



Society of Automotive Engineers, Inc.
TWO PENNSYLVANIA PLAZA, NEW YORK, N.Y. 10001

AEROSPACE RECOMMENDED PRACTICE

ARP 1071

Edit. Revised October 1973

Issued June 1972
Revised

DEFINITIONS AND PROCEDURES FOR COMPUTING THE EFFECTIVE PERCEIVED NOISE LEVEL FOR FLYOVER AIRCRAFT NOISE

1. INTRODUCTION

- 1.1** The introduction of different types of jet engines, some producing audible tones, have prompted studies to obtain an improved single-number measure of complex aircraft flyover noise which is related to subjective response. Previous studies resulted in specification of the noise in terms of the perceived noise level according to the definitions and procedures of SAE ARP 865A.
- 1.2** Several judgment tests on aircraft flyover noise signals having different durations and spectra containing tonal components have shown the desirability of adjustments to the perceived noise level (as computed by the procedures of ARP 865A) to account for the signal time history and the presence of audible discrete frequency components in the sound spectrum.
- 1.3** The effective perceived noise level, EPNL, in decibels, is a single number measure calculated from objective acoustic measurements in accordance with the procedures defined in this document. It is calculated from a time sequence of tone-adjusted perceived noise levels which are calculated from one-third octave band noise spectra. The tone adjustments are determined from one-third octave band spectra, by a procedure which estimates the extent of discrete frequency (tone) components from irregularities in the shape of the one-third octave band noise spectra.

The development of the computational procedure for EPNL is based upon the results of a number of separate judgment tests. It is subject to revision as a result of additional judgment tests of complex flyover noise signals.

2. EXPLANATION OF TERMS

- 2.1** Effective Perceived Noise Level, EPNL: The effective perceived noise level of a given sound is the numerical result of a calculation as specified in Section 3 herein. The unit of EPNL is the decibel; commonly the unit symbol (dB) for decibel is preceded by an abbreviation for EPNL; e.g., 98 EPNdB.
- 2.2** Perceived Noise Level, PNL: The perceived noise level of a given sound is a result of a calculation as specified in para. 2.2 of ARP 865A. The unit of PNL is the decibel; commonly the unit symbol (dB) for decibel is preceded by an abbreviation for PNL; e.g., 98 PNdB.

NOTE: The procedure specified in ARP 865A yields an approximation of the perceived noise level as determined by subjective experiment on a fundamental psycho-acoustical basis: namely, that the perceived noise level of a given sound is numerically equal to the sound pressure level of a reference sound that is judged by listeners to have the same perceived noisiness as the given sound, the reference sound being a band of random noise one octave in width centered on 1000 Hz (cps) that is presented frontally.

- 2.3** Perceived Noise Level, PNL (k): PNL (k) is the perceived noise level calculated from one-third octave band levels determined at the k-th interval of time, where k is a number indicating the number of 0.5-second intervals elapsed from an arbitrary reference time zero of the flyover signal.
- 2.4** Tone-Corrected Perceived Noise Level, PNLT (k): PNLT (k) is the value of PNL (k) adjusted for the presence of tonal components, i.e. $PNLT(k) = PNL(k) + C(k)$, as specified in Attachment 1 of this document.

SAE Technical Board rules provide that: "All technical reports, including standards approved and practices recommended, are advisory only. Their use by anyone engaged in industry or trade is entirely voluntary. There is no agreement to adhere to any SAE standard or recommended practice, and no commitment to conform to or be guided by any technical report. In formulating and approving technical reports, the Board and its committees will not investigate or consider patents which may apply to the subject matter. Prospective users of the report are responsible for protecting themselves against liability for infringement of patents."

- 2.5 Maximum Tone-Corrected Perceived Noise Level, PNLTM: The PNLTM is the maximum value of the PNLT (k) which occurs during an aircraft flyover noise event.

NOTE: The PNLTM will generally be different in value from the perceived noise level calculated from the maximum sound pressure levels occurring in each octave or one-third octave band during a flyover. (In accordance with Note 2, Step 2.2 of ARP 865A, the perceived noise level calculated from the maximum band levels is designated the composite perceived noise level, abbreviated PNLC.) These differences may be accounted for as follows:

- (a) The PNLTM includes a correction for tonal components;
- (b) PNLTM is calculated from a single one-third octave band spectrum, scanned within a very short time interval (not exceeding 50 milliseconds);
- (c) Typically, the maximum sound pressure levels in the individual frequency bands will occur at different times during the flyover.

- 2.6 Tone Corrections: A complex noise signal may generally be said to contain a tonal component if the sound pressure level in a given frequency band, as measured using an appropriate narrow bandwidth filter, is appreciably greater than the sound pressure level in adjacent frequency bands. This characteristic may also be observed when there are several tones with several fundamental frequencies and harmonics or when the noise signal contains a random noise component with significant energy in a narrow band of frequency. This ARP is concerned with tones that are of sufficiently great amplitude that the flyover noise signal is capable of exciting the acoustic sensation of pitch. The manner of determining the presence of tones and the tone-correction factor is defined in Attachment 1.

NOTE 1: Narrow-band analysis of a flyover noise signal may reveal many tonal components that are not significantly audible since they may be masked by accompanying broad band noise or by other tonal components. Tone-correction factors generally are not applied unless the tones, identified by the procedures described in Attachment 1, are distinctly audible.

NOTE 2: The procedures for identification of audible tones described in Attachment 1 yields approximate values for the protrusion of tones above the broad band spectrum. Irregularities in measured one-third octave band noise spectra, due to factors other than tones, may result in incorrect estimates of the tone magnitude and, under some conditions, may identify a tone when none is actually present (a "pseudo" tone). Where it is suspected that an incorrect tone correction has been introduced, supplementary data analyses may be necessary, using filters with band-widths narrower than one-third of an octave. Sources of spectrum irregularities, other than tones, include reflections from the ground plane, fluctuations in sound propagation through the atmosphere, and background levels (ambient acoustical noise or electrical noise).

- 2.7 Duration: In a field situation, the duration of a flyover noise signal may be considered as the time interval in seconds during which the sound pressure levels of the flyover noise noticeably protrude above the sound pressure levels of the ambient noise at the measurement site. The duration, thus defined, is influenced by both the flyover noise signal and the ambient background noise level.

10-dB down duration, d: To minimize the influence of the ambient noise levels the duration, d, often used in the computation of EPNL is called the 10-dB down duration, and is defined as the time interval, in integral multiples of 0.5 second, between the first and last values of PNLT (k) that are 10 dB less than PNLTM. Note: For many aircraft flybys the 10-dB down duration, d, is approximately twice the effective duration, d_{eff} .

Duration Allowance, D: A duration allowance, in decibels, related to signal duration in logarithmic form, may be calculated as follows:

$$D = \text{EPNL} - \text{PNLTM}.$$

NOTE: The antilog of $(D + 10)/10$ is the effective duration of the noise signal. The product of the effective duration, d_{eff} , and the antilog of $\text{PNLTM}/10$ is equal to the time integral of the antilog of $\text{PNLT}(k)/10$ over the event.

3. CALCULATION PROCEDURE

The effective perceived noise level, EPNL, expressed in EPNdB, is calculated in accordance with the following procedure:

Step 1

Sound pressure levels in the 24 one-third octave bands having center frequencies from 50 to 10,000 Hz shall be determined for a continuous sequence of one-half second time intervals throughout the time period of the flyover noise.

NOTE 1: It is recommended that the overall electrical performance of the data acquisition and reduction system meet the requirements of the latest version of SAE ARP 796.

NOTE 2: The data reduction system may be composed of analog and digital elements meeting the performance characteristics of the latest version of SAE ARP 796.

NOTE 3: Measured spectra should be adjusted to compensate for background levels resulting from ambient acoustic noise or electrical noise in the data acquisition or reduction equipment. It is recommended that a one-third octave band spectral analysis be made of background noise levels (resulting from ambient acoustic noise and electrical noise in the data acquisition system) recorded at the same system gain setting as employed during recordings of the flyover noise signals from the aircraft. The spectral noise analysis for the flyover noise signal should then be compared to the spectral analysis of the background noise, and the measured one-third octave band levels, $L(i)_{\text{flyover}}$, should be adjusted to compensate for background noise levels $L(i)_{\text{background}}$ within the range of $3 < L(i)_{\text{flyover}} - L(i)_{\text{background}} < 10$. Values of $L(i)_{\text{flyover}}$ less than 3 dB greater than $L(i)_{\text{background}}$ should be deleted from calculation of PNL or discrete frequency corrections.

Step 2

Perceived noise levels, $\text{PNL}(k)$, shall be calculated for each one-third octave band spectra determined at k -th intervals in accordance with Paragraph 2.2 of SAE ARP 865A.

NOTE 1: In general, computed quantities, such as $\text{PNL}(k)$, PNLM and $C(k)$ values, may be computed to the nearest one-tenth of a dB.

Step 3

The presence of and corrections for tonal components in the spectrum are determined according to Attachment 1 of this document.