

# Background Information on Noise

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## Introduction

This section presents background information on the characteristics of noise as it relates to the aviation alternatives and summarizes the methodologies used to study noise in an aviation environment. This section gives the reader an understanding of the metrics and methodologies used to assess noise impacts and is divided as follows:

- *Characteristics of sound that are important for technically describing sound;*
- *Factors influencing subjective human response to sound;*
- *Sound rating scales used in this study;*
- *Effects of noise on humans; and*
- *Aircraft noise regulatory context.*

## Characteristics of Sound

**Sound Level and Frequency.** Sound can be technically described in terms of the sound pressure (amplitude) and frequency (similar to pitch). Sound pressure is a direct measure of the magnitude of a sound without consideration for other factors that may influence its perception.

The range of sound pressures that occur in the environment is so large that it is convenient to express these pressures as sound pressure levels on a logarithmic scale that compresses the wide range of sound pressures to a more usable range of numbers. The standard unit of measurement of sound is the Decibel (dB), which describes the pressure of a sound relative to a reference pressure.

The frequency (pitch) of a sound is expressed as Hertz (Hz) or cycles per second. The normal audible frequency for young adults is 20 Hz to 20,000 Hz. Community noise, including aircraft and motor vehicles, typically ranges between 50 Hz and 5,000 Hz. The human ear is not equally sensitive to all frequencies, with some frequencies judged to be louder for a given signal than others. As a result of this, various methods of frequency weighting have been developed.

The most common weighting is the A-weighted noise curve (dBA). The A-weighted decibel scale (dBA) performs this compensation by discriminating against frequencies in a manner approximating the sensitivity of the human ear. In the A-weighted decibel, everyday sounds normally range from 30 dBA (very quiet) to 100 dBA (very loud). Most community noise analyses, such as the evaluation of aircraft noise exposure, are based upon the A-weighted decibel scale (dBA). Examples of various sound environments, expressed in dBA, are presented in Figure C1.

***Propagation of Noise.*** Outdoor sound levels decrease as the distance from the source to the receiver increases. This decrease in sound level is a result of wave divergence, atmospheric absorption, and ground attenuation. Sound radiating from a source in an undisturbed manner travels in spherical waves. As the sound wave travels away from the source, the sound energy is dispersed over a greater area, decreasing the sound power of the wave. Spherical spreading of the sound wave reduces the noise level at a rate of six dB per doubling of the distance.

Atmospheric absorption also influences the sound levels received by the observer. The greater the distance traveled, the greater the influence of the atmosphere and the resultant fluctuations. Atmospheric absorption becomes important at distances of greater than 1,000 feet. The degree of absorption varies depending on the frequency of the sound, as well as the humidity and temperature of the air. For example, atmospheric absorption is lowest (i.e., sound carries farther) at high humidity and high temperatures. Absorption effects in the atmosphere vary with frequency. Higher frequencies are more readily absorbed than lower frequencies. Over large distances, lower frequencies become the dominant sound as the higher frequencies are attenuated. Turbulence and gradients of wind, temperature, and humidity also play a significant role in determining the degree of attenuation. Certain conditions, such as inversions, can channel or focus the sound waves resulting in higher noise levels than would result from simple spherical spreading. The effects of meteorological conditions on sound levels are illustrated in Figure C2.

In addition to atmospheric absorption, aircraft noise can also be affected by the physical properties of the surrounding terrain. The magnitude of this terrain-related absorption varies with the angle of the aircraft above the horizon as measured from the observer to the aircraft. Lateral attenuation is influenced by ground reflection, refraction, aircraft shielding, and engine aircraft installation effects. In general, the lower an aircraft is, the greater the lateral attenuation. Lateral attenuation is not considered to be a factor if the angle between the observer and aircraft, as measured from the horizon, is greater than 60°. In this case, the aircraft is essentially overhead the observer.

***Duration of Sound.*** Annoyance from a noise event raises with increased duration of the noise event, i.e., the longer the noise event, the more annoying it is. The “*effective duration*” of a sound is the time between when a sound rises above the background sound level until it drops back below the background level. Psycho-acoustic studies have determined the relationship between duration and annoyance and the amount a sound must be reduced to be judged equally annoying for increased duration. Duration is an important factor in describing sound in a community setting.

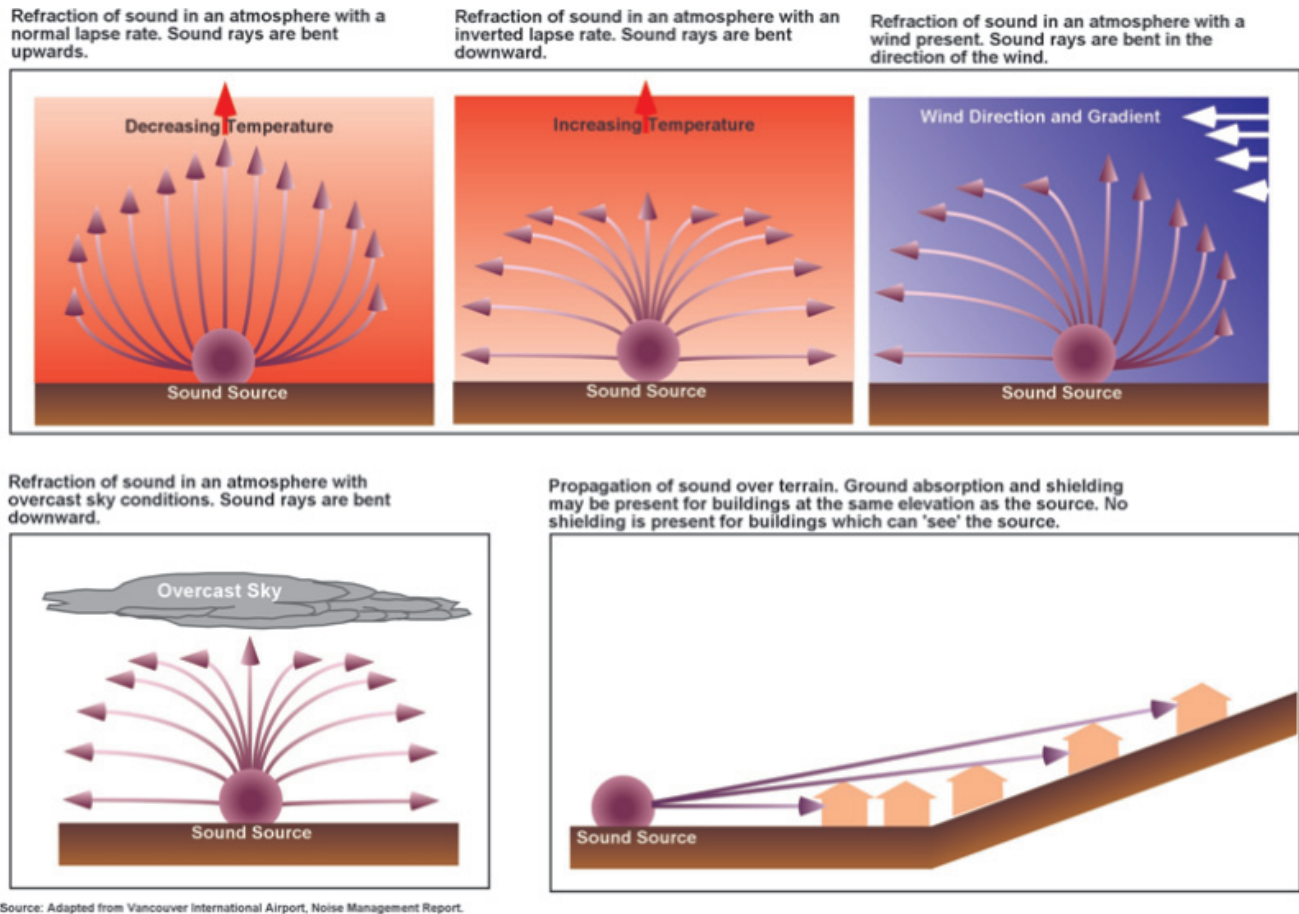
**EXAMPLES OF VARIOUS A-WEIGHTED DECIBEL SOUND ENVIRONMENTS**

dB(A)	OVER-ALL LEVEL Sound Pressure Level Approx. 0.0002 Microbar	COMMUNITY (Outdoor)	HOME or INDUSTRY	LOUDNESS Human Judgement of Different Sound Levels
130		Military Jet Aircraft Takeoff with Afterburner from Aircraft Carrier @ 50 ft. (130)	Oxygen Torch (121)	120 dB(A) 32 Times as Loud
120 110	<b>UNCOMFORTABLY LOUD</b>	Concorde Takeoff (113)	Riveting Machine (110) Rock and Roll Band (108-114)	110 dB(A) 16 Times as Loud
100		Boeing 747-200 Takeoff (101)		100 dB(A) 8 Times as Loud
90	<b>VERY LOUD</b>	Power Mower (96) DC-10-30 Takeoff (96)	Newspaper Press (97)	90 dB(A) 4 Times as Loud
80		Car Wash @ 20 ft. (89) Boeing 727 Hushkit Takeoff (89)	Food Blender (88) Milling Machine (85) Garbage Disposal (80)	80 dB(A) 2 Times as Loud
70	<b>MODERATELY LOUD</b>	High Urban Ambient Sound (80) Passenger Car, 65 mph @ 25 ft. (77) Boeing 757 Takeoff (76)	Living Room Music (76) TV-Audio, Vacuum Cleaner	70 dB(A)
60		Propeller Airplane Takeoff (67) Air Conditioning Unit @ 100 ft. (60)	Cash Register @ 10 ft. (65-70) Electric Typewriter @ 10 ft. (64) Conversation (60)	60 dB(A) 1/2 Times as Loud
50	<b>QUIET</b>	Large Transformers @ 100 ft. (50)		50 dB(A) 1/4 Times as Loud
40		Bird Calls (44) Low Urban Ambient Sound (40)		40 dB(A) 1/8 Times as Loud

"Aircraft takeoff noise measured 6,500 meters from beginning of takeoff roll (Source: Advisory Circular AC-36-3G)"

**Figure C1** Examples of Various Sound Environments in dB(A)

Source: Reproduced From Melville C. Branch And R. Dale Beland, "Outdoor Noise In The Metropolitan Environment". Published By The City Of Los Angeles. 1970.



**Figure C2** Effects of Weather and Terrain on Sound Propagation  
 SOURCE: Adapted from Vancouver International Airport, Noise Management Report.

The relationship between duration and noise level is the basis of the equivalent energy principal of sound exposure. Reducing the acoustic energy of a sound by one-half results in a three dB reduction. Doubling the duration of the sound increases the total energy of the event by three dB. This equivalent energy principal is based upon the premise that the potential for a noise to impact a person is dependent on the total acoustical energy content of the noise.<sup>1</sup> Defined in subsequent sections of this study, noise metrics such as DNL, LEQ, and SEL are all based upon the equal energy principle.

***Change in Noise.*** The human ear is a far better detector of relative differences in sound levels than the absolute values of those levels. For this reason, the human ear is much better at discerning changes between differing noise levels than determining absolute noise levels. Under controlled laboratory conditions, listening to a steady unwavering pure tone sound that can be changed to slightly different sound levels, a person can just barely detect a sound level change of approximately one decibel for sounds in the mid-frequency region. When ordinary noises are heard, a young healthy ear can detect changes of two to three decibels. A five decibel change is readily noticeable, while a 10 decibel change is judged by most people as a doubling or a halving of the loudness of the sound.

***Masking Effect.*** The ability of one sound to prevent or limit a listener from hearing another sound is known as the masking effect. The presence of one sound effectively raises the threshold of audibility for the hearing of a second sound. For a signal to be heard, it must exceed the threshold of hearing for that particular individual and exceed the masking threshold for the background noise.

The masking characteristics of sound depend on many factors including the spectral (frequency) characteristics of the two sounds, the sound pressure levels, and the relative start time of the sounds. Masking effect is greatest when the frequencies of the two sounds are similar or when low frequency sounds mask higher frequency sounds. High frequency sounds do not easily mask low frequency sounds.

## Factors Influencing Human Response to Sound

Many factors influence sound perception and annoyance. This includes not only physical characteristics of the sound but also secondary influences such as sociological and external factors. The *Handbook of Noise Control*<sup>ii</sup> describes human response to sound in terms of both acoustic and non-acoustic factors. These factors are summarized in Table C1.

Sound rating scales have been developed in reaction to the factors affecting human response to sound. Nearly all of these factors are relevant in describing how sounds are perceived in the community. Many non-acoustic parameters play a prominent role in affecting individual response to noise. Background sound, an additional acoustic factor not specifically listed, is also important in describing sound in rural settings. In the analysis of the effects of personal and situational variables on noise annoyance, a clear association of reported annoyance and various other individual perceptions or beliefs has been identified. Fields<sup>iii</sup>, in his analysis of the effects of personal and situational variables on noise annoyance, has identified a clear association of reported annoyance and various other individual perceptions or beliefs. In particular, Fields stated:

*“There is therefore firm evidence that noise annoyance is associated with: (1) the fear of an aircraft crashing or of danger from nearby surface transportation; (2) the belief that aircraft noise could be prevented or reduced by designers, pilots or authorities related to airlines; and (3) an expressed sensitivity to noise generally.”*

Thus, it is important to recognize that non-acoustic factors such as the ones described above as well as acoustic factors contribute to human response to noise.

Table C1

**FACTORS THAT AFFECT INDIVIDUAL ANNOYANCE TO NOISE**

*Boca Raton Airport FAR Part 150 NEM Update*

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**Primary Acoustic Factors**

Sound Level  
Frequency  
Duration

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**Secondary Acoustic Factors**

Spectral Complexity  
Fluctuations in Sound Level  
Fluctuations in Frequency  
Rise-time of the Noise  
Localization of Noise Source

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**Non-acoustic Factors**

Physiology  
Adaptation and Past Experience  
How the Listener's Activity Affects Annoyance  
Predictability of When a Noise will Occur  
Is the Noise Necessary?  
Individual Differences and Personality

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**Source:** C. Harris, 1979

## Sound Rating Scales

The description, analysis, and reporting of community sound levels, such as aircraft noise, is made difficult by the complexity of human response to sound and myriad sound-rating scales and metrics developed to describe acoustic effects. Various rating scales approximate the human subjective assessment to the “loudness” or “noisiness” of a sound. Noise metrics have been developed to account for additional parameters such as duration and cumulative effect of multiple events.

Noise metrics are categorized as single event metrics and cumulative metrics. Single event metrics describe the noise from individual events, such as one aircraft flyover. Cumulative metrics describe the noise in terms of the total noise exposure throughout the day. Noise metrics used in this study are summarized below:

## ***Single Event Metrics***

**Frequency Weighted Metrics (dBA).** To simplify the measurement and computation of sound loudness levels, frequency weighted networks have obtained wide acceptance. The A-weighting (dBA) scale has become the most prominent of these scales and is widely used in community noise analysis. Its advantages are that it has shown good correlation with public response and is easily measured. The metrics used in this study are all based upon the dBA scale.

**Maximum Noise Level (Lmax).** The highest noise level reached during a noise event is, not surprisingly, called the “Maximum Noise Level,” or Lmax. For example, as an aircraft approaches, the sound of the aircraft begins to rise above ambient noise levels. The closer the aircraft gets the louder it is until the aircraft is at its closest point directly overhead. Then as the aircraft passes, the noise level decreases until the sound level again settles to ambient levels. Such a history of a flyover is plotted at the top of Figure C3. It is this metric to which people generally instantaneously respond when an aircraft flyover occurs.

**Sound Exposure Level (SEL).** Another metric that is reported for aircraft flyovers is the Sound Exposure Level (SEL). It is computed from dBA sound levels. Referring again to the top of Figure C3, the shaded area, or the area within 10 dB of the maximum noise level, is the area from which the SEL is computed. The SEL value is the integration of all the acoustic energy contained within the event. Speech and sleep interference research can be assessed relative to single event Sound Exposure Level data.

The SEL metric takes into account the maximum noise level of the event and the duration of the event. For aircraft flyovers, the SEL value is typically about 10 dBA higher than the maximum noise level. Single event metrics are a convenient method for describing noise from individual aircraft events. This metric is useful in that airport noise models contain aircraft noise curve data based upon the SEL metric. In addition, cumulative noise metrics such as LEQ and DNL can be computed from SEL data.

## ***Cumulative Metrics***

Cumulative noise metrics assess community response to noise by including the loudness of the noise, the duration of the noise, the total number of noise events and the time of day these events occur into one single number rating scale.

**Equivalent Noise Level (Leq).** Leq is the sound level corresponding to a steady-state A-weighted sound level containing the same total energy as several SEL events during a given sample period. Leq is the “energy” average noise level during the time period of the sample. It is based on the observation that the potential for noise annoyance is dependent on the total acoustical energy content of the noise. This is graphically illustrated in the middle graph of Figure C3. Leq can be measured for any time period, but is typically measured for 15 minutes, 1-hour, or 24-hours.

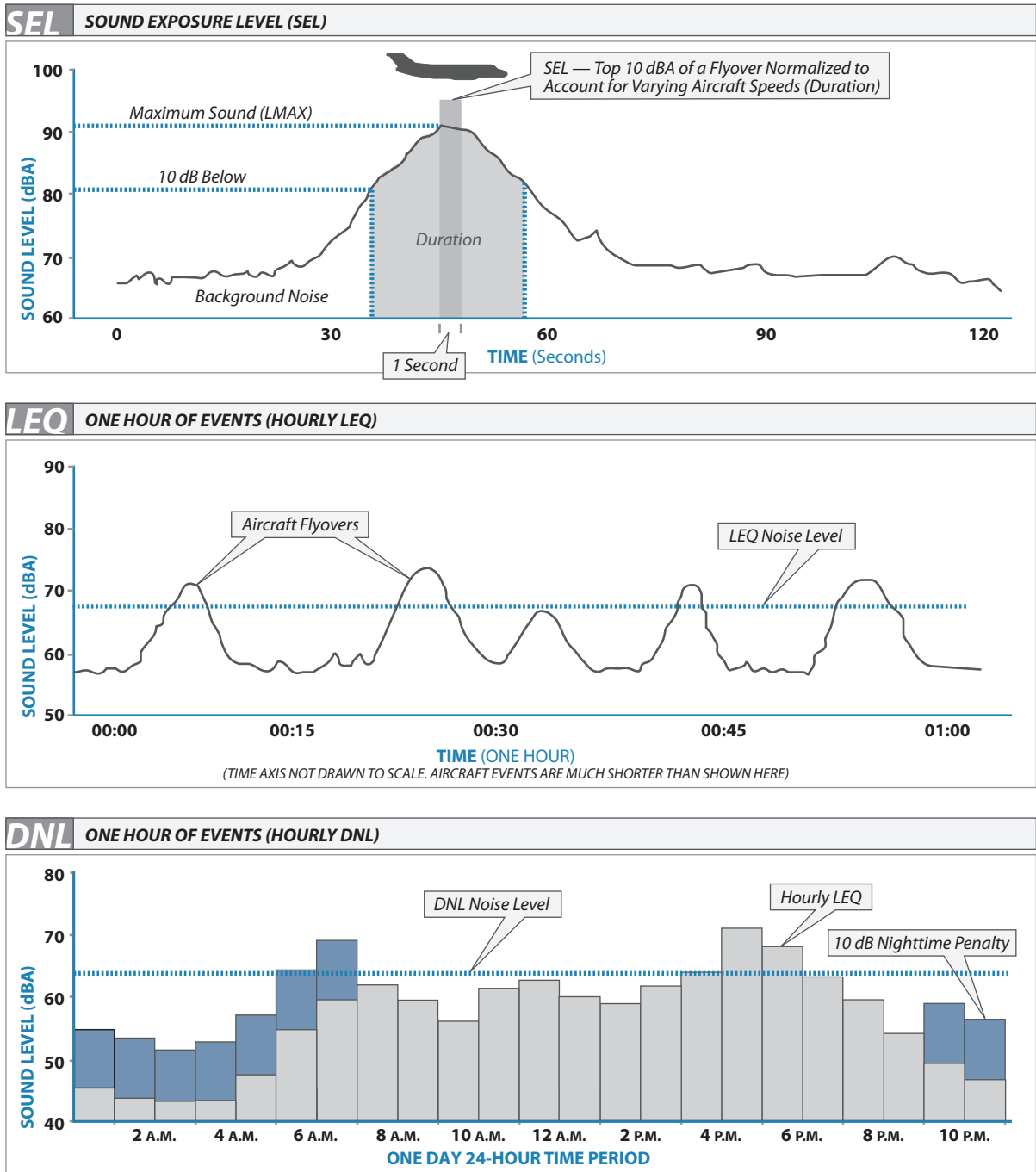
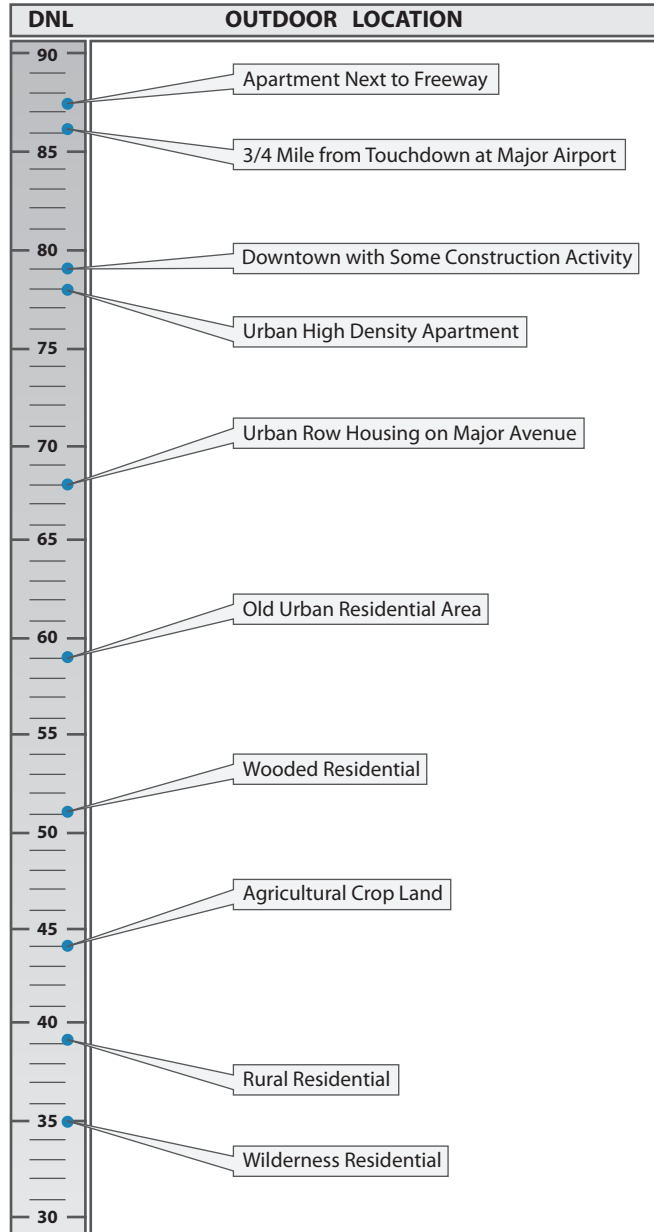


Figure C3 Examples of Lmax, SEL, LEQ, and DNL Noise Levels

**Day Night Noise Level (DNL).** DNL is a 24-hour, time-weighted energy average noise level based on the A-weighted decibel. It is a measure of the overall noise experienced during an entire day. The term “time-weighted” refers to the weightings or penalties attached to noise events occurring during certain sensitive time periods. In the DNL scale, sound that takes place during the night (10 p.m. to 7 a.m.) is weighted by 10 dB. This penalty accounts for the greater potential for noise to cause sleep awakening or communication interference during these hours, as well as typically lower ambient noise levels during these hours. This penalty was selected to attempt to account for the higher sensitivity to noise during nighttime hours and the expected decrease in background noise levels that typically occur during this period. DNL is required by the FAA for airport noise assessments and by the Environmental Protection Agency (EPA) for community noise and airport noise assessment. DNL is graphically illustrated in the bottom of Figure C3. Examples of various noise environments in terms of DNL are presented in Figure C4.



**Figure C4** Sound Levels in Terms of DNL  
 SOURCE: EPA Levels Document, 1974.

## Effects of Noise on Humans

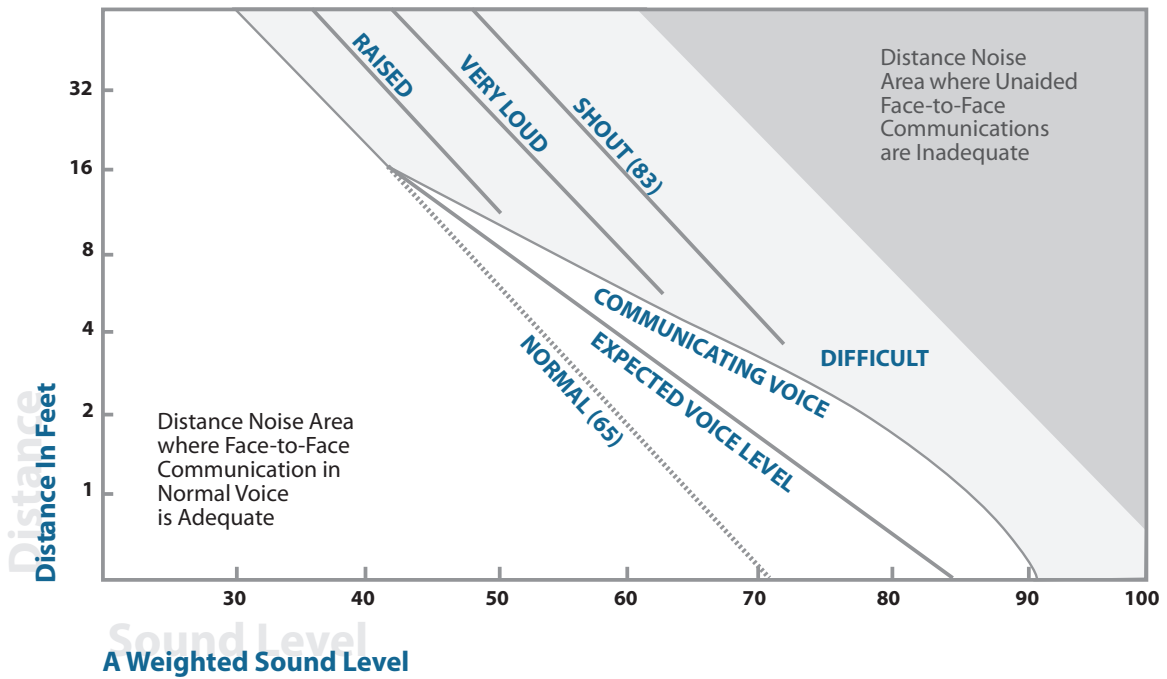
Noise, often described as unwanted sound, is known to have several adverse effects on humans. From these known adverse effects of noise, criteria have been established to help protect the public health and safety and prevent disruption of certain human activities. These criteria are based on effects of noise on people such as hearing loss (not a factor with typical community noise), communication interference, sleep interference, physiological responses, and annoyance. Each of these potential noise impacts on people are briefly discussed in the following narrative:

Hearing Loss is generally not a concern in community noise problems, even very near a major airport or a major freeway. The potential for noise induced hearing loss is more commonly associated with occupational noise exposures in heavy industry, very noisy work environments with long-term exposure, or certain very loud recreational activities such as target shooting, motorcycle, or automobile racing, etc. The Occupational Safety and Health Administration (OSHA) identifies a noise exposure limit of 90 dBA for 8 hours per day to protect from hearing loss (higher limits are allowed for shorter duration exposures). Noise levels in neighborhoods, even in very noisy neighborhoods, are not sufficiently loud to cause hearing loss.

Communication Interference is one of the primary concerns in environmental noise problems. Communication interference includes speech interference and interference with activities such as watching television. Normal conversational speech is in the range of 60 to 65 dBA and any noise in this range or louder may interfere with speech. There are specific methods of describing speech interference as a function of distance between speaker and listener and voice level. Figure C5 shows the relation of quality of speech communication with respect to various noise levels.

Sleep Interference is a major noise concern in noise assessment and, of course, is most critical during nighttime hours. Sleep disturbance is one of the major causes of annoyance due to community noise. Noise can make it difficult to fall asleep, create momentary disturbances of natural sleep patterns by causing shifts from deep to lighter stages, and cause awakening. Noise may even cause awakening, which a person may or may not be able to recall.

Extensive research has been conducted on the effect of noise on sleep disturbance. Recommended values for desired sound levels in residential bedroom space range from 25 to 45 dBA with 35 to 40 dBA being the norm. Some years ago (1981), the National Association of Noise Control Officials<sup>iv</sup> published data on the probability of sleep disturbance with various single event noise levels. Based on laboratory experiments conducted in the 1970s, this data indicated noise exposure at 75 dBA interior noise level event could cause noise induced awakening in 30% of the cases.

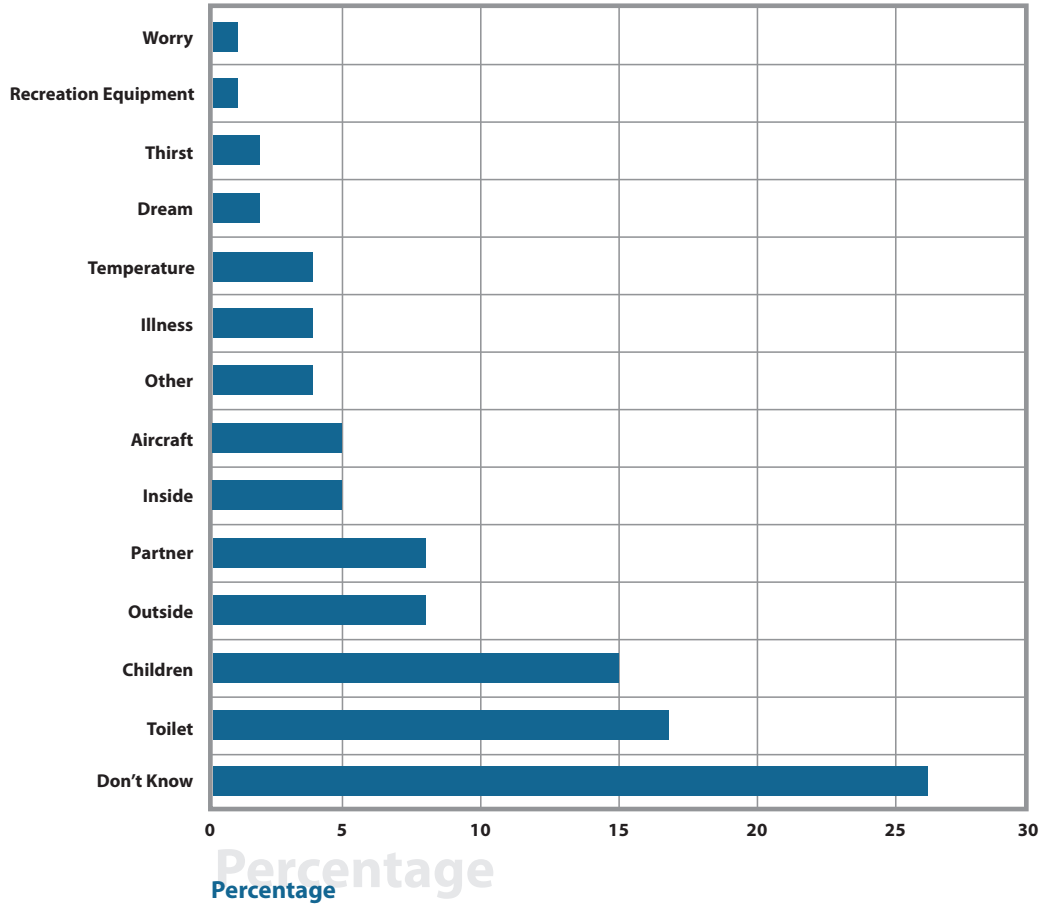


**Figure C5** Speech Interference Levels  
 SOURCE: Noise Effects Handbook, EPA.

However, more recent research from England<sup>v vi</sup> has shown that the probability for sleep disturbance is less than what had been reported in earlier research. These recent field studies were conducted during the 1990s and used more sophisticated data collection techniques. These field studies indicate that awakenings can be expected at a much lower rate than had been expected based on earlier laboratory studies. This research showed that once a person was asleep, it is much more unlikely that they will be awakened by a noise. The significant difference in the recent English study is the use of actual in-home sleep disturbance patterns as opposed to laboratory data that had been the historic basis for predicting sleep disturbance. Some of this research has been criticized because it was conducted in areas where subjects had become habituated to aircraft noise. On the other hand, some of the earlier laboratory sleep studies were criticized because of the extremely small sample sizes of most laboratory studies and because the laboratory was not necessarily a representative sleep environment. The 1994 British sleep study compared the various causes of sleep disturbance using in-home sleep studies. This field study assessed the effects of nighttime aircraft noise on sleep in 400 people (211 women and 189 men; 20-70 years of age; one per household) habitually living at eight sites adjacent to four U.K. airports, with different levels of night flying. The main finding was that only a minority of aircraft noise events affected sleep, and, for most subjects, domestic and other non-aircraft factors had much greater effects. As shown in the Figure C6, aircraft noise was a minor contributor among a host of other factors that lead to awakening response.

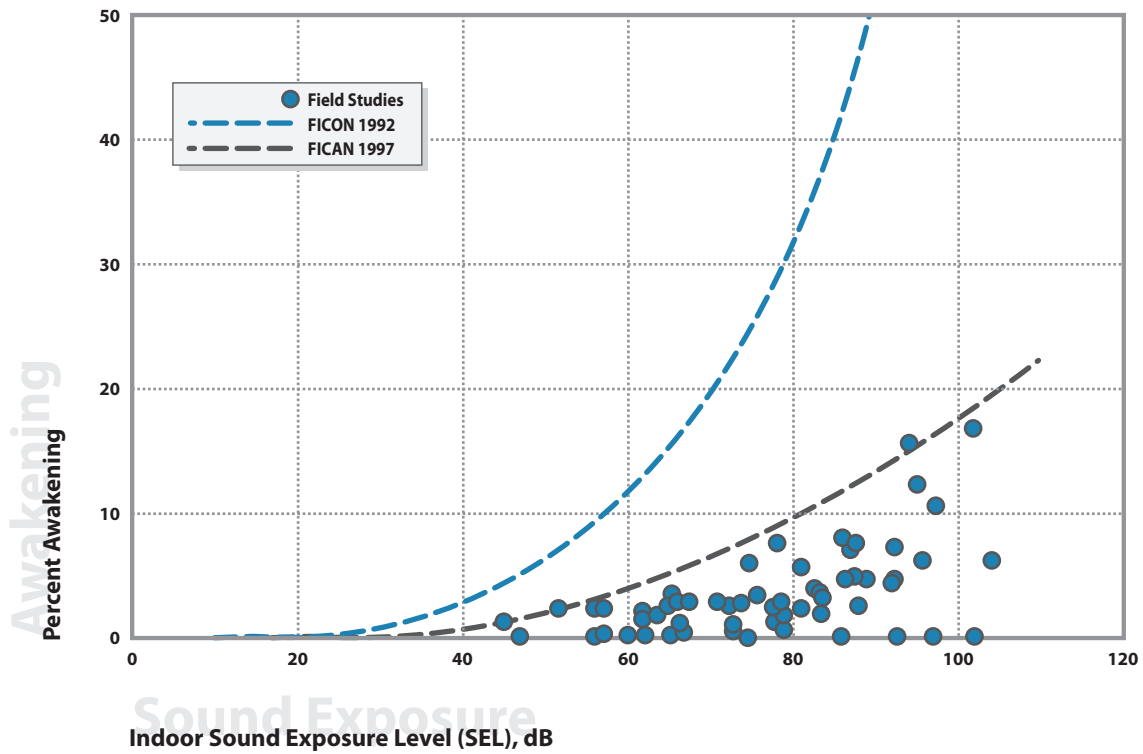
The Federal Interagency Committee on Noise (FICON) in 1992 in a document entitled *Federal Interagency Review of Selected Airport Noise Analysis Issues*<sup>vii</sup> recommended an interim dose-response curve for sleep disturbance based on laboratory studies of sleep disturbance. In June of 1997, the Federal Interagency Committee on Aviation Noise (FICAN) updated the FICON recommendation with an updated curve based on the more recent in-home sleep disturbance studies which show lower rates of awakening compared to the laboratory studies.<sup>viii</sup> The FICAN recommended a curve based on the upper limit of the data presented and, therefore, considers the curve to represent the “maximum percent of the exposed population expected to be behaviorally awakened,” or the “maximum awakened.” The FICAN recommendation is shown on Figure C7. This is a very conservative approach. A more common statistical curve for the data points reflected in Figure C7, for example, would indicate a 10% awakening rate at a level of approximately 100 dB SEL, while the “maximum awakened” curve reflected in Figure C7 shows the 10% awakening rate being reached at 80 dB SEL. (The full FICAN report can be found on the internet at [www.fican.org](http://www.fican.org).)

## Cause of Awakening



**Figure C6** Causes and Prevalence of All Awakenings

SOURCE: Report Of A Field Study Of Aircraft Noise And Sleep Disturbance, 1992. London Department Of Safety.



**Figure C7** FICAN Recommended Sleep Disturbance Curve  
 SOURCE: FICAN Report, 1997.

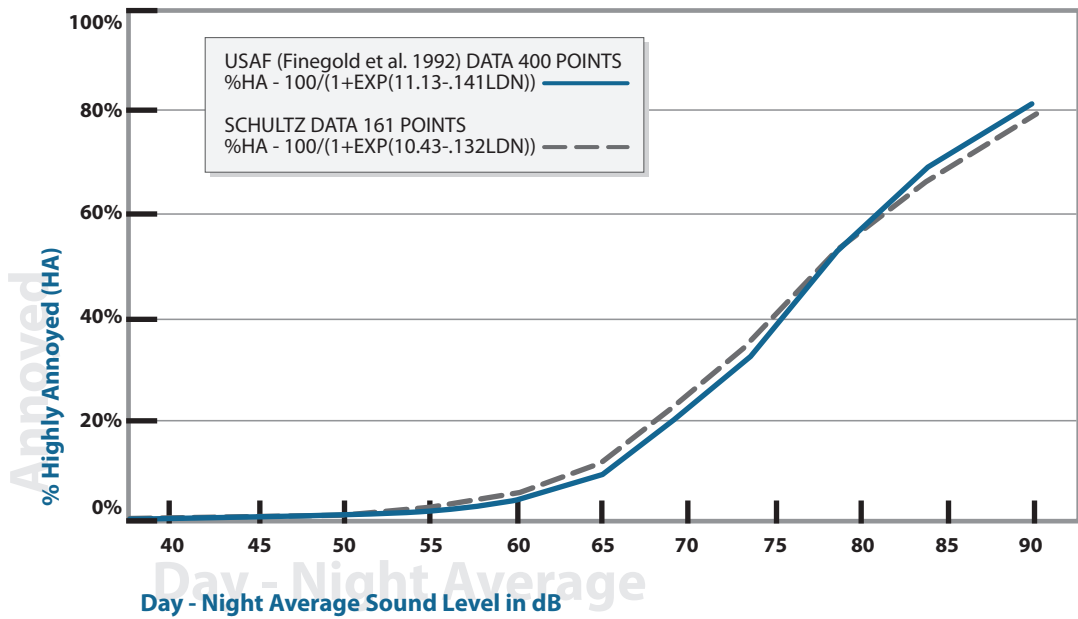
- *Physiological Responses* are those measurable effects of noise on people that are realized as changes in pulse rate, blood pressure, etc. While such effects can be induced and observed, the extent is not known to which these physiological responses cause harm or are a sign of harm. Generally, physiological responses are a reaction to a loud short-term noise such as a rifle shot or a very loud jet over flight.

Health effects from noise have been studied around the world for nearly 30 years. Scientists have attempted to determine whether high noise levels can adversely affect human health apart from auditory damage. These research efforts have covered a broad range of potential impacts from cardiovascular response from fetal weight to mortality. While a relationship between noise and health effects seems plausible, it has yet to be convincingly demonstrated—that is, shown in a manner that can be repeated by other researchers while yielding similar results.

While annoyance and sleep/speech interference have been acknowledged, health effects, if they exist, are associated with a wide variety of other environmental stressors. Isolating the effects of aircraft noise alone as a source of long-term physiological change has proved to be nearly impossible. In a review of 30 studies conducted worldwide between 1993 and 1998,<sup>ix</sup> a team of international researchers concluded that, while some findings suggest that noise can affect health, improved research concepts and methods are needed to verify or discredit such a relationship. They called for more study of the numerous environmental and behavioral factors that can confound, mediate, or moderate survey findings. Until science refines the research process, a direct link between aircraft noise exposure and non-auditory health effects remains to be demonstrated.

- *Annoyance* is the most difficult of all noise responses to describe. Annoyance is an individual characteristic and can vary widely from person to person. What one person considers tolerable can be quite unbearable to another of equal hearing capability. The level of annoyance, of course, depends on the characteristics of the noise (i.e.; loudness, frequency, time, and duration), and how much activity interference (e.g. speech interference and sleep interference) results from the noise. However, the level of annoyance is also a function of the attitude of the receiver. Personal sensitivity to noise varies widely. It has been estimated that 2 to 10% of the population is highly susceptible to annoyance from any noise not of their own making, while approximately 20% are unaffected by noise. Attitudes are affected by the relationship between the person and the noise source (Is it our dog barking or the neighbor's dog?). Whether we believe that someone is trying to abate the noise will also affect our level of annoyance.

Annoyance levels have been correlated to DNL levels. Figure C8 relates DNL noise levels to community response from two of these surveys. One of the survey curves presented in Figure C8 is the well-known Schultz Curve. It displays the percent of a populace that can be expected to be annoyed by various DNL values for residential land use with outdoor activity areas. At 65 DNL, the Schultz Curve predicts approximately 14% of the exposed population reporting themselves to be “highly annoyed.” At 60 DNL, this decreases to approximately 8% of the population.



USAF	0.40	0.831	1.66	3.31	6.48	12.29	22.1	36.47	53.74	70.16	82.64
SCHULTZ	0.576	1.11	2.12	4.03	7.52	13.59	23.32	37.05	53.25	68.78	81.00

CALCULATED % HIGHLY ANNOYED (HA) POINTS

Figure C8 Schultz Curve

The Schultz Curve and recent updates include data having a very wide range of scatter with communities near some airports reporting much higher percentages of population highly annoyed at these noise exposure levels. For example, under contract to the FAA, Bolt Beranek & Newman conducted community attitude surveys in the residential areas south of John Wayne Airport in Orange County in 1981 as part of a study of possible “power cutback” departure procedures. That study concluded that the surveyed population had more highly annoyed individuals at various noise levels than would be predicted by the Schultz Curve. When plotted similar to the Schultz Curve, this survey, indicated the populations in these areas were approximately 5 dB more sensitive to noise than the average population predicted by the Schultz Curve. While the precise reasons for this increased noise sensitivity were not identified, it is possible that non-acoustic factors, including political or the socio-economic status of the surveyed population may have played an important role in increasing the sensitivity of this community during the period of the survey. Annoyance levels have never been correlated statistically to single event noise exposure levels in airport related studies.

- *School Classroom Effects.* Interference with classroom activities and learning due to aircraft noise is an important consideration and has been the subject of much recent research. Studies from around the world indicate that vehicular traffic, railroad, and aircraft noise can have adverse effects on reading ability, concentration, motivation, and long-term learning retention. A complicating factor in this research is the extent of background noise from within the classroom itself. The studies indicating the most adverse effects examine cumulative noise levels equivalent to 65 DNL or higher and single event maximum noise levels ranging from 85 to 95 dBA. In other studies, the level of noise is unstated or ambiguous. According to these studies, a variety of adverse school room effects can be expected from *interior* noise levels equal to or exceeding 65 DNL and or 85 dBA SEL.

Some interference with classroom activities can be expected with noise events that interfere with speech. As discussed in other sections of this report, speech interference begins at 65 dBA, which is the level of normal conversation. Typical construction attenuates outdoor noise by 20 dBA with windows closed and 12 dBA with windows open. Thus some interference of classroom activities can be expected at outdoor levels of 75 to 85 dBA. These levels are included in the Time Above analysis performed as part of this study.

## **Aircraft Noise Regulatory Context**

Noise metrics provide a means for quantifying public or community response to various noise exposure levels. The public reaction to different noise levels has been estimated from extensive research on human responses to exposure of different levels of aircraft noise. Noise standards generally are expressed in terms of the DNL 24-hour averaging scale based on the A-weighted decibel. Utilizing these metrics and surveys, agencies have developed guidelines for assessing the compatibility of various land uses with the noise environment. There are no single event noise based noise/land use compatibility criteria that have been adopted by the federal, state, or local governments.

This section presents information regarding noise and land use criteria useful in the evaluation of noise impacts. The Federal Aviation Administration has a long history of publishing noise/land use assessment criteria for airports. These laws and regulations provide the basis for local development of airport plans, analyses of airport impacts, and the enactment of compatibility policies. Other agencies including the EPA and the Department of Defense have developed noise/land use compatibility criteria. A summary of some of the more pertinent regulations and guidelines are presented in the following paragraphs.

### ***Federal Aviation Administration***

- **Federal Aviation Regulations, Part 36, "Noise Standards: Aircraft Type and Airworthiness Certification".**

Originally adopted in 1960, FAR Part 36 prescribes noise standards for issuance of new aircraft type certificates. Part 36 prescribes limiting noise levels for certification of new types of propeller-driven, small airplanes as well as for transport category, large airplanes. Subsequent amendments extended the standards to certain newly produced aircraft of older type designs. Other amendments have at various times extended the required compliance dates. Jet aircraft may be certificated as Stage 1, Stage 2, or Stage 3 aircraft based on their noise level, weight, number of engines, and in some cases, number of passengers. All Stage 1 aircraft and Stage 2 jet aircraft weighing greater than 75,000 pounds are no longer permitted to operate in the U.S. Although aircraft meeting Part 36 standards are noticeably quieter than many of the older aircraft, the regulations make no determination that such aircraft are acceptably quiet for operation at any given airport or operation.

- **U.S. Department of Transportation/FAA Aviation Noise Abatement Policy.**

This policy, originally adopted in 1976, sets forth the noise abatement authorities and responsibilities of the Federal Government, airport proprietors, state and local governments, the air carriers, air travelers and shippers, and airport area residents and prospective residents. The basic thoughts of the policy are that the FAA's role is primarily one of regulating noise at its source (the aircraft) plus supporting local efforts to develop airport noise abatement plans. The FAA will give high priority to projects designed to ensure compatible use of land near airports, but it is the role of state and local governments and airport proprietors to undertake the land use and operational actions necessary to promote compatibility. In July 2000, the FAA proposed a draft revised policy that can be found on the FAA's web site at: [http://www.aee.faa.gov/noise/aec100\\_files/fr\\_anap.pdf](http://www.aee.faa.gov/noise/aec100_files/fr_anap.pdf)

- **Federal Aviation Regulations, Part 150, "Airport Noise Compatibility Planning".**

As a means of implementing the Aviation Safety and Noise Abatement Act, the FAA adopted Regulations on Airport Noise Compatibility Planning Programs. These regulations are spelled out in FAR Part 150. As part of the FAR Part 150 Noise Control program, the FAA published noise and land use compatibility charts to be used for land use planning with respect to aircraft noise. An expanded version of this chart appears in Aviation Circular 150/5020-1 (dated August 5, 1983) and is reproduced in Figure C9.

These guidelines represent recommendations to local authorities for determining acceptability and permissibility of land uses. The guidelines recommend a maximum amount of noise exposure (in terms of the cumulative noise metric DNL) that might be considered acceptable or compatible to people in living and working areas. These noise levels are derived from case histories involving aircraft noise problems at civilian and military airports and the resultant community response. Note that residential land use is deemed acceptable for noise exposures up to 65 DNL. Recreational areas are also considered acceptable for noise levels above 65 DNL (with certain exceptions for amphitheaters). However the FAA guidelines indicate that ultimately “the responsibility for determining the acceptability and permissible land uses remains with the local authorities.”

- **Federal Aviation Order 5050.4A “Airport Environmental Handbook” and Order 1050.1E “Environmental Impacts: Policies and Procedures”**

The FAA has developed guidelines for conducting environmental studies to meet the requirements of the National Environmental Policy Act (NEPA). Included in the FAA orders is the requirement to evaluate aircraft noise using the DNL metric, as well as to present the impact of proposed airport actions, such as proposed airport development, in terms of the 65 DNL, 70 DNL, and 75 DNL noise contours. Further, these orders also indicate the threshold of project-related significant impacts. Federal requirements dictate that increases in noise levels caused by a federal action in noise sensitive land uses of over 1.5 DNL within 65 DNL are considered significant.

FAA Order 1050.1E states “Analysis within the DNL 60-65 dB contours to identify noise sensitive areas where noise will increase by DNL 3 dB, only when DNL 1.5 dB increases are documented within the DNL 65 dB contour.” It is important to note that the 3 DNL increase is not a threshold of significance, but rather a disclosure of impact.

- **Airport Noise and Capacity Act of 1990 (ANCA)**

The Airport Noise and Capacity Act of 1990 (PL 101-508, 104 Stat. 1388), also known as ANCA or the Noise Act, established two broad directives to the FAA: (1) Establish a method to review aircraft noise, airport use or airport access restrictions, imposed by airport proprietors; and (2) institute a program to phase-out Stage 2 aircraft over 75,000 pounds by December 31, 1999.

LAND USE	YEARLY DAY-NIGHT NOISE LEVEL (DNL) IN DECIBELS					
	BELOW 65	65-70	70-75	75-80	80-85	OVER 85
<b>RESIDENTIAL</b>						
Residential, other than mobile homes and transient lodgings	Y	N(1)	N(1)	N	N	N
Mobile home parks	Y	N	N	N	N	N
Transient lodgings	Y	N(1)	N(1)	N(1)	N	N
<b>PUBLIC USE</b>						
Schools	Y	N(1)	N(1)	N	N	N
Hospitals and nursing homes	Y	25	30	N	N	N
Churches, auditoriums and concert halls	Y	25	30	N	N	N
Governmental services	Y	Y	25	30	N	N
Transportation	Y	Y	Y(2)	Y(3)	Y(4)	Y(4)
Parking	Y	Y	Y(2)	Y(3)	Y(4)	N
<b>COMMERCIAL USE</b>						
Offices, business and professional	Y	Y	25	30	N	N
Wholesale and retail-building materials, hardware and farm equipment	Y	Y	Y(2)	Y(3)	Y(4)	N
Retail trade-general	Y	Y	25	30	N	N
Utilities	Y	Y	Y(2)	Y(3)	Y(4)	N
Communication	Y	Y	25	30	N	N
<b>MANUFACTURING AND PRODUCTION</b>						
Manufacturing, general	Y	Y	Y(2)	Y(3)	Y(4)	N
Photographic and optical	Y	Y	25	30	N	N
Agriculture (except livestock) and forestry	Y	Y(6)	Y(7)	Y(8)	Y(8)	Y(8)
Livestock farming and breeding	Y	Y(6)	Y(7)	N	N	N
Mining and fishing resource production and extraction	Y	Y	Y	Y	Y	Y
<b>RECREATIONAL</b>						
Outdoor sports arenas and spectator sports	Y	Y(5)	Y(5)	N	N	N
Outdoor music shells, amphitheaters	Y	N	N	N	N	N
Nature exhibits and zoos	Y	Y	N	N	N	N
Amusements, parks, resorts and camps	Y	Y	Y	N	N	N
Golf courses, riding stables and water recreation	Y	Y	25	30	N	N

Numbers in parentheses refer to NOTES.

The designations contained in this table do not constitute a Federal determination that any use of land covered by the program is acceptable or unacceptable under Federal, State or local law. The responsibility for determining the acceptable and permissible land uses and the relationship between specific properties and specific noise contours rests with the local authorities. FAA determinations under Part 150 are not intended to substitute federally determined land uses for those determined to be appropriate by local authorities in response to locally determined needs and values in achieving noise compatible land uses.

**TABLE KEY**

SLUCM	Standard Land Use Coding Manual.
Y(Yes)	Land Use and related structures compatible without restrictions.
N(No)	Land Use and related structures are not compatible and should be prohibited.
NLR	Noise Level Reduction (outdoor to indoor) to be achieved through incorporation of noise attenuation into the design and construction of the structure.
25, 30 or 35	Land Use and related structures generally compatible; measures to achieve NLR of 25, 30 or 35 dB must be incorporated into design and construction of structure.

**NOTES**

- (1) Where the community determines that residential or school uses must be allowed, measures to achieve outdoor to indoor Noise Level Reduction (NLR) of at least 25 dB to 30 dB should be incorporated into building codes and be considered in individual approvals. Normal residential construction can be expected to provide a NLR of 20 dB, thus, the reduction requirements are often stated as 5, 10 or 15 dB over standard construction and normally assume mechanical ventilation and closed windows year round. However, the use of NLR criteria will not eliminate outdoor noise problems.
- (2) Measures to achieve NLR of 25 dB must be incorporated into the design and construction of portions of these buildings where the public is received, office areas, noise sensitive areas or where the normal noise level is low.
- (3) Measures to achieve NLR of 30 dB must be incorporated into the design and construction of portions of these buildings where the public is received, office areas, noise sensitive areas or where the normal noise level is low.
- (4) Measures to achieve NLR of 35 dB must be incorporated into the design and construction of portions of these buildings where the public is received, office areas, noise sensitive areas or where the normal noise level is low.
- (5) Land use compatible provided that special sound reinforcement systems are installed.
- (6) Residential buildings require an NLR of 25.
- (7) Residential buildings require an NLR of 30.
- (8) Residential buildings not permitted.

**Figure C9** FAR Part 150 Land Use Compatibility Matrix

SOURCE: FAR Part 150 Guidelines.

Stage 2 jet aircraft are generally older, noisier aircraft (Gulfstream 2, Falcon 20, Lear 25, and B-737-200) than Stage 3 jet aircraft which are newer, quieter aircraft (including but not limited to Lear 35, Gulfstream 5, and B-737-300). To implement ANCA, FAA amended Part 91 and issued a new Part 161 of the Federal Aviation Regulations. Part 91 addresses the phase-out of large Stage 2 aircraft and the phase-in of Stage 3 aircraft. Part 161 establishes a stringent review and approval process for implementing use or access restrictions by airport proprietors.

Part 91 generally states that all Stage 2 aircraft, over 75,000 pounds, were to be out of the domestic fleet by December 31, 1999. For the most part, only Stage 3 aircraft greater than 75,000 pounds are currently in the domestic fleet.

Part 161 sets out the requirements and procedures for implementing new airport use and access restrictions by airport proprietors. Proprietors must use the DNL metric to measure noise effects and the Part 150 land use guideline table, including 65 DNL, as the threshold contour to determine compatibility, unless there is a locally adopted standard more stringent.

The regulation identifies three types of use restrictions and treats each one differently: (1) negotiated restrictions, (2) Stage 2 aircraft restrictions and (3) Stage 3 aircraft restrictions. Generally speaking, any use restriction affecting the number or times of aircraft operations will be considered an access restriction. Even though the Part 91 phase-out does not apply to aircraft under 75,000 pounds, the FAA has determined that Part 161 limitations on airport proprietors' authority will apply to the smaller aircraft.

Negotiated restrictions are more favorable from the FAA's standpoint, but still require unwieldy procedures for approval and implementation. In order to be effective the agreements normally must be agreed to by all airlines using a commercial airport or most operators at a GA airport.

Stage 2 restrictions are more difficult, because one of the major reasons for ANCA was to discourage local restrictions more stringent than 1999 phase-out already contained in ANCA. To comply with the regulation and institute a new Stage 2 restriction, the proprietor must generally do two things. It must prepare a cost/benefit analysis of the proposed restriction and give proper notice. The cost/benefit analysis is extensive and entails considerable evaluation. Stage 2 restrictions primarily apply to Stage 2 aircraft weighing less than 75,000 pounds. Any access restriction requires a Part 161 Study.

Stage 3 restrictions are even more difficult to implement. A Stage 3 restriction involves considerable additional analysis, justification, evaluation and financial discussion. In addition, a Stage 3 restriction must result in a decrease in noise exposure of the 65 dB DNL to noise sensitive land uses (residences, schools, churches, parks). The regulation requires both public notice and FAA approval.

## ***Environmental Protection Agency***

- **Environmental Protection Agency, “Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety”.**

In March 1974, in response to a federal statutory mandate, the EPA published this document<sup>1</sup> (EPA 550/9-74-004) describing 55 DNL as the requisite level with an adequate margin of safety for areas with outdoor uses, including residences and recreational areas. This document does not constitute EPA regulations or standards. Rather, it is intended to “provide State and Local governments as well as the Federal Government and the private sector with an informational point of departure for the purpose of decision-making”. Note that these levels were developed for suburban type uses. In some urban settings, the noise levels will be significantly above this level, while in some wilderness settings, the noise levels will be well below this level. The EPA “levels document” does not constitute a standard, specification or regulation, but identifies safe levels of environmental noise exposure without consideration for achieving these levels or other potentially relevant considerations.

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<sup>i</sup> Environmental Protection Agency, “Information on Levels on Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety,” U.S. Environmental Protection Agency, Office of Noise Abatement and Control, March 1974.

<sup>ii</sup> Harris, Cyril M., “Handbook of Noise Control,” Second Edition, McGraw-Hill Book Co., 1979.

<sup>iii</sup> James M. Fields, Federal Aviation Administration and NASA Langley Research Center, “Effect of Personal and Situational Variables on Noise Annoyance: With Special Reference to Implications for En Route Noise,” DOT/FAA/EE-92/03, August 1992.

<sup>iv</sup> National Association of Noise Control Officials, “Noise Effects Handbook,” 1981.

<sup>v</sup> Department of Transportation, “Report of a Field Study of Aircraft Noise and Sleep Disturbance,” Department of Safety, Environment and Engineering Civil Aviation Authority, December 1992.

<sup>vi</sup> 1992 British + Horne JA, Pankhurst FL, Reyner LA, Hume K, Diamond ID, “A Field Study Of Sleep Disturbance: Effects Of Aircraft Noise And Other Factors On 5,742 Nights Of Actimetrically Monitored Sleep In A Large Subject Sample. *Sleep* 1994 Mar;17(2):146-59.

<sup>vii</sup> Federal Interagency Committee on Noise (FICON), August 21, 1992.

<sup>viii</sup> Federal Interagency Committee on Aircraft Noise (FICAN). (The full FICAN report can be found on the internet at [www.fican.org](http://www.fican.org).)

<sup>ix</sup> Lercher P, Stansfield S. A., Thompson S.J., Non Auditory Health Effects of Noise; Review of the 1993-1998 Period, Noise Effects-98 conference Proceedings, p. 213. 1998.