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# THE DEVELOPMENT OF A CALIBRATION PROCEDURE AND SPECIFICATION FOR INTEGRATING SOUND LEVEL METERS

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## INTRODUCTION

In the late 1970's the Health & Safety Executive (HSE) was using a number of Integrating Sound Level Meters (ISLMs) to determine sample Leq at work places. There were no National or International Standards for assessing the performance of this new type of Sound Level Meter (SLM) therefore a programme of work was initiated to develop an in-house calibration scheme.

## DEVELOPMENT OF CALIBRATION METHOD

The Specification and Calibration Tests evolved from an experimental programme in which possible test signals and test methods were applied to six ISLMs then available - CEL Types, 144, 158, 175, 162, 193 and B & K Type 2218.

A Test Facility was built to generate the signals which might be required; - single sinusoid, two superimposed sinusoids, white-noise, pink-noise, bursts of any of the signals and any number of cycles, shaped decaying bursts and mixtures and/or interleaved combinations of any of these signals.

A good calibration method should both evaluate the performance of the meters and identify any fucntion causing a discrepancy in performance. Thus the tests evaluate as far as possible one factor at a time (eg frequency response linearity, time-averaging). The response of the meter is compared with the true value of the test signal and not with the response of an "ideal" integrator to with the same signal.

### Dynamic Tests

General. ISLMs differ from conventional SLMs in their dynamic and averaging characteristics and therefore new test methods were developed to evaluate these properties.

Pulse handling. It was necessary to introduce a new concept to specify the performance of meters which were required to integrate signals over a wide dynamic range. A new term was evolved - Pulse Range - which is defined as the difference in decibels between the Peak signal level of a tone-burst and the rms level of a continuous low level background signal. Defining the pulse handling capability in this way has the merit of providing a value which is relevant to the user of the meter and can be readily interpreted by him. A Pulse Range of 50dB simply means that signals which have peak values up to 50dB above the bottom of that range will be adequately integrated by the meter.

The test signal consisted of a tone-burst starting and ending at a zero crossing. The greater the number of cycles in such a signal the fewer the harmonic components and because these may mask the true response of the meter, due to the wide tolerances permitted for a standard A-weighting network, a tone-burst of 6 cycles was used. A minimum burst duration of 1 ms was chosen with a signal frequency of 6kHz. This also has the advantage of being at a point where the A-weighting has virtually zero gain.

The test is conducted by combining a single tone-burst with an in phase 6 kHz background signal set at the lower limit of the linearity range of the meter. The Leq of the combination is measured for increasing burst amplitudes until the tolerances for performance are reached. The low level signal is required to provide a reference point. Without this the tone burst is superimposed on the self-noise of the meter which may be unknown causing errors in the calculation of the Leq of the test signal and in comparisons between meters.

A single tone-burst is used because with multiple burst the detector response errors can be masked by a gradual increase in residual level in the detector. This reduces the effective pulse height which in turn reduces the performance requirements of the detector.

The test is performed over the whole dynamic range since it is possible to meet the requirements at the top of a range but to fail at intervals lower down. An example of this is shown in Figure 1 where the errors associated with the intervals between autoranging steps can be seen. The response of the meter may be dependant on tone burst width and therefore the method requires tests to be done over a range of burst widths (Figure 2).

Time-Averaging capability. The Time-Averaging capability of a meter is a measure of its ability to adequately integrate and average signals of fluctuating amplitude. The test comprises measuring the Leq of a tone-burst sequence of known mark-to-space ratio. The ratio and amplitude of the tone-bursts are altered to maintain the Leq and the meter is tested over a range of such duty factors.

## SPECIFICATION

Those test methods and results obtained were embodied in a specification which stipulated the acoustic and electronic performance required and the methods to be used to check conformity. As many requirements of an ISLM (eg microphone performance, A-weighting network) are common to SLMs the Sound Level meter Standard, IEC 651 [1], was used as a basis for the specification. Substantial additions and alterations were made to cope with the different dynamic and averaging characteristics of the ISLM. The specification required a performance close to the then "state-of-the-art" to ensure that it would remain applicable for a number of years. Discussions with a number of instrument manufacturers were held throughout the development of the specification.

### Characteristics

Linearity Range. From our experience of noise measurement in factories a dynamic range of at least 60 dB was considered necessary to encompass the range of sound fluctuation which might be found.

Pulse Range. An ISLM should be capable of integrating a pulse wherever it occurs in the dynamic range, therefore the Pulse Range requirement was set to be 63dB.

Time averaging. The maximum pulse duty factor specified was 40 dB (a mark-to-space ratio of 1 : 9 999). This represents a compromise between testing to the upper limit of the dynamic range and the length of time required to do the test.

### Further Developments

The Specification was used by HSE to purchase of a large number of meters. These, together with a number of prototype meters, were tested against the full specification. This proved the practicality of the Specification and Calibration Methods which were then submitted to the British Standards Institution for consideration for use as a National Standard. The National Committee submitted this proposal to the International Electrotechnical Commission as the basis for an International Standard. The ensuing discussions have led to some minor revisions, the most significant being a change of tone-burst frequency to 4kHz and a relaxation of some of the tolerances. The effects of all changes whether technical or editorial were evaluated in the Laboratory by applying the revised methods to a meter and comparing the results with previous data. A Draft International Standard has now been circulated [2].

Further purchases have resulted in a need for routine calibration of over 250 meters. Thus an Automated Test Facility was developed which is capable of calibrating up to 16 metres with only periodic attention by an operator. It has been in operation for over a year and is a combination of normal production test instrumentation and simple circuitry built in-house. The latter is now avaiable in commercial instruments.

## CONCLUSIONS

Many thousands of measurements have been carried out and these have shown that the test methods developed are able to resolve accurately the detailed performance of ISLMs. The methods used have been capable of automation, facilitating recalibration. The Specification can now be satisified by pocket-sized instruments.

## REFERENCES

[1] "IEC Standard Publication 651 Sound Level Meters", International Electrotechnical Commission 1979.

[2] "Draft Standard Specification for Integrating-Averaging Sound Level Meters", International Electrotechnical Commission Document 29C (Central Office) 1982.



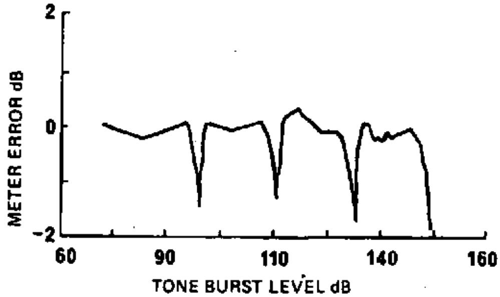


Figure 1 Effect of autoranging on pulse handling.

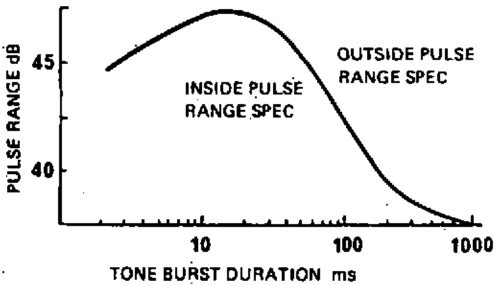


Figure 2 Effect of tone burst duration on Pulse Range.