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STANDARDS IN AIRCRAFT NOISE CERTIFICATION

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INTRODUCTION

The procedure for demonstrating that a new aircraft or derived version of an existing type satisfies certain prescribed noise limits provides an example of a large scale operation in which electro-acoustic standards are of prime importance. The control of aircraft noise by type certification of new aircraft has been in effect for about 10 years now. During this time the initial standard procedures have had two major revisions as experience was gained and refinement continues.

In the test, outlined in Figs 1 and 2, the average value of L_{EPN}* at 3 specified points has to be determined with a 90% confidence limit of ±1.5 EPNdB from a minimum sample of six. On a specific occasion this appears to be quite readily achievable, whether the regulations and standards implicit in them are adequate to ensure the wider aim of comparability between different organisations and different sites has never been formally assessed. Nevertheless the 3rd Edition of the international regulations, embodying the experience of nearly 10 years, ensures close control over all major aspects with two possible exceptions, dynamic effects in the propagation path and the effect of the interference at the microphone from ground reflections.

The International Civil Aviation Organisation (ICAO) is responsible for the formulation and development of aircraft noise certification procedures, working through its specialist Committee on Aircraft Noise. Substantial assistance has been given by the International Organisation for Standardisation (ISO) and the International Electro-technical Commission(IEC) on specialised electro-acoustical matters. The ICAO procedures, entitled Annex 16 to the Chicago Convention on Civil Aviation are almost universally accepted by member states and enacted into national legislation. In the U.K. the Civil Aviation Authority is the body responsible for aircraft noise matters and publishes the ICAO procedures with minor changes as British Civil Aviation Regulation (BCAR) Section N.

The exception is the United States of America which, by virtue of its pre-eminence in world aviation, plus the fact that it was the forerunner in the movement to control aircraft noise nuisance by the certification of new types, persists rather chauvinistically, in formulating its own set of rules in Federal Aviation Regulation (FAR) Part 36.

*Effective Perceived Noise Level.

The concurrent existence of two sets of rules has been a long-standing irritation and inconvenience but happily considerable 'harmonisation' was achieved in 1978 in Ammendment 9 which cites IEC standards in place of ANSI, and employs the same measuring locations and noise limits as the current ICAO document, the Third Edition of 1978.

DEVELOPMENT OF STANDARDS

In its pioneering work in 1968/69 the FAA was able to call upon the specialist knowledge available from the US Society of Automotive Engineers, a body having a long-standing involvement with aviation. Their Aerospace Recommended Practices (ARP) and Aerospace Information Reports (AIR) have provided expert advice and data on a variety of topics for many years. The SAE A21 Committee and specialist sub-committtees participated substantially in the formation of the first noise certification regulation FAR 36.

The international organisation ICAO took longer to formulate its rules which appeared in 1971. It was natural for ICAO to enlist the support of ISO and IEC in the development and revision of the certification procedure and both organisations made valuable contributions to the revision of noise measurement procedures over a period of about 4 years. The involvement of ISO and IEC brought the UK national standards organisation into the activity. Close consultation between the British Standards Institution technical committees and Industry groups such as the Society of British Aircraft Constructors was beneficial in ensuring that practical aspects received adequate consideration. The Civil Aviation Authority also operates a Working Party on noise certification matters, on which representatives from industry and government establishments meet.

EFFECTIVENESS OF STANDARDS

It is very desirable and reassuring to have a measure of the success of a standard procedure or measurement technique. In this instance it might be suggested that a test aircraft should conduct a tour and have its noise measured by a number of organisations at different sites using the standard procedure.

In 1969 prior to the introduction of certification Exercise 'Dummy Run' was organised for UK organisations by the Board of Trade. Noise from a BAC 1-11 aircraft was measured by teams at an airfield in Spain. Exercises of this nature are very expensive. More acceptable, are tests involving the distribution of carefully prepared magnetic tapes or if geographically convenient, have different organisations record and analyse carefully reproduced sounds in a free-field room.

Both these exercises have been used to assess the effectiveness of aircraft noise standards. They omit probably the greatest cause of variability - the propagation path, but nevertheless are an extremely valuable pointer to the degree of control being achieved.

The SAE ran a magnetic tape exercise in 1973 in which 10 organisations in the USA and 3 in Europe participated. It took about 2 years to complete but eventually Stouder and McCann published the findings in 1976. Here in England, the NPL organised a recording exercise in a free-field room at the Laboratory for UK teams, who at the time were all operating with portable equipment. Recently, a similar exercise has been performed by the Helicopter Noise Group of ICAO.

With careful planning, exercises of this nature can be very valuable in revealing points of weakness in the standardisation procedure, but the appraisal and analysis of the data is a monumental task.

A CLOSER LOOK AT THREE FACTORS

The problems arising in the standardisation of 3 selected factors are considered in some detail.

DETECTOR RESPONSE AND EFFECTIVE INTEGRATION TIME

As the noise signal is primarily of a non-stationary, random character the characteristics of the band level detector are of primary importance. As a non-steady sound level is that indicated by a Sound Level Meter conforming to the appropriate standard, it was desirable that the analyzer characteristics should closely match the dynamic behaviour of the electro-mechanical SLM - the SLOW setting being appropriate. This was achieved by specifying the response to a step up and step down tone input signal. The detector also has to satisfy a test for effective integration time based on the variance of the mean square output of a band-limited random input signal. A value of 1.5 seconds was chosen for the integration time.

The advent of true RMS detectors employing digital techniques has simplified the standardisation of detector performance, particularly as a running average of three 0.5 second integration period values, with equal weighting, satisfies the tone step test.

ATMOSPHERIC ATTENUATION

The L_{EPN} declared for the 3 certification measurements has to be calculated for standard day conditions of 70% RH and 25°C. As these rarely exist on the test day, corrections for atmospheric attenuation have to be applied.

Standard values of $\frac{1}{3}$ octave band attenuation (dB/1000ft) are given in ARP 866A based on the results of laboratory experiments and measurements of aircraft flyover noise at different altitudes. The field tests were related to meteorological measurements at 10m above ground level, which have mistakenly been taken to relate frequently to conditions above. Only in situations where the boundary layer is well mixed, with standard or near standard lapse rate is this a reasonable assumption.

The directors of certification tests seek a location with predictable fine weather and low winds. In these areas 10m meteorological measurements are not always representative of the atmospheric conditions on which ARP 866A was based. Temperature inversions are often present in the early morning when winds are likely to be low.

Suspicions about the correctness of atmospheric attenuations persisted for some time. In the 1978 revisions of FAR 36 and Annex 16 the requirement to measure temperature and humidity along the whole sound path was introduced. Restrictions were placed on the maximum attenuation rate and its rate of change. In some cases a 'layered atmosphere' calculation of total attenuation is required.

This action has brought into prominence the problem of accurate measurement of humidity and its spatial uniformity in the boundary layer.

GROUND INTERFERENCE

For rather obscure historic reasons, the height of the microphone above ground level is specified as 1.2m. The signal received by the microphone is therefore the sum of direct and reflected sound rays. If time delays are appropriate and within the correlation time of the analyzer filter, cancellation and reinforcement will occur. This distorts the true amplitude of the signal and causes peaks to be wrongly identified as 'tone' in the tone penalty procedure.

Various ways of overcoming this to enable a free-field result to be obtained are discussed.

APPROACHING THE LIMITS

During the last decade, certification noise levels have been lowered by 8-10 EPNdB, while heavier, noisier versions of the original wide-bodied aircraft have been introduced. Present day margins are now very slender.

As aircraft noise certification becomes more difficult and the limits are approached, better accuracy and increased precision will be demanded. It is highly questionable whether tenth decibel accuracy (in L_{EPN}) is a realistic objective for an outdoor noise measurement on a broad band moving source. Should such effort be put into determining inaudible differences? This question remains to be answered.

The paper concludes by identifying two areas, dynamic atmospheric effects and ground interference, in which it is considered the regulations warrant extension.

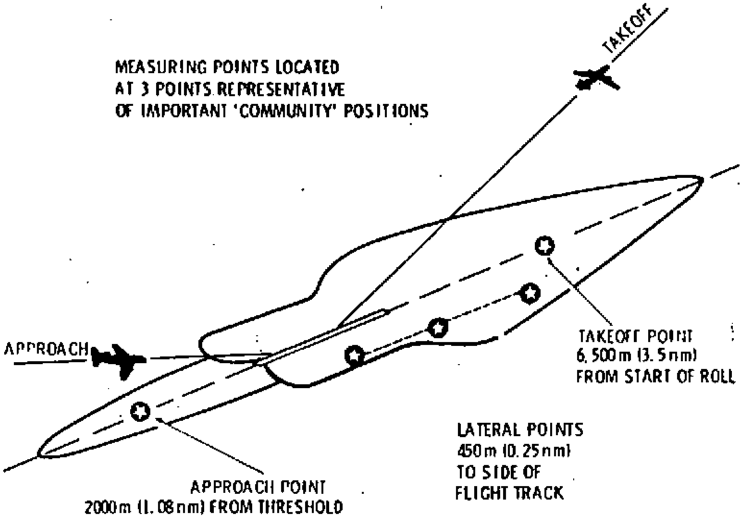


FIG. 1. CERTIFICATION MEASURING SCHEME

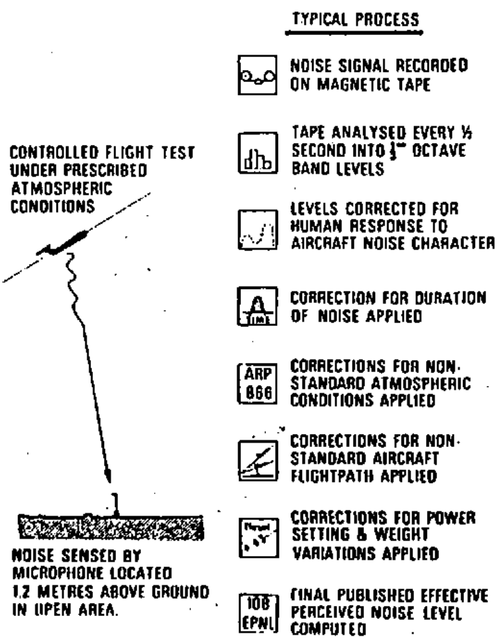
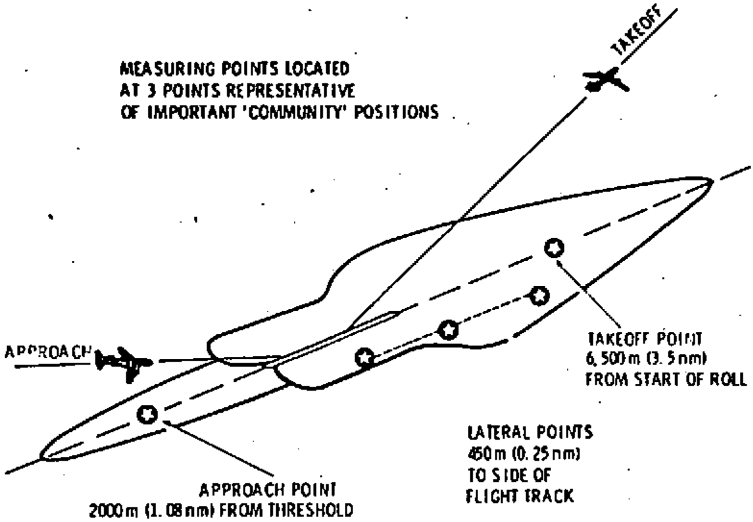


FIG. 2

MEASUREMENT AND ANALYSIS PROCEDURE



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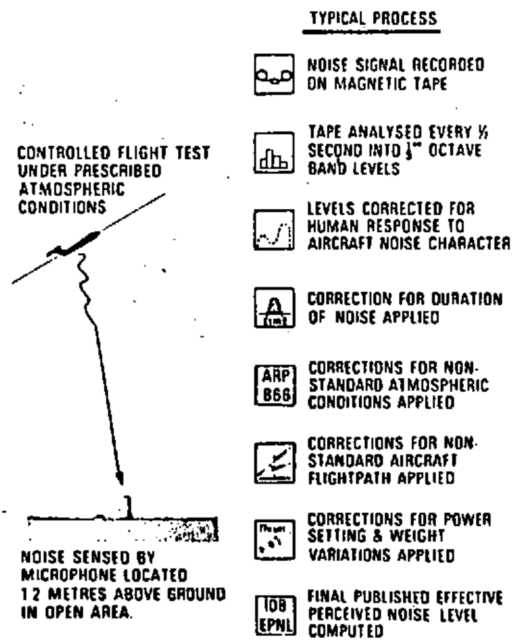

FIG. 2

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