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Additive Evaluation Criteria for Aircraft Noise

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Impact of Outstanding Single Noise Events.

In practice, the occurrence of unexpected aircraft noise events will frequently evoke intense complaints about annoyance over such events.

The "*unexpected*" nature of such events might comprise especially sharply increased maximal sound-pressure levels. Thus complaints arise invariably when previously unknown, noisier, aircraft types appear, or when unusually shallow takeoff-climb profiles are practiced by otherwise well-known aircraft at extremely high takeoff gross weight, or when a change in flightpaths decreases the distance between emissive source and immissive receptor.

The differences between the newly perceived and complained-about maximal noise levels and the previously customary average value pf maximal noise levels are in general markedly greater than their influence on the equivalent noise level, L_{eq}.

No wonder, therefore, that there is a growing body of observations that the equivalent noise level Leq and the evaluation criteria derived therefrom are no longer the sole acceptable and adequate descriptors of aircraft noise in terms of human annoyance (Refs. 1, 2, 3)..

It is recognized that the relationship between the volume of complaints and the corresponding maximum noise levels does in fact depend on the circumstances of the complainants and the time of year. In summertime, when windows are generally held open, even an unexpected noise level in excess of as little as 75 dB(A) can occasion complaints. If exterior noise levels exceed 90 dB(A) without any mitigating factors, massive reactions by the populace affected should be anticipated.

Frequency of Occurrence of Outstanding Single Noise Events.

The frequency of occurrence of the respective noise events is also a factor. Admittedly there is an effect of adaptation. Unquestionably, a single daily event with a maximum noise level in excess of 100 dB(A} will initially give rise to a substantial annoyance. In the longer run, assuming that the unavoidability of such an event is taken into account, such an event will, however, find acquiescence. In this connection one may frequently hear the opinion that 15 to 20 annoying noise events per day can be tolerated, implying that people can adapt themselves to such events, even if initially they had been regarded as "*unexpected*" and objectionable.

An Assessment Criterion.

If these premises are accepted, then one may consider the possible practical value of the addition of the maximal noise level, subject to an as yet to be specified factor, to the well-known cumulative noise descriptors L_{eq}, L_{dn}, etc. One might start by considering the difference between the L_{eq} and the average maximal noise level of the twenty loudest single noise events on an average day. Here, as is well known, the average maximal noise level is determined from the expression

If that difference exceeds 20 dB(A), then even

$$L_{\overline{max}} = 10 * \log \frac{1}{N} \sum_{i=1}^{N} 10^{L_i/10} \, dB(A)$$

with a low L_{eq} and correspondingly high maximum noise levels massive complaints should be anticipated. A somewhat less sharply focused consideration of the maximum noise levels was adopted in the recent revision of a German standard noise-mitigation standard (Ref. 4). In that standard the scope of noise-mitigation measures is defined generally with reference to L_{eq}, as is the international custom. If the average maximal noise level $\overline{L_{max}}$ of the *entire* aircraft fleet mix, that is. not only that of the noisiest class of aircraft, exceeds the L_{eq} by more than 20 dB(A) and if, concurrently, more than 20 daily aircraft noise events exceed the L_{eq} by more than that noise-level difference, then the difference $\overline{L_{max}} - 20$ becomes the key criterion for noise-mitigation measures.

Do Quieter New Stage-III Aircraft Abate Annoyance Over Residual Noisy Aircraft?

It might be significant that an increasing participation of quieter aircraft in the aircraft fleet mix, for example, ICAO Annex 16, Chapter 3 (FAR-36, Stage III) air-craft, may depress the value of $\overline{L_{max}}$. Inasmuch as the number of Chapter-2 (Stage-II) aircraft is diminishing with time, but their participation may still exceed a daily number of 20 operations at a major airport, there is no assurance that a decrease in the $\overline{L_{max}}$ of the overall aircraft fleet mix can achieve a proportional decrease of the total annoyance.

Assessment Procedure.

A forecast of the numerical occurrence of the anticipated maximal noise levels without pre-existing noise-level measurements requires a knowledge of the scatter distribution of that level above and below the corresponding average maximal noise level. A statistical correlation of a large number of data from aircraft-noise-monitoring sensors located at various distances both directly underneath and laterally disposed relative to an aircraft flight-path has in fact supplied a basis for the determination of the distribution of the maximal noise levels about the average value, $\overline{L_{max}}$, of each type of aircraft reflected in Fig. 1. This distribution is given both for the takeoff climb and for the landing approach.

The foregoing procedure, it is evident, applies only if a single flight track or flyway is found to govern the immission levels. Should several different flight tracks, flyways, or runways participate in creating the noise-immission impact, then the immission levels must be determined separately for each flight track, and the respective frequencies must then be summated. The same applies to separate aircraft types with differing noise-emission characteristics. The legend for Fig. 1 supplies a key for a corresponding calculation scheme.

At all monitoring locations investigated to date, the deviation of the locally determined values of $\overline{L_{max}}$ was found to be less than ± 1 dB(A). Deviations of less than 1 dB(A) are generally disregarded. The frequency distribution appearing in Fig. 1 can be employed also in those cases when deviations from calculated statistically averaged immission levels, attributed to exceptional local conditions, are known to exist.

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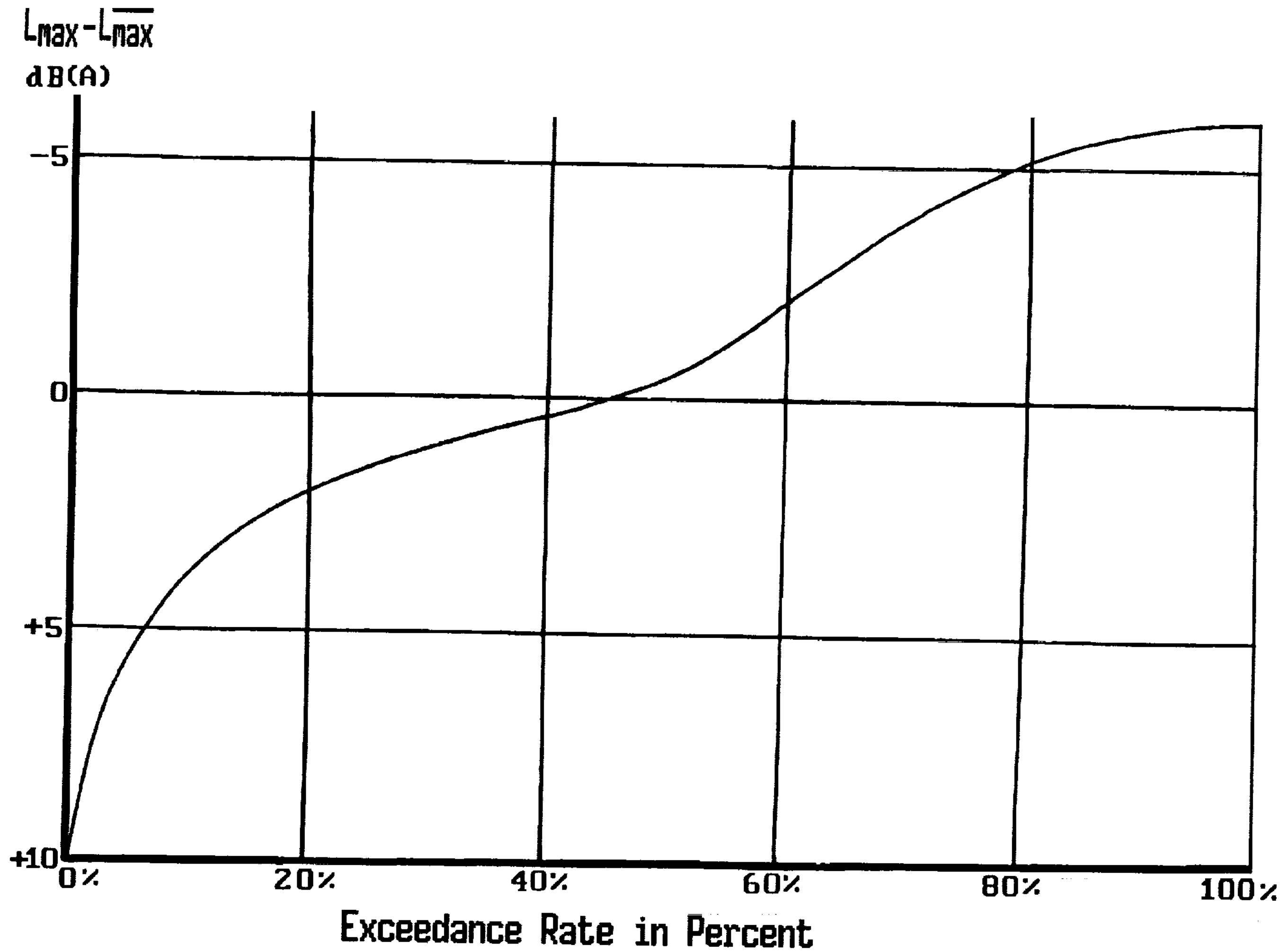

Fig. 1. The Likelihood of Deviation of a Specified L_{max} from a Logarithmically Averaged $\overline{L}_{max}$.

Example A. If $\overline{L}_{max}$ of aircraft type X_1 at immission location Y underneath a given flight track is 85 dBA, what is the exceedance rate for a L_{max} = 90 dBA of that type of aircraft at that location underneath the same flight track? $L_{max}-L_{max}$ = + 5 dBA. The diagram yields an exceedance rate of 6% of all aircraft of the type X_1 for that location underneath the same flight track.

Example B. If $\overline{L}_{max}$ of aircraft type X_2 at the same immission location Y underneath the same flight track is 92 dBA, the diagram yields for the exceedance rate for L_{max} = 90 dBA, that is, for the case of $L_{max}-L_{max}$ = -2 dBA a value of 59% of the total number of operations.

Summation. The absolute exceedance numbers for both types of aircraft must then be added to determine the total number of L_{max} exceedance events above 90 dBA.