effectiveness conclusion (p. II-5-3) requires an assertion, nowhere made explicit, that the cost of noise is much nearer to \$100 (or more) per person, per year, than to \$10. This cost refers to persons in the "L_{dn} = 65 area." So crude an approach is clearly suspect--if a noise reduction procedure shifts Mr. A from the L_{dn} = 90 contour to L_{dn} = 20, and Mr. B from L_{dn} = 66 to L_{dn} = 64, these two events are "scored" the same, and there is no argument to indicate why such discrepancies might "average out." The assumption (p. II-4-7) of uniform population density is, of course, suspect, though to an undeterminable degree ameliorated by the "correction" noted near the bottom of the page. An unknown error is introduced by dealing (p. II-4-1) with an "average airport" rather than attempting some degree of further disaggregation; clearly disaggregation to the level of "all individual major airports" would have involved an impossible amount of work for the Task Group, but perhaps some intermediate stance would have been feasible. At any rate, normal professional practice in cost-benefit analysis would call for some "sensitivity analysis" to supplement the "point estimates" given. We believe EPA should commission a more detailed and sophisticated version of this necessarily hurried and ad hoc cost-benefit analysis.

4. Yet another difficulty is that the noise measures employed (L_{dn}, NEF) are largely of the nature of consensual artifacts rather than "derived quantities"--they combine relevant factors, but the mode of combination is sufficiently arbitrary that numerical manipulation of these measures as indices of "noise impact" is always cause for discomfort. This comment, and that in (3) above, does not mean that the Task Group could have been expected to invent significant new methodology or to gather significant new data. But these comments do point up some of the multiple uncertainties in the cost-benefit analysis, uncertainties which might have been more explicitly noted, and also used as a reason for tempering the conclusion emerging from that analysis.

5. The discussion of the effectiveness and necessity of monitoring (pp. II-3-12 ff.), and the associated finding (p. II-5-3, top) are based on opinion and (necessarily imperfect) recollection of experience. We believe that experimentation on this topic is likely to be fruitful, and should be considered. More generally, the theme of planning to observe and learn from early efforts is disturbingly absent.

6. Noise certification for airports, and grants to A/P's of related powers, are very reasonable, but still leave open the question of what criteria and policies the FAA will follow in deciding whether or not to certify.

7. Principle #1 p. II-6-1. The Department wishes to state in the strongest terms, its disapproval of this type of analysis. Firstly, the whole purpose of this study is to arrive at some idea of the cost and technological feasibility of controls and noise abatement procedures. Secondly, the concept of public welfare demands a balancing of the costs and benefits involved in reducing noise. Thirdly, it should be evident to the most casual observer that many standards imposed by the Clean Air Act have not proven either reasonable or achievable and that the imposition of regulations without basis is unworkable. Finally, while regulations based on achievable control technology may in fact act as an impetus to new technological developments, new technology cannot be manufactured out of whole cloth in an attempt to meet unreasonable regulations.

Technical Comments

1. Page II-1-3, bottom: Text notes that "safety" is an elusive judgemental quantity. "Economic reasonableness," cited on the same page, is even more difficult to assess.

2. Page II-2-2, para. 3: This unexplained uniqueness of treatment for National Airport will certainly strike the reader. If no special effort was made to use this special situation as a test-bed for information-gathering, that is a real pity.

3. Page II-2-5, para. 3: To assert that an operation is safe, _if_ done exactly right, evades the basic question.

4. Page II-2-8: Meaning of (10+)? Bottom of p. II-2-5 indicates "near 10" rather than ">10" is intended. Page II-2-9, 2(a): to 10 → +10.

5. Page II-2-11, top panel: "Acclerate" should be "Accelerate."

6. Page II-2-15, para. 3, line 9: WHO precomputes and transmits this figure?

7. Page II-2-17, para. 4, end: Close parentheses.

8. Page II-2-26, para. 1, lines 3-4: Basis for estimate? Para. 5, lines 3-5: A reference should be given for this appraisal, say that of Figure II-3-2.

9. Page II-2-30: Prefer to see life-cycle costing of the equipment.

10. Page II-2-31, para. 2, lines 3-4: This should not be dismissed out of hand. The reader who shares this view could be placated by a reference forward to the bottom of p. II-4-7.

11. Page II-2-34, para. 3: Text seems to be presuming quite a lot.

12. Page II-2-36, para. 1, line 2: "It's" should be "its."

13. Page II-3-4: This and Figures II-3-3, 4, 5 lack references.

14. Page II-3-5, para. 5, line 6: as a criterion.

15. Page II-3-16, para. 3, lines 1-3: Evidence?

16. Page II-4-6, option 2, line 2: "eduction" should be "education."

17. Page II-4-7, end: Basis?

18. Page II-6-2, 1d: Recommend to whom?

Task Group III - _Impact Characterization of Noise Including Implications of Identifying and Achieving Levels of Cumulative Noise Exposure_

General Comments

The treatment of aircraft noise as but one component in the overall noise environment has been advocated by those at the National

Bureau of Standards working with noise programs. The employment of a weighted sound level measurement and the use of an "average sound level" concept for cumulating noise exposures also appears quite reasonable for the stated objective.

Task Group IV - Noise Source Abatement Technology and Cost Analysis Including Retrofitting

Our comments on this Report are addressed only to Section IV-4. An adequate review of Section IV-4 is not possible without also reviewing several of the reference documents noted in the text which were not available to us. Therefore, we offer only a few general comments and point out some specific points in the Section that should be clarified and considerably strengthened before the document plays a significant role in decisions on how and when to carry out noise reduction programs that consume billions of dollars of the nation's resources.

General Comments

Section IV-4 at best is no more than a beginning attempt at a tentative identification of the costs and a few other variables involved in approaches to cope with aircraft and airport noise. As an academic discussion of a pressing problem it is a contribution. But it needs considerable shoring up before being used in making far-reaching policy decisions.

While the document does give some estimates of costs and effectiveness, it provides no estimate of public benefits derived from a reduction in noise level and leaves many important cost questions unanswered. For example, how much better off would mankind be with a reduction of 45 to 40 on the NEF scale, or by protecting every person exposed to L_{dn} = 60 or greater? What financing has been developed? How will the airlines, airports and communities raise the money to pay for the various strategies and how will this likely affect other desirable programs?

Specific Points

1. On page IV-4-1, the document identifies the null strategy as one in which "no aircraft/airport noise reduction program is undertaken." But on page IV-4-2, "the null case" is described as a "do-nothing source treatment strategy" involving several "situations." Of the four situations listed and analyzed, only the first, The Cost of a Judicial Alternative, seems a really do-nothing strategy. The other three are definite, positive action programs with significant effects on the operations and costs of airlines and on communities and the costs of airport operation. This conflict needs to be cleared up.

2. At the top of page IV-4-2, the document indicates performance gains that "might further offset some of the cost [illegible] could result [illegible] modification of the engines in existing narrow bodied aircraft with advanced noise technology engines (refan). But on page IV-4-50, reference is made to "potential lost productivity of retrofit aircraft which could result from changes in performance, weight, or fuel consumption." This raises the question "Will the 'refanned' aircraft perform better or worse than their unmodified counterparts?" The document should give an answer to this question.

3. Also on page IV-4-2, the document says this: "The subsequent text will investigate the existence of a definite market incentive to move forward with an airport noise reduction program and delineate the potential financial, economic, social, and cultural dislocations that may result if a national noise reduction program is not implemented." To say the least, it is very difficult to find where these factors were treated at all in the document. This, despite the clear and full treatment they should receive in a document intended to be used to support important policy decisions. Indeed, an investigation of "financial, economic, social, and cultural dislocations" is an important part of any benefit analysis which is so totally lacking in Section IV-4.

4. On page IV-4-15, the document says air cargo shipments can be placed in three distinct categories and gives the first one as "routine planned traffic that could be diverted to surface transportation because it is not perishable." The description of this category would be acceptable if it had stopped with "routine planned traffic." But the remaining modifying phrases make it extremely misleading. With average freight revenue per ton-mile of nearly 25 cents for air and 8.2 and 1.6 cents, respectively, by truck and rail, it would not be practical to ship by air, "traffic that could be diverted to surface transportation". Some traffic cannot be diverted to surface transport without increasing total physical distribution costs, and that most likely is why the shipper sends it by air in the first place. This point is made as an illustration of the lack of reality and [illegible] in other analyses in this Section.

5. The document gives another category of air cargo as "emergency traffic which is unplanned and highly time sensitive". Then on page IV-4-16, after no analysis and after giving no facts, it concludes, "Therefore, a few hours' delay in most 'emergency' traffic [illegible] result primarily in inconvenience, not spoilage". We suggest that this issue demands both more facts and more analysis. Many so-called "emergency" air shipments are made to meet particular market arrival times, to repair expensive equipment, and to keep production on schedule. Some emergency shipments are made to save lives. Thus, a

few hours' delay could mean missed sales, excessive down-time for expensive equipment and machinery, disrupted production schedules - all of which raise costs - and in some instances, possible loss of life. These are the main reasons more analysis is needed.

6. A similar weakness in the document is indicated in item "6," at the top of page IV-4-18. This item suggests that the only consequence worth worrying about is loss of revenue to the airlines. We suggest that at least as important is the impact on shippers and the general public, which the document hardly analyzes at all.

Task Groups V - <u>Review and Analysis of Present and Planned FAA Noise Regulatory Actions and Their Consequences Regarding Aircraft and Airport Operations</u>

and

VI - <u>Military Aircraft and Airport Noise and Opportunities for Reduction Without Inhibition of Military Missions</u>

<u>General Comments</u>

We would highlight the following points:

1. It is estimated that the system cost to implement the Task Groups' recommendations would total $31.0 - $42.0 billion. This figure is broken down as follows: $21 - $31.5 billion for charges in land use, $6.0 million for aircraft engine retrofitting, $691.0 million resulting from imposition of flight curfews, and $117.0 million due to changing of aircraft operating procedures necessary to achieve a reduction in community noise levels.

2. This may well be beyond the financing capability of the aviation industry. Forecasts of airline traffic indicate that it will continue to expand at a high rate and the airline industry will need to spend more than $27 billion during this decade for new aircraft and related ground equipment. The industry will need to raise these funds primarily through additional equity and debt since present and projected levels of earnings will not provide sufficient capital. Aircraft manufacturers face a similar problem in obtaining the development funds required to produce "ecologically conscious" aircraft and engines, since their high debt/equity ratio makes it practically impossible to attract outside investment capital.

3. The added cost of the proposed regulations, which may or may not achieve a real reduction in noise under conditions of flight safety and economic performance, will be prohibitive for the industry to absorb. These costs, of $31.0 to $42.0 billion, when added to the projected 10-year need of $27 billion to meet demand, total $58 to $69 billion. Average annual expenditures by airlines, aircraft

manufacturers and airport operators would be approximately $6 to $7 billion yearly which represents a 100 percent increase in an industry with a rate of return of less than half [illegible] by the CAB as "a fair and reasonable" standard.

Industry Views

In concluding, we wish to list the following comments which have been received from industry spokesmen. We take no position on these points.

1. The reports represent the opinion of the chairman and are not truly "consensus" reports as labeled.

2. The reports do not present a balanced representation of all views.

3. There is an absence of an adequate description of the vast amount of work on these subjects in the last decade, many of the approaches advocated in the reports have been discarded over the years for rather completely documented safety and economic reasons.

4. Unified regulation of the airline industry by the Federal Government is essential, any options provided local jurisdictions or airport operators should be subject to specific approval by the FAA.

5. Although Congress directed that a study of the implications of a cumulative noise exposure level be undertaken, Task Group III has, in fact, designed a cumulative noise exposure method and recommended specific acceptable levels.

6. There is no agreement, supported by facts, regarding the cumulative noise exposure formula set forth in the Task Group III report or that an L_{dn} of 80 DBA is the appropriate limit to be prescribed.

7. There is no adequate basis to establish [illegible] noise level limits for "health and welfare" purposes.

8. Whatever noise measurement standard is used, or whatever cumulative noise exposure formula is determined to be appropriate must be workable for regulatory and enforcement purposes. The proposals set forth in Task Group III report do not fit these requirements.

9. If EPA should announce a health related noise limit, this could become the basis for civil claims for alleged personal injuries from all sources of noise.

10. A number of recommendations of Task Group II involve judgments on the safety aspects of aviation. This is an area of FAA expertise and should not be assumed by EPA or its Task Groups.

Sincerely,

Assistant General Counsel
for Legislation

Rec'd 23 JUL 1973

DOUGLAS AIRCRAFT COMPANY
3855 Lakewood Boulevard Long Beach, California 90801

C1-25-3787

June 29, 1973

Mr. Henning von Gierke
Chai m..n, Task Group 3
Officc of Noise Abatement and Control
Environmental Protection Agency
Crystal Mall Building 2
1921 Jefferson Davis Highway
Arlington, Virginia 20460

Dear Henning:

We have reviewed the June 1, 1973 draft report of Task Group 3. Attached are a number of comments both relative to the report and relative to the operations of the task groups.

We appreciate the opportunity to have participated in the activities of the task group and also the opportunity to have our comments included in the final report.

There is a tremendous amount of data in this report and the time available to review it has been short. We may well have overlooked some key elements of the report on which we should have preferred to comment. Under these circumstances, failure to raise objections to any particular element of the report should not necessarily be construed as an endorsement.

We will take this opportunity to compliment you on having performed a minor miracle in getting this report together considering the complexities of the aircraft noise problem, the widely diverse views of those involved in the problem and the very short time that was available.

Very truly yours,

A. L. McPike
Director
Industry Association Activities

ALM:ab
att.

MCDONNELL DOUGLAS CORPORATION

Attachment to:
C1-25-3787
June 29, 1973

COMMENTS ON DRAFT REPORT FOR TASK GROUP 3

1. We agree that it is vital to establish a consistent basis for evaluating community response to noise. We cannot disagree with the selected concept of a yearly average cumulative noise exposure level. We endorse the concept of evaluating the impact of aircraft/airport operations using an equivalent noise level measured at the location of the listener. We support the choice of A-weighted sound pressure level, in dB, as the preferred noise measurement quantity.

2. The draft does not discuss the issue of the possible adaptation of people to noise. Evidence available to us indicates that some people do adapt to high noise levels over a period of time and that this adaptation affects their response. We feel that the report should discuss the changes in response that occur due to adaptation.

3. We support most of the conclusions and recommendations. We are not convinced, however, by the material presented in the draft that appropriate choices have been made for maximum permissible cumulative noise exposure levels (outdoor day-night average sound levels).

4. The information on speech interference does not seem to be applicable here. If an L_{dn} of 60 dB was the result of an unvarying background noise level, then the concept might be applicable. In the case of aircraft noise, however, there are many noise peaks during which speech communications can be difficult or impossible. The average speech interference level would probably still be such that speech communications would primarily be rated as acceptable.

5. The selection of $L_{dn} = 60$ dB as a long range goal from the viewpoint of annoyance seems to be completely arbitrary. On the one hand, it seems questionable to accept a long range goal that admits nearly one out of every four people will be highly annoyed by noise. On the other hand, the level selected leads to such large impact areas around airports that practical considerations will probably rule out ever achieving the goal.

6. Correlating the data in the report dealing with percent people annoyed and with the number of people exposed to various L_{dn} levels indicates that about 70 percent of the highly annoyed people reside outside the L_{dn} 70 zone and that only about 2 percent of the highly annoyed people are inside the L_{dn} 80 zone. If this interpretation is correct, we obviously do more good for more people by minimizing the noise of aircraft farther out rather than quite close to the airport. However, by implying that large areas around airports are completely unacceptable will ensure against the general acceptance of the concept. Therefore, it is urged that the recommendation for the 60 dB long range goal be coupled with recognition of the practical problems and great costs involved in achieving the goal.

7. We concur with, and support, the position presented in the letter submitted by the Aerospace Industries Association relative to the Task Groups operations and reports.

APPENDIX I

LIST OF REFERENCES AND MATERIAL NOT PROVIDED IN THIS DOCUMENT. THIS MATERIAL IS AVAILABLE IN THE PERMANENT FILES OF TASK GROUP #3.

Mailing list for TG3.

Letter from Robin Gegauff, dated March 2, 1973, concerning noise from operations at Boston-Logan. EPA reply dated March 12.

Draft text on "Noise Exposure Units," dated 26 February 1973.

Report of World Health Organization on "Urban and Occupational Noise" (WHO/OH/73.12) dated 13-17 Dec 1971.

"House Noise Reduction Measurements for Use in Studies of Aircraft Flyover Noise". SAE, Inc., document AIR1081, October 1971.

Testimony of Mayor Merle Mergell, Inglewood, California, presented to the Aviation Subcommittee of the United States Senate Commerce Committee, March 30, 1973.

Comments of the Honorable Mario Biaggi to the U.S. House of Representatives, 28 Feb 1973, published in the Congressional Record, March 1, 1973, page E1149.

Draft Text on "The Meaning of the 'Public Health and Welfare' Pursuant to the Noise Control Act of 1972" by Richard Rice, 23 March 1973.

Letter from Ruth and Walter O. Bahler, dated 26 April 73, concerning noise and safety problems of "touch and go" training operations of Moffett Field. Also letter reply from Task Group 1 chairman, dated 4 May 1973.

Letter from Randolph Subregion Community Council dated 16 April 73 and letter reply from John Schettino, Director, Aircraft/Airport Noise Study, dated 4 May 1973.

Report of the Aviation Advisory Committee, 3 January 1973.

"A Preliminary NASA Report to the Environmental Protection Agency for the Aircraft/Airport Noise Study," February 28, 1973. (Chapters include Impact Characterization Analysis, Source Abatement Technology, Operating Procedures, Military Aspects.)

Integrated Noise Exposure and Its Relationship to Other Noise Measures.

"A Summary of Two Community Surveys on the Effects of Aircraft Noise" by D. M. Zamarin, L. E. Langdon and R. F. Gabriel. IRAD Final Report No. MDC J5033, March 1971.

"Aircraft Noise and the Community: Some Recent Survey Findings: by A. A. Burrows and D. M. Zamarin, Douglas Aircraft Co. Paper 5891, 26 April 1971.

"The Effect of Aircraft Noise Exposure Variables on Television Viewers" by L. E. Langdon, Jr., R. F. Gabriel, and L. R. Creamer, Douglas Aircraft Co., Report No. MDC J5605, June 1972.

"Investigation of DC-8 Nacelle Modifications to Reduce Fan-Compressor Noise in Airport Communities," by L. E. Langdon, R. F. Gabriel and A. H. Marsh, NASA Report No. CR-1710, Dec 70.

Paper on "Hearing Loss Expected for Various Noise Exposure Values" prepared by Daniel L. Johnson, AMRL (EPA).

Paper titled "Percent of the Time that Speech Interference Will Occur for Various Leq Values" prepared by Daniel L, Johnson, AMRL (EPA).

Addendum No. 1 to "Percentage of Time Speech Interference Will Occur For Various Leq Values" by Daniel L. Johnson, AMRL (EPA), dated 26 April 1973.

Addendum No. 1 to "Hearing Loss Expected For Various Noise Exposure (NE) Values" by Daniel L. Johnson, AMRL (EPA), dated 26 April 1973.

Memo from Dr. Lawrence A. Plumlee, M.D., of EPA Office of Research and Monitoring, dtd February 22, 1973, concerning noise of police helicopters. ONAC reply dtd March 10.

Letter from M. P. Kelly of Opa-Locka, Florida, concerning noise from Opa-Locka Airport, dtd February 12, 1973. EPA reply dtd March 13, 1973.

NASAO letter dated March 16, 1973, stating their position regarding need for development of a uniform state law covering land use control around airports, and need for Federal guidelines.

"A Proposed System for Aviation Noise Measurement and Control," by R. W. Simpson and A. P. Hays, FTL Report R73-2, dtd January 1973, Massachusetts Inst. of Technology.

Letter from John S. Moore, Division of Noise Pollution Control, Illinois Environmental Protection Agency, dated 20 June 1973.

Letter dated 10 May 1973 from William Becker of the Air Transport Association. Subject: Comments Regarding Draft Report of EPA Task Group 3.

Letter from Al McPike, Douglas Aircraft Company. Subject: Comments Regarding Draft Report of EPA Task Group 3.

Letter dated 18 May 1973 from Robert S. Bennin, Director, Bureau of Noise Abatement, City of New York.

Letter dated 22 May 1973 from Harvey H. Hubbard, Head, Acoustics Branch, Langley Research Center, NASA.

Letter dated 24 May 1973 from Boeing Commercial Aircraft Company.

GLOSSARY FOR NOISE MEASURES

sound pressure level - In decibels, 20 times the logarithm to the base ten of the ratio of a sound pressure to the reference sound pressure of 20 micro pascals (20 micro newtons per square meter). In the absence of any modifier, the level is understood to be that of a mean-square pressure.

sound level - The quantity in decibels measured by a sound level meter satisfying the requirements of American National Standards Specification for Sound Level Meters S1.4-1971. Sound level is the frequency-weighted sound pressure level obtained with the standardized dynamic characteristic "fast" or "slow" and weighting A, B, or C; unless indicated otherwise, the A-weighting is understood. The unit of any sound level is the decibel, having the unit symbol dB.

average sound level - the level of a constant sound which, in a given situation and time period, has the same sound energy as does a time-varying sound. The average sound level is also called the equivalent sound level. Technically, the average or equivalent sound level is the level of the time-weighted, mean square, A-weighted sound pressure. The time interval over which the average is taken should always be specified.

sound exposure level - the level of sound accumulated over a given time interval or event. Technically, the sound exposure level is the level of the time-integrated mean square A-weighted sound for a stated time interval or event, with a reference time of one second.

$L_{(t)}$ time-varying noise level

L_A A-weighted sound level

L_b "background" or "residual" sound level, A-weighted

L_d	daytime average A-weighted sound level between the hours of 0700 and 2200.
L_e	Sound exposure level - the level of sound accumulated during a given event.
L_{dn}	day-night average sound level - the 24 hour A-weighted equivalent sound level, with a 10 decibel penalty applied to nighttime levels.
L_{eq}	average, or equivalent A-weighted sound level over a given time interval.
L_h	hourly average A-weighted sound level
L_n	nighttime average A-weighted sound level between the hours of 2200 and 0700.
L_{max}	maximum A-weighted sound level for a given time interval or event
L_x	x-percent sound level, the A-weighted sound level equalled or exceeded x % of five
ΔL	difference in decibels between two different A-weighted sound levels