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EVALUATION OF LOUDNESS EQUIVALENT METERS

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Evaluation of L_{eq} Meters

Introduction

L_{eq} meters are almost exclusively calibrated using a continuous input signal. This calibration only confirms that the L_{eq} meter can measure sound pressure level, but tells nothing about the L_{eq} meters ability to measure impulsive signals. The Health & Safety Executive have produced a much needed draft standard for L_{eq} meters which, it is expected, will form the basis of an international standard. The work presented here describes the use of a tone-burst generator which has been developed in order to investigate certain aspects of the draft standard, with reference to specific L_{eq} measuring systems.

Tests

The type of input signal which most readily distinguishes between sound level meters and the different grades of L_{eq} meters proposed in the draft standard is that which consists of high amplitude impulses; the maximum amplitude and mark:space ratio of these impulses being different for each grade of instrument. The output of the tone-burst generator, which has been developed in order to produce such impulses, consists of integral cycles of 6KHz sinusoid with a variable, but pre-determined, mark:space ratio; each cycle starting and ending at a zero-crossing. The tone-burst generator also produces these impulses in the presence of a completely variable level of background signal of identical frequency which is phase-locked to the pulses.

A continuous sinusoidal signal at 6KHz is applied to the L_{eq} meter to be tested, and the level of the input is adjusted to give a reading of approximately 10 dB above the bottom of the indicator range. A series of tone-bursts is then substituted for the continuous signal and the level of the input is increased to give an identical L_{eq}, ie if the number of pulses in a given period is reduced by a factor of 10, the level of the pulses must be increased by 10dB to maintain the same L_{eq}. The permissible error for different combinations of mark:space ratio and signal amplitude is specified in the draft standard as the Exchange Rate Tolerance. Although such a test does measure the exchange rate, it is also a measure of the instruments ability to handle impulsive signals, however, this is of no serious consequence since the main reason for using an L_{eq} meter in place of a sound level meter is to accurately integrate high level transients.

A further test is specified in the draft standard which measures the maximum impulse which the L_{eq} meter can measure, to within a certain tolerance of the error allowed by linearity tests performed using a continuous signal. This impulse is presented to the meter in the presence of a continuous background signal which is set at a level corresponding the bottom end of the dynamic span. The result of this test is called the Peak Factor capability and is expressed as the ratio of the peak value of the impulse to the rms level of continuous background signal.

To have any confidence in the results in any of the above tests, there must be complete confidence in all of the testing equipment. An important part of this work was to conduct a thorough examination of the signal sources used and to consider any possible irregularities in measurements due to properties of the signal, or of the measuring equipment. A transient recorder was used to check that the tone-bursts started and stopped at zero and several spectrum analyzers were used to check the frequency content of the signal source.

Results

Instrument	Input Signal Mark:Space Ratio/Level			
	1:9/+10dB	1:99/+20dB	1:999/+30dB	1:9999/+40dB
1	0.4, 0.2	7.5, 5.8	∞, 9.8	∞, ∞
2	0.2, 0.3	0.9, 1.1	5.5, 3.5	∞, 3.8
3	0.0, 0.0	0.3, 0.3	3.4, 1.9	∞, 2.7
Reference Standard	0.2 (0.5)	0.4 (0.5)	0.6 (1.0)	1.0 (1.0)
4	0.0	0.0	0.0	0.3
5	0.0	0.0	0.0	<0.1

Fig.1 Exchange Rate Error for some of the meters which were tested.

The results of the exchange rate test are shown in Fig.1. The input signal levels shown are relative to the continuous signal which is applied to the meter as the reference level. The errors shown in the table are the difference between the reading with the reference level applied and the reading with the specified mark:space ratio and level, expressed in decibels.

Initially the test was carried out using only a single cycle in the tone-burst. Where an instrument failed to meet a certain standard, which is shown as in the table, the test was repeated using a series of ten cycles in each tone-burst and a correspondingly larger gap between bursts. This accounts for the readings where two errors are given for each input signal mark:space ratio and level; the first reading corresponding to the single cycle test, and the second, to the ten cycle test.

Discussion

The five instruments whose exchange rate errors appear in Fig.1 are all instruments which are described by their manufacturers as precision grade. Therefore, the reference standard included in the table corresponds to a Type 1 peak instrument as specified by the Health & Safety Executive in their draft standard which was supplied to instrument manufacturers for a competitive tender. Since that time the exchange rate tolerance has been increased, and the current proposed tolerances are shown in brackets for comparison. It can be seen, however, that this does not affect the ranking.

The draft standard allows for instruments with a reduced peak factor capability. This restricts the range of mark:space ratios over which the instrument must measure and also increases the permissible error. On the basis of the above results, instrument no.3 may be considered as a type 1 non-peak instrument under both the original and the relaxed specifications, and instrument no.2 may be considered as marginal for type 1 non-peak under the relaxed specification only.

It is interesting to note that instruments 1-3 calculate L_{eq} from a rectified signal, ie from sound pressure level, whereas instruments 4 and 5 calculate L_{eq} directly, ie from sound pressure. Instruments 1-4 have a digital display and presumably digital processing, whereas instrument 5 has an analogue display and analogue processing. This information suggests that optimum accuracy cannot be achieved by calculating L_{eq} from sound pressure level and contradicts a popularly held view that digital instruments are inherently more accurate.

Conclusion

The results of this work emphasize the great disparity between instruments which nominally measure the same parameter. The proposed standard is obviously much needed in order to help both the prospective customer and the instrument manufacturer.