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TOWARDS A NEW ISO 3891

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From the beginning, aircraft have been noisy. Richard Pierce's attempts at controlled flight, in March 1903, resulted in real threats of physical action about the noise [1] and other things - such as his continual crash landing on his neighbours' property. Things were no better in 1926 when the Aeroplane Magazine published an article on using a steam aero engine to cut the noise [2]. But in the main, people were tolerant and accepted the noise as a necessary side effect in the cause of progress. That is until the advent of the jet engine into commercial use, when public reaction to the noise was so intense that authorities had to take notice.

Studies of aircraft noise and human reaction became popular in many universities who set up institutes expressly for that purpose. Some of the leading psychophysicists, and in particular Stanley Smith Stevens [3] developed noise descriptors especially for aircraft noise - inevitably based on scaling techniques. The Perceived Noise Level [4] was the first and was eagerly snapped up by legislators for noise control around the major airports. The Port of New York Authority was first in the field, setting noise limits of 112 PNdB by day and 102 PNdB at night at certain sensitive areas, and the British Airports Authority followed shortly after with 110 PNdB by day and 100 PNdB at night. With other airports likely to follow this trend, an international standard for the description of aircraft noise was felt a prime requirement and in the early 1960s a working group was set up within ISO/TC43 Acoustics, the Secretariat of which was held by the British Standards Institution. The working group produced a draft (number 879) which was accepted in October 1966 to become ISO recommendation R507-1966. It utilised the then new "peak PNdB" unit (maximum perceived noise level) based on research work by Stanley Smith Stevens and Professor C Zwikker [5] . However as a result of the November 1966 London Conference, it was decided to revise the recommendation to take account of new research by Karl Kryter [6].

A new draft was produced and circulated in December 1968. It utilised the new "Effective Perceived Noise Level" EPNdB [7] which was based on the maximum perceived noise level with a duration correction. The draft was accepted as a revision of R 507-1966 and was published as: ISO 507:1970 "Procedure for describing aircraft noise heard on the ground". At the same time as this revision, the working group produced a recommendation R 1761 which became ISO 1761:1970 "Monitoring aircraft noise around an airport." This Standard did not measure PNdB but specified instrumentation using a filter based on the inverse of the 40 noy curve (which it specified in an annex) and measured the maximum level of an overflight. To this level was added 7 to approximate peak PNdB. Alternatively the Standard allowed one to measure the maximum A weighted sound pressure level and add between 9 and 14 (dependent on the frequency of the noise) to approximate peak PNdB. So the Standard really didn't measure in PNdB at all, but the results of aircraft noise monitoring were published as PNdB values.

Even as these Standards were being developed, the PNdB was being refined and re-refined. Karl Kryter introduced a process whereby the sound was measured in ½ second intervals [6,8] and the PNL calculated for each of these small intervals. For these, the EPNL was calculated, and finally the maximum value taken. So once again the Standard was reviewed. The new Standard, which was published in 1978, was ISO 3891 and it incorporated the new way to calculate the noise in EPNdB. It is believed the committee who prepared this Standard included Fritz Ingerslev, Douglas Robinson, Frederick Greatrex and Bill Galloway. Their Standard lasted for 13 years.

As a result of public reaction, the International Civil Aviation Organisation took up the challenge to bring down noise levels by introducing noise certification for aircraft starting in 1972 [9] and utilised the method of measurement given in ISO 3891. This has had a very significant effect in reducing the noise of individual aircraft, and such a measure is fine for that purpose when time is not of the essence, for EPNdB cannot be measured in real time. But the measure and methodology of ISO 3891 is of limited use in environmental management strategies and compliance measurements. Also, since ISO 3891 was published in 1978, aircraft noise certification under Annex 16 to the Convention on International Civil Aviation, with revised sound measurement and analysis procedures, has been adopted internationally. As a result, in 1990 ISO's Technical Committee 20 "Aircraft and Space Vehicles" suggested ISO 3891:1978 was no longer appropriate and should be withdrawn.

The international standard ISO 3891:1978 was formulated and drafted in the early 1970s when the aircraft scene was dominated by turbojet and low bypass ratio turbofan aircraft. It provided a methodology for the measurement of aircraft sound and for aircraft noise certification at

a time when computers were in their infancy and sound integrating instrumentation was only a design concept. Noise logging was possible only through use of the tape recorder and the graphic level recorder. With time, as with all mechanical things, designs are improved and such was the progress in aero-engine research, searching for ways to reduce emissions of all forms, that the noise spectra changed significantly; the engines also becoming quieter as bypass ratios and power increased. Since that time also, noise logging instrumentation has come onto the scene, which, together with other advances in instrumentation, has changed the ways that sound can be measured.

The proposal to withdraw ISO 3891:1978 was considered at the 1991 ISO/TC43/SC1 Plenary meeting in Sydney, when it was argued that the Standard was not specifically for aircraft noise certification alone, but formed the basis for aircraft noise measurement and description in many countries. It was put to the Committee that the standard should be revised, bringing it up to date with modern techniques and instrumentation. It should be one that is useful to airport and local authorities using simple units to enable compliance measures to be easily undertaken and include a methodology for aircraft noise management, but exclude all reference to aircraft noise certification. This was agreed in principle.

The official proposal to revise ISO 3891:1978 was put out by the Secretariat of ISO/TC43/SC1 for voting by the participating member countries, with a reply due date of 19930331. At the same time, the standard was due for the five year review ballot, and this was circulated by ISO Central Office for reply also by 19930331. From the two ballots it was clear that the large majority of member countries favoured revision of the standard. This was discussed at the 1993 Plenary meeting of ISO/TC43/SC1 in Oslo where a resolution was passed; establishing a working group for the purpose of revising ISO 3891:1978, with this author as convener and project leader. So once again the standard for the description of aircraft noise heard on the ground was to be revised.

Following the inauguration of the working group, 13 countries nominated 17 experts to the group, and a further five acknowledged world experts were invited to participate. With 22 members and participants in this working group, from 13 countries widely separated by distance, arranging to meet as a group is very difficult - hence the major interchange of work in the group is carried out by mail and by facsimile. The first working draft of the new standard was circulated to all members in April 1995 for comment, and the comments discussed in the third meeting of the working group which was held in July 1995 at Newport Beach California.

One of the first tasks was to reconcile the time weighting used. In alignment with the new IEC standard on sound level meters [10] the base metrics would certainly have to be the A-frequency-weighted Sound Pressure Level in decibels, the A-frequency-weighted Sound Exposure in pascal-squared-seconds (Pa^2s or "pasques"), and $L_{max,S}$ or the maximum

one second short Leq in decibels. From these, any other metrics required could be derived. There was a need to resolve the conflict between the exponential-time-weighting used for the sound pressure level and $L_{max,S}$, and the "linear" (i.e., no)-time-weighting used for the other two. Also, as aircraft noise certification was NOT to be included, a decision had to be made if EPNL was to be retained in its present form, or modified to an unweighted short Leq base, or not included at all. In the end it was decided not to include it or any measure that involved a frequency analysis other than the A frequency weighting.

The principal metrics used in the first draft were L_{max} (based on a one second short Leq) and sound exposure in pascal-squared-seconds. Such a radical change from traditional measures led to numerous questions as some members felt that to use anything other than logarithms would be confusing to general users of the standard: Indeed one went so far as to question the value of the standard if logarithms were not used. There are, of course, very good reasons for using the new units, rather than for all measures to be in decibels [11]. Perhaps the most compelling reason, besides that of simplicity and transparency, is that modern instrumentation almost without exception, works using increments of sound exposure - a linear measure - before converting to decibels where required. However, the draft standard will be written in such a way that the user has the choice of whether the measure is to be linear (using sound exposure in pascal-squared-seconds) or to be logarithmic (using sound exposure level in decibels.)

The use of L_{max} based on a one second short Leq, rather than on exponential time weighting S, may come with some surprise and with concern from traditionalists. There was considerable discussion on the compatibility of measurements taken using no time weighting with those taken using "S" time weighting. Foremost were worries about the reproducibility of results for L_{max} with a rapidly changing sound level if one was using a one second short Leq. Those involved with the new sound level meter standard [10] suggested this could easily be overcome by utilizing a maximum one second short Leq from a 65 ms rolling concatenation for Lmax - something easily put into the modern sound level meter operating systems. This would of course involve a modification to some meters, which was not recommended unless absolutely necessary and in the best interests. This view was reinforced by recent research [12], involving a large number of aircraft noise event measurements, that showed the difference between L_{max} based on a one second short Leq and L_{max} based on exponential time weighting S, to be less than ½ decibel with a standard error also of less than ½ dB, and thus within the permitted tolerances of Grade/Class 1 sound level meters [13]. But again the draft standard will be written in such a way that the user has the choice of whether the measure is to be linear (using the maximum 1 second short Leq) or to be logarithmic (using $L_{max\ slow}$.)

The question of seasonal and time of day weightings also has been discussed at length. It was agreed that those using the standard should have the choice of whether or not they use a time of day weighting and the hours that it would employ. The draft must be written in such a way that this will be possible. On the other hand there seemed to be no reason for a seasonal weighting, and no recommendation or mention would be made of this. It was agreed, though, that there should be an informative annex on these types of weighting as used throughout the world.

The scope of the standard also has been discussed at length as there were questions on whether the group was exceeding its brief in bringing in "management". The original proposal, as discussed at the ISO Plenary meetings in Sydney 1991, was not to withdraw ISO 3891 but to review and update it to include the measurement and assessment of aircraft noise immission with suggested strategies for its management. From this discussion a consensus was reached that the draft should be in a number of parts so that those using the Standard could use just part of it if they wished and not be obliged to use the entire Standard to conform - this particularly on the management side. Thus it was decided that the draft would be produced in 4 parts as follows:

Part 1: "Description and measurement of aircraft noise heard on the ground" - a general standard, on the description and measurement of aircraft noise as heard on the ground, which will be directly comparable with and complementary to ISO 1996 "Acoustics - Description and measurement of environmental noise - Part 1: Basic quantities and procedures."

Part 2: "Unaccompanied long-term monitoring of aircraft noise." - a standard on the procedures necessary for the unaccompanied monitoring of aircraft noise, concentrating on event based and long term statistical based measurements by fixed noise monitoring terminals. This will include measurements of environmental factors and single events for enforcement purposes.

Part 3: "Short term monitoring of aircraft noise" - a standard covering the use of temporary noise monitoring systems and including the procedures for obtaining statistically correct values for longer term evaluations.

Part 4: "Airport noise management and compatible land-use planning" - a standard to cover management strategies (a) for airports with aircraft over 9 tonnes, and (b) for airfields with aircraft under 9 tonnes and no jets.

A most important discussion point has been the delimitation of where the new standard would sit in relation to ISO 1996 - should it include all the ground operations that involve sound from the aircraft propulsion and power systems, or should it relate only to the aircraft in flight? If it were the latter, some real difficulties arise in determining the exact point in the operation where the standard becomes applicable. Ideally the Standard should be able to cover all aircraft operations including ground operations - taxiing and use of auxiliary power units at the gate. It was felt that

unfortunately there were far too many complications to include any ground operations. These should really come under a Standard for industrial noise. There was consensus that this Standard would cover noise from aircraft as they entered the runway prior to take-off, and finish as the aircraft left the runway after landing. In this and in another important issue - that of the inclusion or not of a measure for any related impulsive sounds - there will be a close relationship with the ISO working group given the task of reviewing ISO 1996

Other topics discussed included the use of one third octaves for special purposes. It was decided that the use of one-third octaves was beyond the scope of this standard which would include A frequency weighting only

Measurements to compare with prediction techniques also would not be included, and in the scope it would state that the measurements will not be anywhere near those levels calculated in a prediction model. The preparation of a draft standard on such measurements could well form work in the future for the group.

A second draft of Part 2 and Part 3 has been completed (November 1995) and a second draft of Part 1 and Part 4 will have been completed by the end of 1996. Committee drafts of each part are planned for circulation to member countries by June 1997.

Disclaimer: This paper has been written for information and discussion purposes. The ideas are the author's own and do not necessarily represent the views of any organisation for which the author works or has worked.

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