DOES YOUR SOUND LEVEL METER MEET ITS SPECIFICATION? A USER'S EXPERIENCE

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INTRODUCTION

Early sound level meters are very different from those available today. There is now a wide choice of both instrument design and capability. Many instruments currently available offer complex, on the spot, analyses in hand-held units. Simple pocket-sized instruments have capabilities exceeding those of large cumbersome meters ten years ago.

But what of the accuracy of the new meters? This paper considers the provisions given in standards and international recommendations designed to ensure the accuracy and quality of sound level meters. The test methods used by the Health and Safety Executive for testing and evaluation of sound level meters are described along with some general comments on the results of 'acceptance' tests performed on various meters, over a number of years.

STANDARDS

International and British standards define the performance characteristics of instruments, and lay down tolerances for the accuracy of particular parameters. The aim of a standard is to ensure consistency of performance between different instruments. The standards also define the necessary tests to establish conformance. Separate, but inter-related, standards apply to Sound Level Meters (SLMs) and Integrating-averaging Sound Level Meters (ISLMs). Another standard applies to Personal Sound Exposure Meters (PSEMs, dosemeters). These are listed in the table below:

International Standard	British Standard	Instrument type
IEC 651:1979 [1]	BS 5969:1981 [2]	SLM
IEC 804:1985 [3]	BS 6698:1986 [4]	ISLM
in preparation	BS 6402:1983 [5]	PSEM

IEC 651 and BS 5969 are identical standards, as are IEC 804 and BS 6698. Older SLMs may conform to standards which are now obsolete: IEC 123:1961 [6] and IEC 179:1965 and 1973 [7] are approximately equivalent to Types 3 and 1 respectively of IEC 651.

The SLM and ISLM standards define four grades of instrument, Types 0 to 3. The accuracy requirements and some performance criteria are reduced as the Type number increases. The standards state the suitability of the different Types to be:

- Type 0 - as a laboratory reference standard
- Type 1 - for field use where the acoustic environment can be closely controlled or specified
- Type 2 - for general field applications
- Type 3 - field noise survey applications

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The frequency weighting, directional characteristics and environmental sensitivity requirements of the SLM and ISLM standards are identical. SLMs and ISLMs of a given Type number will have the same accuracy for steady sound. However the ISLM standards, IEC 804 and BS 6698, define additional tests and requirements for measuring sound that is time-varying and in such circumstances an integrating meter will give a more accurate measure of equivalent continuous sound pressure level, Leq. It should be noted that, although IEC 804 is consistent with relevant requirements of IEC 651, an ISLM conforming to IEC 651 does not necessarily conform to IEC 804. Always check if the standard quoted in the specification is the most relevant.

The PSEM standard, BS 6402, defines only one grade of instrument whose performance is close to, but not the same as, a Type 2 SLM or ISLM. The proposed international standard for PSEMs is aiming to be consistent with all relevant requirements of IEC 804 for Type 2 instruments.

What accuracy can be expected from an instrument which conforms to one of these standards? The standards define the overall accuracy only under reference conditions ie. at the calibration level and frequency and in a free sound field. The allowed tolerances for each instrument type are:

IEC 804 and IEC 651 (BS 5969 & BS 6698)	Type 0 - ±0.4dB	BS 6402 - ±1.0dB
	Type 1 - ±0.7dB	
	Type 2 - ±1.0dB	
	Type 3 - ±1.5dB	

The standards require that some means, usually an acoustic calibrator, be available and used prior to a measurement so that this accuracy can be realised. However, at other frequencies or levels a wider tolerance on accuracy can be expected. As a rough estimate, where the sound has no dominant frequencies and the impulsiveness of the sound is not approaching the limits of the instrument's capabilities, the inaccuracy, in dB, may be 1.5 to 2 times greater than the values quoted above. Note - the accuracy of a dosemeter is often more severely limited because the instrument and microphone are worn on the body. Estimations of these errors is beyond the scope of this paper.

<u>How is conformance with a standard decided?</u>
Within the UK there are no approval or type testing procedures. It is the responsibility of the manufacturer to ensure his instruments meet any standards he specifies. The Organisation Internationale de Metrologie Legale (OIML) recommends the extent of testing for evaluating a meter for conformance to IEC 651 in its Recommendation No. 58. The recommendation applies to instruments which are to be used for regulatory enforcement. Recommendation 58 specifies a detailed testing for type evaluation and a reduced procedure for verifying the performance of a particular instrument once the type performance is established. However the OIML recommendations are not legally binding. A separate, but related, recommendation for ISLMs is being compiled.

HSE IN-HOUSE TESTING

The Health and Safety Executive (HSE) currently holds over 330 ISLMs and PSEMs in addition to some older SLMs. Since the bulk of these instruments are used by the enforcing Divisions of HSE each is recalibrated annually in-line with

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the OIML Recommendations.

The calibration procedures have been evolved by the Noise and Vibration Section of the Research & Laboratory Services Division of HSE. Work on developing test methods started some 10 years ago when HSE first purchased some early 'Leq' meters. A specification for these new instruments was developed at the same time and used as the basis of the subsequent bulk purchase of 'Leq' meters. The specification and test methods ultimately became IEC 804 and BS 6698.

Although the requirements set by the standards apply to the complete instrument including microphone most of the testing can be done using electrical signals fed to the meter via a 'dummy' microphone. The signals consist of sinusoids, tone-bursts and square pulses and enable the performance of the meter to be fully assessed. However certain instrument characteristics such as frequency response can only be fully tested in a carefully controlled sound field. Initially all acoustic testing used a multi-level, multi-frequency close-coupled acoustic calibrator but over the past year these results have been cross-checked with free-field tests in the Section's anechoic chamber.

Before purchasing new noise instrumentation, potentially suitable instruments are evaluated by the Noise & Vibration Section; usually on a one-off basis. Once the most appropriate instrument has been selected and purchased the first 10-30 delivered are tested in depth. These 'acceptance' tests are to establish the optimum routine calibration procedure for that type of instrument. Each instrument is tested, at close intervals, to the extremes of its specification. Once a typical performance is established a reduced test procedure based on the performance in the initial tests is used for subsequent deliveries and routine re-calibration. Although OIML defines a reduced test procedure for verification of performance it has been found necessary to decide the extent of routine testing on the actual instrument performance. Thus a reduced procedure concentrates on testing where performance varies considerably between meters of the same type or where the performance comes close to the limits of the allowed specification.

RESULTS OF TESTS

Integrating sound level meters

The percentage of meters failing to meet specification on 'acceptance' testing was 38%. This result is for the bulk of the integrating sound level meters purchased by HSE ie those models for which more than 10 have been purchased and tested in detail. The results come from three different makes (4 models); three are Type 1 instruments and one a Type 2 instrument. Common faults found were:

- Linearity errors within the linearity range
- Frequency response (when tested acoustically)
- Time-averaging errors
- Gross level range change errors (>10dB)
- Trivial electrical & mechanical defects eg. sticking meter movements, faulty contacts

The overall percentage given above excludes the very first tests on one model in which a design fault was discovered. Only faults found on this model after the design error was rectified are included.

Personal sound exposure meters

HSE has purchased far fewer dosemeters than ISLMs. Generally most PSEMs are simpler instruments with a lower performance specification than ISLMs. However in 1985 the Noise and Vibration Section investigated the performance of logging dosemeters, devices which record a time history of the sample period as well as the overall dose during the exposure period. Three different models, from different manufacturers were assessed against BS 6402 and IEC 804.

Two of the instruments claimed conformance with IEC 651 Type 2, none mentioned any conformance with BS 6402 or IEC 804. Testing showed only one instrument met BS 6402 and just squeezed into IEC 804 Type 2; one conformed to BS 6402 but only after a frequency dependent linearity error, which took it outside the manufacturer's specification, was rectified; one failed to meet IEC 804 or BS 6402. All instruments were limited by a poor response to impulsive signals made up of tone bursts.

Between 1984 and 1985 HSE purchased 5 conventional and 21 logging personal sound exposure meters. Of these PSEMs, 12% failed the 'acceptance' testing; the most common fault was a high electrical background noise (self-counting).

WHAT CAN USERS DO?

How to select an accurate instrument

There is no foolproof way of avoiding faulty instruments. As the results above show even a new instrument claiming conformance to a standard may be sent from the manufacturer with an undetected fault. However here are some basic rules to help avoid those inaccurate instruments.

1. Check the instrument conforms to the relevant recognised standard.
2. Ask the manufacturer if testing by an approved laboratory has confirmed the performance specified.
3. Ask the manufacturer what testing they do on individual instruments.

Simple ways to check and maintain the accuracy of an instrument

The only way to fully check an instrument is to go through all the tests required in the standard and to re-check the instrument at regular intervals. For the average user this is impossible so some simple tests and checks which should be adequate to weed out most faulty instruments are given below:

1. Always use a good quality calibrator with a suitable microphone coupler which gives a known level at the microphone of the instrument used.
2. Record the level of the calibration before making any adjustment to the sensitivity. A calibration record will show any drift or abnormal changes in sensitivity.
3. In HSE's experience the most significant linearity errors occur within a level range rather than on changing the level range. In addition the linearity errors usually occur in the same pattern across the range whatever level range is set. So a check of linearity can be made with a single level calibrator if there is a level range control. Calibrate the instrument as usual and check the level indicated on all other ranges capable of displaying the calibration level. Any differences in

measured calibrator level are most likely due to non-linearity within the linearity range.

4. Using a multi-level calibrator (if one is available) check the linearity errors at different levels within a level range and check errors between the level ranges with a signal at the same relative level within each level range.
5. Using a multi-frequency calibrator (if one is available) test the frequency response of the instrument. It will be necessary to correct the quoted calibrator level at different frequencies for the microphone and coupler used. If this information is not available with the calibrator the manufacturer of the instrument may be able to supply it. With multi-frequency calibrators used within HSE the difference between free field and the corrected calibrator response is usually within ±0.3dB at frequencies from 250Hz to 4kHz. Larger variations occur at 125Hz.
6. If more than one instrument is available cross-check their measurements. The measurements should be very similar if the sound is steady without any dominant tones. Larger variations may occur if the sound is impulsive.
7. Check the background electrical noise of a PSEM by leaving it undistrubed in a quiet room for about two hours. A count exceeding 8%, for a 90dB criterion level, accumulated within 2 hours corresponds to a background noise level of over 85 dB(A).

CONCLUSIONS

Experience gained in testing integrating sound level meters over the last 10 years has shown that a significant percentage fail to meet their specification on delivery. Thus purchasers should check their instruments carefully before accepting them from the manufacturer.

REFERENCES

[1] International Electrotechnical Commission "Sound level meters" Publication 651 (1979).

[2] British Standards Institution "Specification for Sound level meters" BS 5969 (1981).

[3] International Electrotechnical Commission "Integrating-averaging sound level meters" Publication 804 (1985).

[4] British Standards Institution "British Standard Specification for Integrating-averaging sound level meters" BS 6698 (1986).

[5] British Standards Institution "British Standard Specification for Personal sound exposure meters" BS 6402 (1983).

[6] International Electrotechnical Commission "Recommendation for Sound level meters" Publication 123 (1961).

[7] International Electrotechnical Commission "Specification for Precision sound level meters" Publication 179 (1965 and 1973).