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PATTERN EVALUATION AND PERIODIC VERIFICATION OF SOUND CALIBRATORS

P Hanes & S P Dowson

Centre for Ionising Radiation and Acoustics, National Physical Laboratory, Teddington, TW11 0LW, UK

1. INTRODUCTION

Sound calibrators and pistonphones are used to establish and maintain the acoustical sensitivity of sound level meters and other acoustical measurement systems. To ensure that these calibrations are well-founded, the performance of the sound calibrator itself must be verified. Performance requirements for sound calibrators are given in IEC 942:1988 [1], and a framework of tests for both pattern evaluation (type testing) and periodic verification is given in OIML R102:1992 [2].

This paper describes the current status of the specification standard, which is under review, and discusses the development of the services for pattern evaluation and periodic verification of sound calibrators provided by the National Physical Laboratory (NPL).

2. SPECIFICATION STANDARD

The International Electrotechnical Commission (IEC) is the standardising body responsible for the provision of specification standards for acoustical instruments, and for the revision and updating of those standards. IEC 942, published in 1988, provides specifications for sound calibrator performance (including pistonphones), but does not contain any detail of test methods for either pattern evaluation of a new model of instrument, or for the periodic verification of particular instruments on a regular basis. The International Organization of Legal Metrology (OIML) in its Recommendation R102 suggests a framework of tests to be undertaken for pattern evaluation and periodic verification, but again provides no detail on how to perform the tests.

IEC Technical Committee 29 'Electroacoustics' therefore established a Working Group to write a supplement to IEC 942 giving details of actual

test methods for sound calibrators, with the aim of ensuring greater consistency between different test houses, so that all would pass or fail a particular device. However when the Working Group started its task, it identified many ambiguities in IEC 942 where the requirements were incomplete and open to interpretation. Also, some of the tight tolerances were not achievable in practice, particularly for performance over a wide range of environmental conditions. A request for a limited revision of IEC 942 was therefore made, and accepted by IEC.

The revision of the document is now well advanced and contains both performance specifications and Annexes describing the necessary tests and test methods for both pattern evaluation and periodic verification. The document has been circulated to national committees as a committee draft and has received a positive vote, and the next stage will be circulation as a draft International Standard.

The draft has maintained 3 Classes of sound calibrator - Class 0 which is expected to be used in the laboratory and Classes 1 and 2 which are expected to be used as field calibrators. A new classification system has been introduced to remove the confusion surrounding the existing `L' marking, to make clear when corrections due to ambient environmental conditions have to be applied for the device to meet the standard, and to show whether the device complies over the full or limited range of environmental conditions given in the standard. In addition, the tolerances have been broken down into those applying at reference environmental conditions, with an additional element for operation over the wider range of conditions specified. In a departure from its current practice, TC29 agreed at a recent meeting that all new specification standards, or revisions of existing standards that it issues, must include a component within the specification tolerances to cover the expanded uncertainty of measurement of an average highly competent test laboratory. A device will then only comply when the measured value, increased by the expanded uncertainty, lies within the specification tolerances given in the standard.

3. PERIODIC VERIFICATION

The performance of a sound calibrator will vary throughout its lifetime, due to the effects of component ageing and general use and wear, often resulting in a change of output signal from the sound calibrator. The performance of a calibrator should therefore be tested periodically to verify that it still meets the requirements of its stated performance Class. The principal quantities measured are: sound pressure level, fundamental frequency, total harmonic distortion, stability of sound pressure level and stability of fundamental frequency.

NPL has provided a calibration service for sound calibrators for over 30 years, giving calibrations traceable to UK national standards for individual customers and for laboratories NAMAS-accredited through the United

Kingdom Accreditation Service (UKAS). Sound calibrators may be calibrated for use with a variety of types of measurement microphones. For IEC Types LS1, WS1, LS2 or WS2 [3, 4] the sound pressure level output is measured using the insert voltage technique with the calibrator coupled to an NPL-calibrated reference standard microphone of the required type. For IEC Type WS3, the sound pressure level is obtained by use of a ratio technique and application of a correction to the level obtained using a particular model of IEC Type WS2 microphone. Fundamental frequency and total harmonic distortion are also measured. For a level of confidence of at least 95 %, the current best measurement uncertainties for these quantities are 0.04 dB, 0.1 Hz and 0.5 % distortion respectively. The largest contribution to the uncertainty in the measurement of the sound pressure level is due to the uncertainty in the calibration of the reference microphone, which at best is 0.03 dB at a 95% confidence level.

The calibration service has recently been extended to include measurements of the short-term stability of the calibrator under test [5]. These additional tests measure the fluctuations in the sound pressure level and fundamental frequency output. Fluctuations are measured over a 20 s period, and use of an automated measurement system allows simultaneous measurement of all parameters for a particular sound calibrator. The current best measurement uncertainties are 0.01 dB for stability of sound pressure level and 0.01 % of fundamental frequency for stability of frequency. The results of all these measurements, together with a statement of compliance, or non-compliance, with the performance requirements of IEC 942:1988 for the appropriate Class, are provided as a verification service.

4. PATTERN EVALUATION

Although the measurements described above verify the performance of individual calibrators at approximately reference environmental conditions, the influence of a range of conditions that might influence the performance of a calibrator must be tested at some stage. Periodic verifications do not test the effects of extremes of temperature, relative humidity and static pressure that the calibrator may encounter in general use, nor do they consider the electromagnetic emissions or susceptibility of the calibrator. Such full testing of a model of calibrator is termed a pattern evaluation.

NPL is currently developing its services to provide pattern evaluations of new models of calibrator to the revised standard, when published. The extent of these tests entails measurements over a period of weeks. To minimise the time taken to evaluate a model of instrument, new dedicated facilities have been installed at NPL. A purpose-built temperature- and humidity-controlled chamber allows measurements to be performed over the full ranges specified in the revision of IEC 942: temperature: -10 °C to 50 °C; relative humidity: 10 % to 90 %. The chamber allows the temperature and relative humidity to be varied simultaneously to achieve combinations

of conditions within these limits. A new pressure vessel allows the influence of static pressure (in the range 65 kPa to 108 kPa) on the calibrator to be thoroughly tested.

In addition, these facilities can also be used to provide manufacturers with data on test prototypes in advance of formal pattern evaluation.

At present, tests of electromagnetic compatibility are not specified in the revision of IEC 942, as a further Working Group under TC29 is charged with producing suitable emc tests for all acoustical instruments. Until these product specific tests are available generic standards have to be used. It is probable that NPL will sub-contract these emc tests to a laboratory accredited in this field through UKAS.

Following publication of the revision of IEC 942 and its Annexes, NPL intends to perform and report pattern evaluation measurements under the OIML Certificate System [6]. The aim of this System is to encourage consistency of testing from one country to another by use of a standardised test report format, and so reduce the need for expensive re-testing in individual countries before sales of a particular model are permitted.

5. SUMMARY

The current version of IEC 942:1988 is at present undergoing a revision. The revised document aims to remove current ambiguities, as well as including more realistic tolerances and Annexes giving details of test methods for both pattern evaluation and periodic verification. It is expected that the tolerances will also include the expanded uncertainty of measurement of a typical highly competent test house, so it should be clear whether a particular model or specimen of calibrator fully meets the requirements of the revised standard.

NPL is developing its current services for sound calibrators and expects to be in a position to provide full pattern evaluation of new models of device to the revised standard when it is published, together with an updated version of the current periodic verification test.

6. REFERENCES

[1] 'Sound calibrators', International Standard, IEC 942:1988

[2] 'Sound calibrators', International Recommendation, OIML R 102:1992

[3] 'Measurement microphones - Part 1: Specifications for laboratory standard microphones', International Standard, IEC 1094-1:1992

[4] 'Measurement microphones - Part 4: Specifications for working standard microphones', International Standard, IEC 1094-4:1995

[5] P Hanes, 'Sound calibrators: calibration, verification and pattern evaluation', Proceedings of the Institute of Acoustics, 15, 5, 53-56 (1995)

[6] 'OIML Certificate System for measuring instruments', OIML Document, 1991