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REPORT

A review report of the current status of specification standards, calibration and testing of noise-measuring instrumentation in the UK and their application to MCERTS

Susan P Dowson and Mark Jiggins

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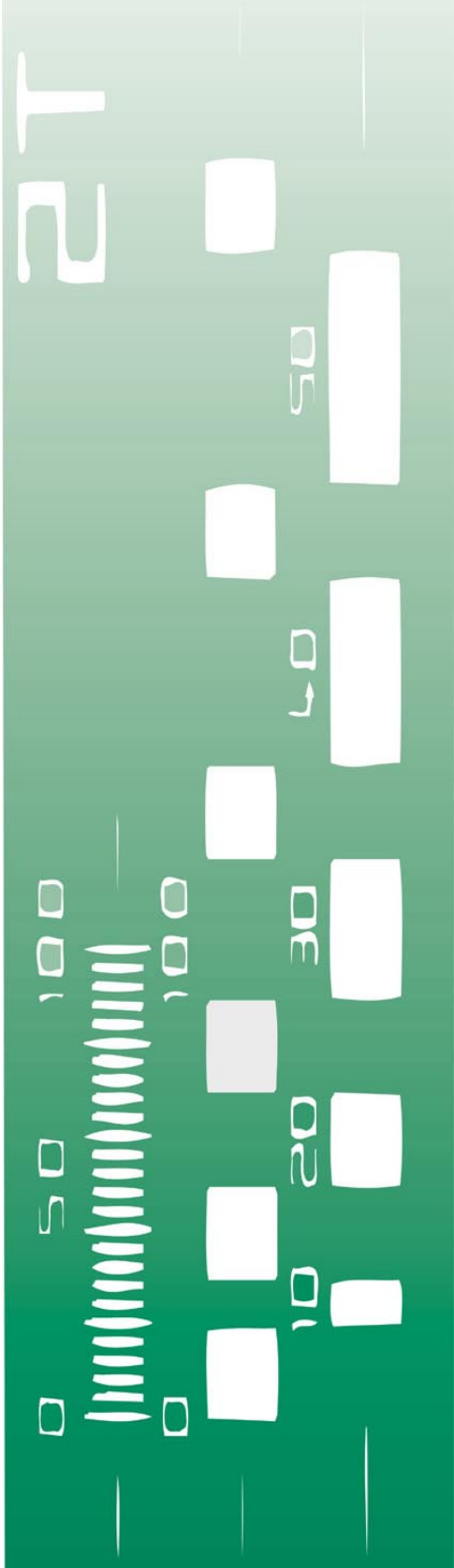

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A REVIEW REPORT OF THE CURRENT STATUS OF SPECIFICATION STANDARDS, CALIBRATION AND TESTING OF NOISE-MEASURING INSTRUMENTATION IN THE UK AND THEIR APPLICATION TO MCERTS

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ABSTRACT

The August 2000 legislation which introduced Integrated Pollution Prevention and Control, brings noise and vibration within the Environment Agency's regulatory functions for the first time. To assist with these regulatory functions in other areas the Agency has already established the Monitoring Certification Scheme (MCERTS) which sets standards and provides arrangements to ensure that the necessary monitoring data is reliable and of demonstrable quality. This report, for the National Compliance Assessment Service of the Environment Agency, provides details of specification standards, calibration and testing of noise-measuring equipment in the UK, based on the use of sound level meters and sound calibrators. It also outlines the skill-base necessary for noise monitoring personnel. Finally, the report discusses the implications of adopting MCERTS in this area and makes specific recommendations for consideration by the Environment Agency.

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Approved on behalf of the Managing Director, NPL
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EXECUTIVE SUMMARY

This report submitted by NPL to the National Compliance Assessment Service of the Environment Agency, is **A review report of the current status of specification standards, calibration and testing of noise-measuring instrumentation in the UK and their application to MCERTS**.

The main objectives of the report are:

- to supply the Environment Agency with a general knowledge of the specification standards, calibration and testing of noise-measuring equipment in the UK, in particular for sound level meters and sound calibrators
- to discuss the specification standards in relation to the product certification required by the Monitoring Certification Scheme (MCERTS) and the application of the MCERTS scheme
- to provide additional relevant background information in the area of noise and vibration measurement and instrumentation.

The report provides an outline of instrumentation and standardization, together with details of the current international specification standards for sound level meters and sound calibrators, which are under revision. Up-to-date information of the progress of these revisions and the current status of the revised documents is also included.

The report reviews the current situation regarding testing and calibration of noise-measuring equipment in the UK, and also provides information on vibration measuring instrumentation and standards. It also outlines the skill-base necessary for noise monitoring personnel.

Finally, the report discusses the implications of adopting MCERTS in this area, both in terms of the product certification requirements for monitoring instrumentation, and the competency certification arrangements for noise monitoring personnel. Specific recommendations for consideration by the Environment Agency are summarized below:

Product certification for monitoring instrumentation

- if the Environment Agency decide to mandate pattern evaluation testing for instrumentation used for MCERTS, this should follow exactly the tests in IEC 61672 Part 2 for sound level meters and IEC 60942 Annex A for sound calibrators. Testing should be performed under the OIML Certificate System, including production of a Pattern Evaluation Report, for sound calibrators using the version given in Annex C of IEC 60942, and for sound level meters following the relevant Part of IEC 61672 when it is published
- it would be preferable to require the use of class 1 instruments for MCERTS work
- as a minimum, the Environment Agency should consider making ISO 9000 registration a requirement for any laboratory performing pattern evaluation tests
- if the Environment Agency feels that pattern evaluation of instrumentation should be performed within the UK and not overseas, then it should discuss with DTI a means of providing appropriate funding, perhaps via a joint Department initiative
- the Environment Agency should require regular periodic verification of individual specimens of sound level meter, using the tests of IEC 61672 Part 3 when published, and the tests should

be performed by a UKAS-accredited laboratory

- a maximum interval of two years between sound level meter verifications should be required
- the Environment Agency should require each sound level meter to have an individual sound calibrator associated with it
- the sound calibrator should be calibrated at least every year by a UKAS-accredited laboratory, and should meet the requirements of IEC 60942 for the appropriate class
- for vibration, advice on instrumentation and testing should be sought from the two UKAS-accredited laboratories and from the holder of the primary standard, PTB in Germany.

Competency certification of noise monitoring personnel

- where measurements are performed as part of routine monitoring of process emissions then the measurement operative must be trained to a minimum standard of the Institute of Acoustics Certificate of Competency
- where a person is involved with setting emission limits, defining measurement methodology, establishing monitoring locations, monitoring vibration emissions or dealing with any noise control measures then they must be trained to a minimum standard of the Institute of Acoustics Diploma in Acoustics and Noise Control (including the appropriate modules).
- consideration should be given to allowing demonstration of the competency requirements of the MCERTS scheme by other equivalent academic means.

1 INTRODUCTION

The Environment Agency is the regulatory authority in England and Wales responsible for regulating processes under Integrated Pollution Control (IPC). The Environment and Heritage Service regulates IPC processes in Northern Ireland, whilst the Scottish Environmental Protection Service regulates IPC in Scotland. During the next six years, all IPC processes will be regulated under the Pollution Prevention and Control Regulations, which were introduced in 2000 and make the legal provisions for the Integrated Pollution Prevention and Control Directive (IPPC). IPPC is a regulatory system that employs an integrated approach to control the environmental impacts of certain industrial activities. It applies to industry sectors for energy, metals, minerals, chemicals, waste management and a group of other activities such as textile treatment, food production and intensive farming of pigs and poultry. To assist with these regulatory functions the Agency established the Monitoring Certification Scheme (MCERTS), to respond to the need to set standards and provide arrangements to ensure that the monitoring data necessary is of high quality and reliable. The Scheme initially focused on instruments used for monitoring emissions via chimney stacks to the atmosphere.

The IPPC legislation brings noise (and vibration) within the Agency's regulatory functions for the first time. The Environment Agency have therefore commissioned a review report from the National Physical Laboratory (NPL) on the current status of specification standards, calibration and testing of noise-measuring instrumentation in the UK and their application to MCERTS.

2 OBJECTIVES OF THE REPORT

The main objectives of the report are:

- to supply the National Compliance Assessment Service of the Environment Agency with a general knowledge of the specification standards, calibration and testing of noise-measuring equipment in the UK, in particular for sound level meters and sound calibrators

- to discuss the specification standards in relation to the product certification required by the Monitoring Certification Scheme (MCERTS) and the application of the MCERTS scheme

- to provide additional relevant background information in the area of noise and vibration measurement and instrumentation.

3 INTEGRATED POLLUTION PREVENTION AND CONTROL (IPPC)

IPPC involves determining the appropriate controls for industry to protect the environment via use of a 'single permit' process. To obtain a permit, operators have to show that they have developed proposals to apply the 'Best Available Techniques' (BAT) and meet certain other requirements. The aim of BAT is that the selection of techniques to protect the environment should achieve an appropriate balance between realising environmental benefits and costs incurred by the operators.

The Agency states that its aims in implementing IPPC are to:

- protect the environment as a whole
- promote the use of 'clean technology' to minimise waste at source
- encourage innovation, by leaving significant responsibility for developing satisfactory solutions to environmental issues with industrial operators, and
- to provide a 'one stop shop' for administering applications for permits to operate.

Once a permit has been issued, other parts of IPPC apply, such as compliance monitoring, permit reviews etc. The Agency is moving towards increased reliance on operator self-monitoring and use of continuous monitoring and sampling systems.

Under IPPC permits, operators within the controlled industries will be required to carry out compliance monitoring programmes for noise (and vibration) where appropriate. The Agency therefore needs to establish its technical requirements for noise (and vibration) monitoring, and is considering the possibility of adopting MCERTS in this area. The Environment Agency summarizes the main benefits of MCERTS as:

- MCERTS is a certification scheme that is both acceptable and formally recognised internationally
- it provides assurance to regulatory authorities that monitoring equipment and services approved to MCERTS standards are fit for purpose and capable of producing results of the required quality and reliability
- it gives users of the monitoring equipment or services confidence that they are robust and conform to the Agency performance standards
- it supports the delivery of accurate and reliable data to the public

and

- it provides the framework whereby further monitoring instrumentation and other aspects of compliance monitoring can be formally certified.

To adopt MCERTS in the noise and vibration area, the main aspects to consider are the product certification requirements for monitoring instrumentation, and the competency certification arrangements for noise monitoring personnel. For the instrumentation, where existing specification standards and verification/testing procedures exist, the Agency is keen to make use of these standards and methods where applicable.

4 INSTRUMENTATION AND STANDARDIZATION

4.1 Instrumentation

The most commonly-used instrument for measuring noise is a sound level meter. This generally consists of a microphone, a signal processor and a display device. The signal processor includes the combined functions of an amplifier with a specified and controlled frequency response, a device to form the square of the frequency-weighted time-varying sound pressure, and a time integrator or time averager. The microphone may be positioned in close proximity to the body of the meter or it may be some distance away and connected via an extension cable. Various accessories are often available for sound level meters, for example to provide protection against ambient conditions such as wind or rain, and these accessories can affect the performance of the meter. Other devices such as analysers may also be used, but these are generally manufactured to meet the same requirements as sound level meters. There are three main UK manufacturers of sound level meters, who can generally also supply sound calibrators. These are listed below together with their website addresses:

- Casella-CEL Ltd website www.cel.ltd.uk
- Castle Group Ltd website www.castlegroup.co.uk
- Cirrus Research plc website www.cirrusresearch.co.uk

In addition there are several overseas manufacturers of equipment including:

- Brüel & Kjær website www.bk.dk
- GRAS website www.gras.dk
- Larson Davis website www.larsondavis.com
- Norsonic website www.norsonic.com
- Quest website www.quest-technologies.com
- Rion website www.rion.co.jp
- 01 dB website www.01db.com

In order to provide a day-to-day spot-point calibration of the sound level meter, a sound calibrator is normally used with the sound level meter. Sound calibrators are designed to produce one or more known sound pressure levels at one or more frequencies, when the calibrator is coupled to specified models of microphones. Use of the sound calibrator therefore allows a check or adjustment of the overall sensitivity of the acoustical measuring system to be performed on a regular basis.

Simple Type 2 (see Section 5.1) sound level meter kits, including a sound calibrator, can be purchased for under £500, whereas for the more accurate Type 1, prices typically start at just over £1000, and depending on the features may approach ten times that price. Sound calibrators themselves typically cost a few hundred pounds. It is estimated that 4,000 to 5,000 sound level meters are sold in the UK each year. Further details of manufacturers and suppliers can be found in the ‘Buyers’ Guide’ and ‘Institute Register’ published by the Institute of Acoustics.

The performance requirements for both sound level meters and sound calibrators are given in international specification standards – see Section 5.

4.2 International Electrotechnical Commission (IEC)

The international organization responsible for producing specification standards for all electrical, electronic and related technologies, including acoustics, is the International Electrotechnical Commission (IEC). IEC was founded in 1906 and now has a membership of more than 50 participating countries, including all the world’s major trading nations and a growing number of

industrializing countries.

IEC has a structure consisting of Technical Committees (TCs), each dealing with a particular area, and within the TC, Working Groups (WGs) are set up to work on specification documents for particular instruments.

The relevant committee for acoustics is TC 29 'Electroacoustics'. Currently, the Chairman is Knud Rasmussen of Denmark and the Secretariat is also held by Denmark. TC 29 meets approximately every 18 months. Generally, the National Committees in each member country, such as the British Standards Institution (BSI) in the UK, appoint members to relevant WGs. However, each member of a WG or project team then acts as an individual expert and not as a representative of the National Committee, although often in practice the views are very similar. For acoustics, BSI appoints experts who are members of its own parallel committee EPL 29 'Electroacoustics'. Each IEC WG has a Project Leader or Convenor who is nominated at the time the work is proposed. Convenors are responsible for preparation of the various draft documents and for ensuring that drafts are produced on time.

At present, IEC TC 29 has 9 Working Groups (WGs) covering microphones, sound level meters, sound calibrators, audiometers, audiometric couplers, filters, hearing aids and electromagnetic compatibility requirements. The relevant WG for sound level meters is WG4, and for sound calibrators is WG17 – see section 7. Individual WGs meet in conjunction with the main TC 29 meetings and it is the responsibility of the Convenor to arrange any interim meetings. Depending on the current activity of the WG, either one or two meetings are usually held between the main TC 29 meetings.

IEC TCs, including TC 29, also have official liaisons with other International Committees such as the International Organization for Standardization (ISO) and the International Organization of Legal Metrology (OIML). ISO publishes many standards in the acoustics area, but whereas IEC deals mainly with instrumentation, ISO deals mainly with measurement methods. Interestingly, this is not true for vibration where ISO also provides the specification standards for the instrumentation.

4.3 International Organization of Legal Metrology

The International Organization of Legal Metrology (OIML) is an international organization that has an interest in the legal requirements for measuring instruments, which includes sound level meters. It was established in 1955 to promote the global harmonization of legal metrology procedures. OIML is an inter-governmental treaty organization. It has a technical committee structure, similar to that of IEC, with the committee experts being appointed by the Member States. TC13 'Measuring instruments for acoustics and vibration' is the relevant committee for acoustics and vibration, and Susan Dowson of NPL is the UK member.

OIML produces written International Recommendations, which provide Members with an internationally agreed-upon basis for the establishment of national legislation on various categories of measuring instruments. However the extent of implementation depends on national regulations. OIML also administers the OIML *Certificate System for Measuring Instruments* which was introduced in 1991, to lower costs associated with international trade of measuring instruments subject to legal requirements. The System has two main aims, firstly to ensure consistency in pattern evaluation testing of new models of instrument to the standard specification in many measurement fields, by specifying the tests and giving a format in which the results are to be quoted, so that, secondly, results performed in one country will be accepted by other countries within the OIML system. Mutual recognition of results would remove the need for manufacturers to undergo the expensive process of parallel testing of their products in many countries. Details of instruments that have been pattern evaluated under the OIML Certificate System are given on the OIML website at www.oiml.org. Currently no acoustical instruments are recorded there as having been tested under the scheme.

4.4 Standards in Europe and the UK

The European Committee for Electrotechnical Standardization (CENELEC) works closely with IEC to expedite the publication and common adoption of International Standards. In most cases in the acoustics area CENELEC usually publishes standards identical to the IEC version, but with an EN prefix to the standard number. Once CENELEC has selected an international standard for its own work (which very often is the IEC proposed document), all National Committees are required to stop work on the same subject and await the outcome of the CENELEC procedure. Following approval, each European Standard (EN) must be implemented at national level by being given the status of a national standard, and by withdrawal of any conflicting standard. This is a difference from IEC standards for which adoption is not mandatory. In the UK documents are given the prefix BS EN. Hence it is now unusual to publish a purely ‘British Standard’ document.

5 CURRENT SPECIFICATION STANDARDS

5.1 Sound level meters

Detailed performance requirements for sound level meters are currently specified in two international standards - IEC 60651 (formerly IEC 651) 'Sound level meters', originally published in 1979 [2] and IEC 60804 (formerly IEC 804) 'Integrating-averaging sound level meters' originally published in 1985 [3]. Tests for electromagnetic compatibility have recently been added to both standards. For IEC 60651 this meant the simple addition of an amendment, but due to past amendments IEC 60804 had to be re-issued as a second edition in 2000 [4], with the remainder of the text being unchanged. Both of these standards are dual-numbered as BS EN 60651 [5] and BS EN 60804 [6] respectively.

Both IEC 60651 and IEC 60804 give quite detailed specification requirements. Four accuracy classes are specified Type 0, Type 1, Type 2 and Type 3, with the tolerance limits around the design goals increasing with Type number. The main characteristics specified in IEC 60651 can be summarized into five main areas as follows:

- directional characteristics – ideally a sound level meter is equally responsive to sounds arriving from any angle of incidence
- frequency weighting and amplifier characteristics – A, B, C-weighting
- time weighting, detector and indicator characteristics – fast, slow, impulse, peak, r.m.s., sound pressure level linearity, range control accuracy
- sensitivity to various environments – static pressure, air temperature, humidity, mechanical vibrations, high sound pressure levels, electrostatic discharge, immunity to power- and radio-frequency fields and conducted disturbances
- and, more recently, emissions.

IEC 60804 gives the relevant specifications for integrating-averaging meters for:

- integrating and averaging and indicator characteristics - equivalent continuous sound pressure level L_{eq}, sound exposure level
- overload sensing and indicating characteristics – overload monitor and latched indication
- the directional and frequency weighting characteristics and the sensitivity to various environment specifications from IEC 60651 also apply.

IEC 60651 and IEC 60804 also give many other detailed specifications, and provide full specifications relevant to pattern evaluation (or type testing) of new models of instrument, although they do not consider uncertainties in the measurements performed to demonstrate conformance to the standard, or give very detailed test methods. However, the standards do not deal explicitly with the periodic verification of conformance of individual specimens of sound level meter.

Due to the demand for such a verification test within the UK, a British Standard, BS 7580 'The verification of sound level meters', originally published in 1992, was therefore written to specify a sufficient but limited set of tests based on IEC 60651 and IEC 60804 to verify the accuracy of an instrument at regular intervals. The remit of the BSI working group was well defined. It was to draw up a standard with sufficient detail to ensure consistency of testing between different test houses, and the tests should be sufficient to verify the accuracy of the meter at regular intervals. It was <u>not</u> permitted to substantially alter any of the tests in IEC 60651 or IEC 60804. The WG used as its basis two documents produced by OIML.

These OIML documents, Recommendation R58 [7] for sound level meters and OIML R88 [8] for integrating-averaging meters, suggest a framework of tests drawn from IEC 60651 and IEC 60804 to be performed for both pattern evaluation and for periodic verification. However they do not give any detail on the method of performing the tests, and describing this important aspect was the main task of

the BSI WG. BS 7580 applies to all Types of meter and assumes that the instrument was originally manufactured in accordance with IEC 60651 or IEC 60804 as appropriate.

BS 7580 : 1982 was renumbered and republished in 1997 as BS 7580 : Part 1 : 1997 [9], and a further issue of the standard was published, dated April 1999. This latest version confirms that uncertainties of measurement of the testing laboratory are not to be considered for the demonstration of conformance with BS 7580, as no allowance was made for these uncertainties in the tolerances given in IEC 60651 and IEC 60804.

Part 2 of BS 7580 was issued in 1997 [10], and this gives a shortened procedure for the verification of Type 2 instruments. For Part 2 to apply, either the model of instrument must have successfully undergone a full pattern evaluation test or the individual specimen must have previously passed BS 7580 Part 1. Part 2 allows the user to specify the ranges and features to be tested, and so can be tailored to a particular use.

The current sound level meter standards IEC 60651 and IEC 60804 are currently under revision, and progress on the revision is discussed in Section 7.

5.2 Sound calibrators

Detailed performance requirements for sound calibrators are currently specified in IEC 60942 : 1997 [11]. This is dual numbered in the UK as BS EN 60942 which was published in 1998 [12], and superseded BS 7189 : 1989 [13], which was equivalent to the first international standard on sound calibrators IEC 942, published in 1988 [14]. There is also an OIML Recommendation R102 [15] based on IEC 942 which specifies tests to be performed for both pattern evaluation and periodic verification, and gives a Pattern Evaluation Report format for tests of new models of meter [16]. No detailed methodology for the tests is given.

IEC 60942 : 1997 specifies three accuracy classes of sound calibrator - class 0, 1 and 2. The class number increases as the tolerances around the centre values are broadened. The standard specifies tolerances on the absolute value and stability of the sound pressure level and frequency generated, and an overall limit for total distortion when the calibrator is coupled to a specified model and configuration of microphone, and it also gives tolerances for equivalent free-field or diffuse-field sound pressure levels, for example when coupled to a given model of sound level meter. It also describes the effect of changing environmental conditions on the calibrator output, for example, static pressure, air temperature and relative humidity. A recent amendment has added tests of electromagnetic compatibility. For the first time, annexes giving detailed test methods for both pattern evaluation of new models of instrument and periodic verification of individual specimens are also included.

This current version of IEC 60942 was one of the first international acoustical specification standards to include maximum expanded uncertainties of measurement, and these uncertainties of measurement of the testing laboratory must be taken into account when determining conformance of a sound calibrator to the standard. The uncertainties of measurement depend on several factors including the calibration of the instruments in the measurement chain which give traceability to primary national standards, and also on the random uncertainty of repeat measurements performed on the actual device under test. The actual uncertainties must not exceed the maximum permitted values given in the standard, otherwise the results cannot be used to demonstrate conformance of a sound calibrator to the standard.

However in IEC 60942 : 1997 these maximum permitted expanded uncertainties of measurement are only included in the testing annexes and not in the tolerances in the main body of the standard. Mainly for this reason, the standard only just achieved a positive vote, allowing it to be published, and IEC TC 29 therefore took the view that work on the revision of the document should start immediately

it was published. This is now proceeding and progress is discussed in Section 7.4. For this reason the corresponding OIML document has not been updated from the 1992 version.

6 TESTING OF SOUND LEVEL METERS AND SOUND CALIBRATORS IN THE UK

6.1 Pattern evaluation

In some countries, such as Germany and France, it is mandatory for all models of sound level meter used for legal metrology purposes to be pattern evaluated and then verified on a regular basis, to check the performance of the instrument against the tolerances for the appropriate class. Whilst pattern evaluation of new models of instrument is not mandatory in the UK, it is still important for UK manufacturers who wish to sell their products abroad. Current there are no organizations in the UK that perform pattern evaluations of acoustical instruments.

Pattern evaluations are normally performed by national metrology institutes (NMIs), and within Europe the Physikalisch-Technische Bundesanstalt (PTB) in Germany has a long history and experience of performing these tests, and is internationally recognised for these services. The other European laboratory well-known for pattern evaluations is the Laboratoire National d'Essais (LNE) in France.

The full addresses for PTB and LNE are:

Physikalisch-Technische Bundesanstalt (PTB) Bundesallee 100 D-38116 Braunschweig Germany Tel: +49 531 592 3006 Website: www.ptb.de	Laboratoire National d'Essais (LNE) 29 avenue Roger Hennequin 78197 Trappes France Tel: +33 1 3069 1488 Website: www.lne.fr

Over recent years within the UK, initially in response to demands from manufacturers, NPL has been developing its capability in this area, with the aim of providing pattern evaluation services for sound level meters as well as for sound calibrators. A large proportion of NPL's work in the standards area is performed as part of the Acoustical Metrology Programme funded by the DTI's National Measurement System Policy Unit. This programme of work is agreed and funded for a three-year period, with the next Programme due to start in October 2001. As part of the formulation phase for the next programme, which was recently conducted by NPL on behalf of DTI, all existing activities have been carefully reviewed and scrutinised. This included work on developing pattern evaluation and verification tests to the new drafts of IEC 61672 as they appear, and also provision of sound calibrator pattern evaluation and periodic testing to the new version of IEC 60942 when it is published. As a result of the formulation process NPL makes recommendations to DTI, who together with an advisory group of experts from the field, make the final decision on the nature of the work DTI will fund over the next three years.

To continue the work on pattern evaluation and verification, funding would be required for the further development of the services, and when these are complete to fund maintenance of the services, in terms of equipment calibration, required validation, and control over software etc.

Although no specific discussions have taken place with UK manufacturers on any perceived impact if pattern evaluation were mandatory for instrumentation used for MCERTS work, several key manufacturers and suppliers were contacted as part of the formulation process for the new Acoustics Programme. Views were sought on whether or not NPL should continue with the development of pattern evaluation services, and if so, whether there would be any guarantee of submissions of

equipment from the manufacturers to justify maintaining the services. Two UK manufacturers regularly have instruments pattern evaluated, usually by PTB. The conclusion of these enquiries was that UK manufacturers are likely to continue to be satisfied by services provided by PTB.

By agreement of DTI and its industrial advisory group, development of pattern evaluation testing will therefore be brought to a close at NPL in September 2001. However, NPL will continue to perform research and development work in support of the revision of the sound level meter standard (see section 7), and will continue to provide the Convenor for the WG on sound calibrators. NPL will also have research facilities available in these areas for particular investigations required by manufacturers or users.

6.2 Periodic verification and uses of sound level meters within the UK

A full pattern evaluation test to the relevant IEC standard, particularly for sound level meters, is very labour-intensive and hence expensive taking many weeks of work, and whilst this cost can be borne by a manufacturer launching a new instrument, it is not practical for all instruments to be subjected to a complete test on a regular basis, hence the need for a more limited periodic test.

Within the UK periodic verification has a higher profile, with BS 7580 being mentioned in several measurement standards. Sound level meters are often exposed to hard use in the field, and failure or changes in performance do occur, with the microphone being particularly vulnerable. BS 7580 is a clear route to give the user confidence in his measuring equipment if challenged in a court of law.

The following list gives examples of users who benefit, or could benefit, from having a well-defined basis for the verification and calibration of their measuring equipment, together with details of the measurements they typically perform:

- residential noise imission monitoring and neighbour noise complaint investigation eg. sources such as music from places of entertainment, industrial sources such as fans, compressors, etc. Neighbour noise measurement - these may be general nuisance assessments under the Environmental Protection Act 1990 [17], Noise and Statutory Nuisance Act [18] or by Environmental Health Officers using the procedure in the Noise Act 1996 [19]. Specifically, the 1996 Noise Act stipulates that sound level meters used for measurements must be verified, together with the associated sound calibrator, not more than 24 months before use. When using BS 4142 ‘Method for rating industrial noise affecting mixed residential and industrial areas’ [20], specific reference is made to BS 7580 when extensive testing of instrumentation is required

- background/ambient noise monitoring – monitoring of existing ambient noise levels in order to consider the impact of a proposed planning development. Background noise levels are also measured when assessing likelihood of complaints from proposed or existing industrial noise sources using BS 4142

- industrial/commercial noise emission monitoring – checking of site noise emission values against those permitted by planning conditions. Evaluation of noise control works to check performance and minimise emissions

- noise at work assessment – measurement of the exposure to noise in the workplace by factory inspectors making measurements under with the Noise at Work regulations [21]. These implement the EC directive on noise at work, and include activity based and whole day exposure measurements. The requirements for calibration however are somewhat vague. The meter, which is usually a Type 2, should be 'fully checked at least every two years.' As a sound calibrator is also required, BS 7580 seems the appropriate standard on which to base the tests and this is consistent with the guidance issued by the Health and Safety Executive

which mentions accredited calibration laboratories

- entertainment noise emissions – assessment of audience exposure levels and emission levels to surrounding areas

- machinery sound power measurement – declaration of the emitted sound power requires measurement of the total sound power emitted by the source. Machinery cannot now be marketed within the EU unless it carries a conformity mark stating the sound power level. From 2001, measurements of noise emitted by machinery used outdoors comes under Directive 2000/14/EC [22]. Simple sequential measurements of sound power can be performed on steady sources with a sound level meter, often fitted with a filter set

- construction sites – measurement of the activity based source levels and background ambient levels at the planning stage. Checking compliance with site noise emission or imission values during site operation. A sound level meter of Type 1 is preferred but at least Type 2 should be used, with periodic tests referencing the requirements in BS 4142. Also, those making measurements of noise emission of construction machinery, where in the UK the noise-testing must be performed by an accredited laboratory

- room/building acoustics – measurement of background noise levels inside rooms. Generally the sound level meter is used in conjunction with a filter set to provide octave or one-third octave band levels. Measurement of reverberation times of rooms and auditoria, where the microphone/pre-amplifier is sometimes used to feed signals to other instrumentation. Measurement of the standardised level difference for compliance with the Building Regulations – Part E "Passage of Sound" [23]

- transport related exposure/imission measurement – measurements to check exposure to transport related sources such as road, rail and air, including those using the well-known document on 'Calculation of Road Traffic Noise' [24], which also gives details of equipment specifications and calibration requirements

- vehicle inspectors measuring motor vehicle noise, which is regulated by EC Directives, and implemented in the UK in the Motor Vehicles (Construction and Use) Regulations. Although BS 3539 [25] has not been withdrawn there is a statement in BS 7580 indicating that a meter which complies with BS 7580 is also deemed to conform to BS 3539

- audiometry – background noise measurement inside audiometric booths, calibration of audiometric systems and setting up levels for sound field audiometry

- general company Quality System requirements where there is a traceability requirement.

It is now quite common for sound level meters to have octave or one-third octave filters fitted as standard. These are not covered by the sound level meter specification standards, but in a separate standard, IEC 61260 [26]. Some units also provide much more extensive facilities, especially those meters based around a portable PC, where in-situ recording of audio samples of signals is now common place.

Any test to BS 7580 must be performed by a laboratory with equipment with appropriate calibrations, traceable to national standards. All the facilities which a meter possesses and are described in the standard must be tested, and the meter must have a sound calibrator associated with it. This sound calibrator must have been calibrated within the last year and conform to the relevant standard on sound calibrators in respect of sound pressure level, frequency and distortion. Under BS 7580 the sound level meter verification must be performed at least every two years, unless the particular

application of the meter makes it subject to other requirements.

The tests in BS 7580 fall into two groups - those performed electrically and those performed acoustically. Prior to any measurements the sensitivity of the meter is adjusted using its own calibrated sound calibrator, and then a measurement of self-generated noise is performed with the microphone removed. Various electrical signals as specified in the standard are then applied to test the following:

- linearity
- frequency weightings
- time weightings F and S
- peak response
- r.m.s. accuracy
- time weighting I
- time averaging
- pulse range
- sound exposure level
- overload indication

The test for peak response is included, but as this is only specified in IEC 60651 for Type 0 meters, it cannot be mandatory for other Types, so a Type 1, 2 or 3 meter cannot fail to conform to BS 7580 as a result of this test alone. Similarly the overload indication test was altered slightly to make it more meaningful.

The instrument complete with microphone is then calibrated using a continuous acoustical signal of frequency 1000 Hz at a sound pressure level in the range 73 dB to 125 dB. The sensitivity of the meter is adjusted, if necessary, so that the meter reads correctly. This acoustical calibration may be performed either in a plane progressive sound field by comparing the response of the instrument with that of a reference microphone substituted at the same position in the sound field, or by application of a standard sound calibrator, when corrections for the difference between the free-field and pressure response of the instrument must be applied. It is through this acoustical calibration that traceability to national standards is established. For the measurements in a plane progressive sound field the traceability is through the reference microphone, which will itself have been calibrated by the primary reciprocity technique [27] and standard corrections applied for free-field use. If a standard sound calibrator is used, this will have been calibrated using a reference microphone, which in turn has been calibrated either by comparison or by the reciprocity technique, again providing a direct line of traceability.

Finally the complete instrument is verified acoustically at 125 Hz and 8000 Hz, typical of the frequency range of use, to ensure it is within tolerance and that no microscopic hole exists in the microphone diaphragm. In addition to the two methods mentioned above an electrostatic actuator may be used, with appropriate corrections applied. Finally the associated sound calibrator is re-applied and the indication of the instrument recorded. This value should be used to adjust the sensitivity of the meter whenever it is used in future.

Assuming the meter meets all the tolerances for the appropriate Type, a certificate is issued stating conformance with the standard. BS 7580 also gives full details of the information to be provided on the certificate.

6.3 Calibration and testing of sound calibrators

There are two tests that can be performed on a sound calibrator to verify its accuracy at regular intervals. The first is purely a calibration, and standards laboratories such as NPL and also some UKAS-accredited calibration laboratories provide this service. The sound pressure level, frequency and total distortion generated by the calibrator are measured when it is coupled to a specified model

and configuration of microphone, and the values are then presented in the form of a calibration certificate. The microphone has already been calibrated and it is through this microphone calibration that the measurements of the sound calibrator are traceable to national standards. The measured values for the sound calibrator can of course be used to check the measured parameters against the requirements for the appropriate class of sound calibrator given in IEC 60942. The second is a verification service simply in terms of a 'pass/fail' for the parameters given in the standard. These tests are detailed in Annex B of IEC 60942 and cover sound pressure level, sound pressure level stability ie. short-term fluctuations, frequency and total distortion. If the sound calibrator performance is dependent on ambient pressure or temperature then it is possible that a barometer and/or thermometer could be supplied with the instrument. The standard allows for single point checks of these devices, although in reality no manufacturer is known to supply a thermometer, as most calibrator temperature coefficients are small. In the UK no organizations currently provide a periodic verification test to IEC 60942, although if requested NPL could currently do so.

6.4 Accredited calibration organizations within the UK

6.4.1 The accreditation process

Formal accreditation of both testing and calibration for many measurement disciplines within UK is performed by the United Kingdom Accreditation Service (UKAS). To receive accreditation organizations are audited by an assessment team, which normally consists, as a minimum, of a Technical Officer from UKAS and a Technical Assessor who has expertise in the particular field for which the laboratory is applying for accreditation. Normally the Technical Officer also acts as the lead assessor. The laboratory must have a Quality Manual in place covering the area for which it is seeking accreditation as well as the necessary documentation and controls for performing the calibrations.

Accreditation is against a standard set of documents. Until recently, in the UK, the main documents have been the NAMAS Accreditation Standard M10 [28], the M10 Supplement [29] and NAMAS Regulations M11 [30]. Currently accreditation is now moving to a more international footing with the accreditation standard being ISO 17025 [31]. All new accreditations are against this standard and existing laboratories have to demonstrate they are meeting ISO 17025 by the end of June 2002, otherwise their accreditation will be cancelled.

The first key item covered by ISO 17025 is management requirements under the headings of organization, quality system, document control, review of requests, tenders and contracts, sub-contracting, purchasing services and supplies, service to the client, complaints, control of non-conforming work, corrective action, preventive action, control of records, internal audits and management reviews. The second key item relates to technical requirements including general requirements, personnel, accommodation and environmental conditions, test and calibration methods and method validation, equipment, measurement traceability (it is necessary for the laboratory to hold appropriate reference standards with traceable calibrations), sampling, handling of test and calibration items, assuring the quality of test and calibration results and reporting the results. More details of the requirements under each of the headings can be found in the standard itself. ISO 17025 covers both calibration and testing laboratories. For the purposes of accreditation in the UK the calibration of sound calibrators and the verification of sound level meters are both covered by a 'calibration' rather than 'testing' accreditation.

Briefly, the accreditation process is as follows: initially the assessors generally undertake a 'pre-assessment visit', which takes the form of a discussion on the accreditations the laboratory are seeking and what will be required for them to achieve this, as well as giving an opportunity for the assessors to become familiar with the organization and its work, before the formal process of accreditation begins. Following that, and agreement by the laboratory to pay the appropriate fees, a formal 'assessment visit' takes place. During this the assessors seek to ensure not only that the requirements of ISO 17025 are met but also that the laboratory is following the requirements of its own Quality

Manual (which generally mirrors the requirements of ISO 17025). The assessors study the relevant manuals and paperwork, look in detail at the measurement laboratory, personnel, instrumentation and methods, and select and witness a particular calibration or test etc. Usually an audit device is provided, for which UKAS know the calibration values. The laboratory's results can then be compared with these known values, and calculations performed on the acceptability of the results.

During a visit the assessors record observations on any particular items they feel may not be following the laboratory's own Quality Manual or technical procedures, or may not be following ISO 17025. The process is completely 'open' and throughout the visit each assessor is accompanied by a member of the laboratory staff, who signs the record to show that any Observation is indeed a true fact. Later the lead assessor classifies these Observations and some will become non-compliances, and in this case the lead assessor notes against which clause of ISO 17025 the non-compliance applies. Corrective actions are then suggested by the laboratory and agreed by the assessors, and then the laboratory is given a set time period in which to perform these corrective actions. When these actions are successfully performed, either accreditation is granted in the case of an initial assessment, or maintained in the case of subsequent re-assessment or surveillance visits. For serious non-compliances, such as major breakdown of the Quality System a laboratory may be suspended, although this occurs rarely. Each accredited laboratory receives a surveillance visit every 12 months, with a more thorough re-assessment visit every 4 years.

Each accredited test or calibration, where applicable, has a best measurement capability associated with it in terms of an uncertainty of measurement for a coverage factor k = 2, corresponding to an approximate confidence level of 95%. This information together with the calibrations or tests for which the laboratory is accredited is included on the Schedule for the laboratory issued by UKAS. For calibration laboratories this information can be found on the UKAS Calibration Website at www.ukas.org.

There are therefore clear advantages in using UKAS-accredited laboratories for calibrations, as they have been independently assessed and have in place mechanisms which should continue to ensure validity of their results.

6.4.2 Organizations UKAS-accredited for sound level meter testing and sound calibrator calibration

NPL currently performs verifications to BS 7580 for sound level meters and performs calibrations of sound calibrators and is UKAS-accredited for these services, and so performs tests and calibrations for individual customers. One of NPL's primary roles is also to provide reference acoustical standards to other UKAS-accredited laboratories as well as to those who run 'internal' calibration services within their own companies.

At present there are five other laboratories accredited by UKAS to perform tests on sound level meters and/or sound calibrators, although their scope of accreditation does vary considerably, for example they are not all accredited to perform tests to BS 7580 Part 1. The six laboratories are:

Centre for Mechanical and Acoustical Metrology National Physical Laboratory Queens Road Teddington TW11 0LW Tel: 020 8977 3222	A V Calibration Unit 13C Old Bridge Way Shefford Bedfordshire SG17 5HQ Tel: 01462 638600

Brüel & Kjær A Division of Spectris UK Ltd Bedford House Rutherford Close Stevenage Hertfordshire SG1 2ND Tel: 01438 739100	Casella CEL Ltd Regent House 1 Wolseley Road Kempston Bedford MK42 7JY Tel: 01234 844161
MTS Consultancy 16 Scardale Crescent Scarborough North Yorkshire YO12 6LA Tel: 01723 500779	Services Electrical Standards Centre Defence Evaluation and Research Agency 'Aquila' Golf Road Bromley Kent BR1 2JB Tel: 020 8285 7407

It is estimated that between 600 and 700 accredited calibrations of both sound calibrators and sound level meters are performed each year in the UK. Prices vary considerably depending on the test and organization involved, but as an example the NPL prices currently quoted are from £113 for a sound calibrator and from £445 for a sound level meter.

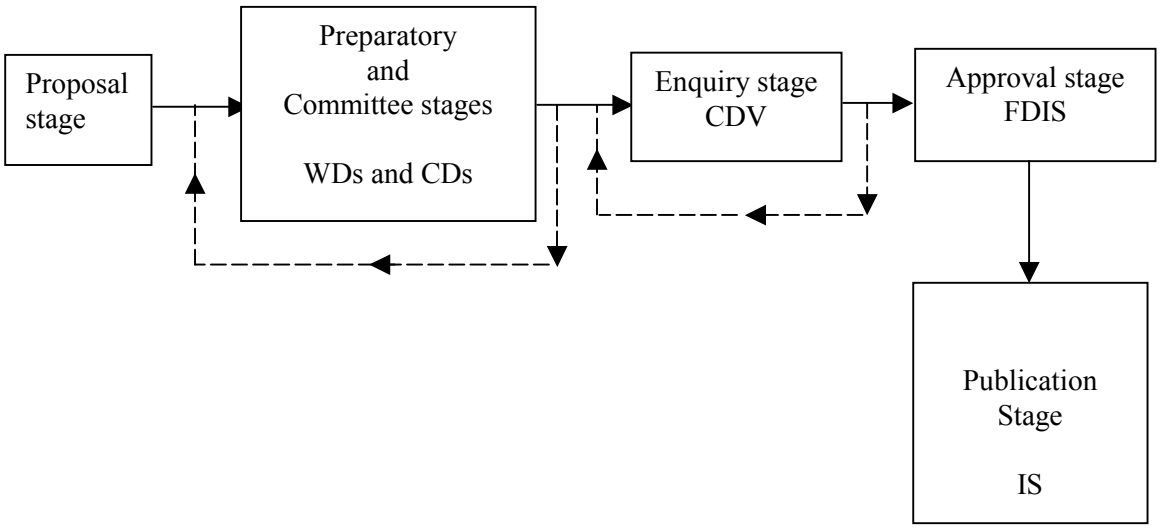
NPL was the first laboratory to introduce a verification service for sound level meters, but recognising that a UKAS accredited service to BS 7580 Part 1 is now available from three other suppliers, the service at NPL will no longer be supported from October 2001, although there will still be a capability to perform special investigations.

7 CURRENT REVISIONS OF SOUND LEVEL METER AND SOUND CALIBRATOR STANDARDS

7.1 The revision process

A new process has recently been introduced for the maintenance and revision of IEC standards, with the aim of fulfilling the need expressed by industry for stable publications. Under this new scheme, when a standard is published the Foreword will contain details of its 'maintenance cycle'. This will inform the user of the standard of the date when the standard will next be considered for review. The date will be suggested by the WG who has worked on the standard and agreed by the TC. Typically the maintenance cycle will be in the range from 2 years to a maximum of 5 years for a technical specification. In exceptional cases a review may be permitted before this time but only with permission of the IEC. At an appropriate point in the maintenance cycle, a maintenance team (MT) be set up, and its members may be the same or different from those who developed the original publication.

The revision of a standard under IEC follows virtually the same process as that for production of a new standard. The Figure below shows the process for a new standard.



During the *preparatory* and *committee* stages drafts are produced as agreed within the WG (MT). The Convenor normally generates the text, first in terms of Working Drafts. These are circulated to the WG members, and any comments discussed at WG meetings, following which the text is updated as agreed to become the next draft version. When the WG feel the document is suitable to be circulated as a Committee Draft (CD) it is submitted to the full National Committees for comment. In the UK it is at this stage that BSI normally publishes the draft as a Draft for Public Comment (DPC), so any interested parties can read the draft and submit comments on it. Three months are allowed for circulation of the document and submission of the comments to IEC.

Depending on the nature of the comments received the WG may decide to prepare further CDs. When the WG are satisfied that the majority of comments have been successfully dealt with, the document proceeds to the next stage, the Committee Draft for Vote (CDV). At this stage the document should be available in English and French, and for this enquiry stage a five month period is allowed for circulation to National Committees for comments and vote. The CDV is the last stage at which technical comments can be considered. Occasionally it is at this stage that BSI produce the Draft for Pubic Comment. If the CDV meets the voting criteria for approval a revised version of the document

is then sent to IEC Central Office within a period of four months for Final Draft International Standard (FDIS) processing.

For the *approval* stage the FDIS is circulated to National Committees for a two month voting period. Each National Committee's vote must be clear: positive, negative or abstention. The approval criteria is the same as for a CDV. If a document is approved it is published, and if not it is referred back to the TC to be reconsidered.

The *publication* stage is the responsibility of Central Office, and the document should be published within two months of the approval of the FDIS.

A similar, but not quite identical process exists for preparation of ISO documents, under the International Organization for Standardization.

7.2 Revision of sound level meter standards

Both IEC 60651 and IEC 60804 are currently under revision within IEC, and have been for many years. It is intended that a single publication will cover both sound level meters and integrating-averaging sound level meters. The work is being conducted within IEC TC 29/WG4. The convenor is Alan Marsh of the USA, and UK experts were nominated from BSI EPL 29. They are Susan Dowson, who is responsible for most of the work on sound level meters at NPL, Richard Tyler of AVI Ltd. who has experience in design and testing of sound level meters, and William Richings who is retired, having spent many years in the acoustics measuring instrument field.

The revision is a major task, not least because of the continuing advances in computing and design technology. The need to include maximum expanded uncertainties of measurement within the tolerances within the standard has delayed the revision process further, as many of the tests in the standard are new or variations of older tests. It was therefore necessary for members of the WG to perform some of the new tests to provide data on uncertainties to the WG, all of which took time.

As a result it has been decided that the new standard which has the title 'Sound level meters' and the number IEC 61672, will be published in Parts. Part 1 will give the 'Specifications', Part 2 'Pattern evaluation tests' will give detailed test methods for evaluation of new models of meter, Part 3 'Periodic tests' will give detailed test methods for regular testing of individual specimens of meter. This is the first time that detailed methodologies have been given in sound level meter standards, and when Part 3 is published it will fulfil the same rôle for meters manufactured to IEC 61672 as BS 7580 plays currently for meters manufactured to IEC 60651 and IEC 60804. Hence there will be no requirement for a new British Standard to replace BS 7580.

To date, work has concentrated on the first two Parts of IEC 61672. Part 1 has received a positive vote at the CDV stage (IEC document no. 29/460/CDV), and at the last meeting of IEC TC 29/WG4 in November 2000 all the comments were discussed and minor changes agreed. Following implementation of these changes to the text the document has been forwarded IEC for corresponding changes to the French text, and subsequent preparation and circulation to National Committees as an FDIS. This voting circulation will take two months, and if approved the document will then be published. It is therefore expected that the standard will be published in the latter part of 2001.

Part 2 has just been circulated for the required five-month period as a CDV, with a closing date for comments and votes of 12 October 2001. The IEC document no. is 29/494/CDV. A meeting of the WG is scheduled for November 2001 to discuss comments, and assuming a positive vote is received it is hoped that, following any changes agreed at this meeting, the document will proceed to FDIS stage with publication sometime during 2002. Parallel voting on the CDV is currently taking place within CENELEC.

Work has yet to begin in earnest on Part 3, although the WG realises that this part on periodic testing is likely to be the Part of most interest to users, who wish to verify the continuing performance of their instruments, as well as meeting the needs of various measurement procedure standards and Quality Systems.

There has been some discussion on general points for Part 3. Many of the WG members, including those from the UK, are aware of the need to limit the cost of the testing, although for those countries where periodic testing is mandatory for legal metrology purposes (such as Germany and France) this is not such an important consideration. The cost is clearly related to the time taken to perform the tests, and the agreed aim of the WG is to propose tests that can be completed in one day, including the time taken for production of the associated certificate. The WG feels that modern-day circuitry within the sound level meter is less likely to suffer changes than circuitry of the past, and so more accent should be put on the acoustical testing in a periodic test, to provide a more thorough check of the microphone itself. It is therefore likely that more extensive acoustical testing will be performed than the three frequencies currently used by BS 7580. The electrical performance tests will be developed from the corresponding electrical signal tests in Part 2. The leader of the WG expects to work on the text for Part 3 during this year, so that initial discussion can take place at the planned November 2001 meeting. This document will follow the same IEC comment and voting procedures as Parts 1 and 2. Although NPL currently has no plans to launch an accredited service to this Part 3 when published, it is expected that some of the other organizations currently accredited for BS 7580 testing, will be interested in developing such a service.

Two further Parts for IEC 61672 are planned for the future. The first of these will provide the OIML Pattern Evaluation Report Format to be used by those working under the OIML Certificate System. The second will consider the overall uncertainties of measurement to be expected when making measurements with a sound level meter that conforms to IEC 61672. No work has yet started on these two Parts.

It is intended that IEC 61672 will be a joint IEC and OIML Publication, showing close liaison between the two organizations, assuming that the voting procedures can be performed in parallel.

7.3 Overview of key differences between IEC 61672 and the existing standards

Without discussing in detail the individual features and tests, the following is a brief summary of the key difference between IEC 61672 and the existing standards:

- IEC 61672 Part 1 ‘Specifications’ covers sound level meters, integrating and integrating-averaging sound level meters in a single document

- there are only 2 accuracy classes instead of the 4 Types in the current standards

- many tolerances are greater than in IEC 60651 and IEC 60804. This is because IEC 61672 includes the uncertainty of measurement of ‘an average highly-competent’ testing laboratory in the tolerances. This maximum permitted expanded uncertainty, calculated according to the ISO Guide [32], is also quoted separately, which enables manufacturers to calculate the proportion of the tolerance available for design purposes, and prevents laboratories with very large uncertainties from making measurements of conformance. Results can only be used to determine conformance with the standard if the actual uncertainties are less than the maximum permitted

- A-weighting is mandatory for all instruments, and C-weighting is mandatory for class 1 meters at least for conformance testing. The optional LINEAR frequency response of IEC 60651 has been re-named, more appropriately, FLAT, and it must extend from less than 31.5 Hz to greater than 8 kHz. A new optional ZERO frequency response or Z-weighting is included which is constant over the frequency range specified for the sound level meter. B-weighting is no longer used in

current documents and has been omitted

- after much debate, TC 29 decided that in future the reference conditions for all its standards will be 23 °C and 50% relative humidity. For IEC 60651 and IEC 60804 these were 20 °C and 65% relative humidity respectively

- specifications for electromagnetic compatibility are included in Part 1 and are based on the most up-to-date generic standards

- Part 2 gives detailed test methods for pattern evaluation of new models of sound level meter, with the aim of ensuring consistency between different laboratories and countries

- Part 3 will give detailed test methods for periodic testing, again with the aim of ensuring consistency, and removing the need for local verification standards such as BS 7580

- a joint publication with OIML is planned.

Throughout the preparation of IEC 61672 the WG has aimed to make the documents as user-friendly and easy to understand as possible, within the constraints of the complex nature of some of the technical issues involved, to help consistency of interpretation wherever the standard is used.

7.4 Revision of sound calibrator standard

IEC 60942 is currently under revision with in IEC. The relevant WG is IEC TC29/WG17, with the UK leading the work as the Convenor is Susan Dowson of NPL. The other UK members are John Kuehn, who worked for many years for Brüel & Kjær in the UK, and Richard Tyler of AVI Ltd.

WG17 have had several meetings since work started in 1997, and the revision is progressing well with significant simplification of its contents. A single document contains the specifications, an Annex giving detailed test methods for pattern evaluation of new models or designs of sound calibrator, an Annex giving detailed test methods for periodic testing of individual specimens of sound calibrator in use, and a new Annex which gives the OIML Pattern Evaluation Report Format to be used by those laboratories making pattern evaluation measurements under the OIML Certificate System.

A CDV has just been circulated for the 5-month voting and comments period, with a closing date for comments and votes of 12 October 2001. The IEC document no. is 29/493/CD, and this document is also available within the UK as a Draft for Public Comment. As there is much common membership between WG4 and WG17, the next meeting of the WG will also be held in November 2001 to discuss the comments. Assuming a positive vote is received, it is expected that following minor changes agreed at this meeting the document will proceed to FDIS stage, with publication during 2002. Parallel voting on the CDV is also currently taking place within CENELEC.

7.5 Overview of key differences between the revision of IEC 60942 and the existing standard

At the outset, WG17 took the view that the revised standard should be a much simpler than the existing IEC 60942, which had become quite complex and difficult to understand, with time-consuming and hence expensive conformance tests. A summary of the key differences from the existing standard is as follows:

- the standard no longer covers equivalent free-field or diffuse-field levels but considers only the ‘pressure’ situation, so considerably reducing the number of maximum uncertainties of

measurement that have to be quoted to cover the various different cases

- there are three classes of calibrator - laboratory standard (class LS), class 1 and class 2. Class LS are normally only used in the laboratory, class 1 are primarily intended for use with class 1 sound level meters and class 2 with class 2 sound level meters

- the tolerance limits, which include maximum permitted uncertainties of measurement, are based on the use of a laboratory standard microphone as specified in IEC 61094-1 [33] in demonstrating conformance of a class LS sound calibrator to the standard; class 1 and class 2 tolerances are based on the use of a working standard microphone as specified in IEC 61094-4 [34] to demonstrate conformance. The maximum permitted uncertainties of measurement are also quoted separately

- a multi-level or multi-frequency sound calibrator will have the same class designation for all frequency and sound pressure level combinations which conform to the standard

- annexes are included giving details of the tests for pattern evaluation of new models of sound calibrator and the details of tests for periodic testing of individual specimens, and wherever possible the WG has reduced the number of tests required compared with the existing version of IEC 60942

- a new annex is included which gives the OIML Pattern Evaluation Report Format, for those laboratories making pattern evaluation measurements under the OIML Certificate System

- specifications for electromagnetic compatibility are included and are based on the most up-to-date generic standards

- a joint publication with OIML is planned.

8 NOISE STANDARDS RELEVANT TO IPPC EMISSION MONITORING

Most processes with noise emissions that are likely to be controlled under the IPPC regulations can loosely be categorised as industrial noise sources. Traditionally, noise emissions from sources of this nature have been assessed and controlled with the aim of preventing or minimising the adverse affects of the noise on nearby residents, thereby avoiding complaints of noise nuisance. Some processes will have been controlled at the planning stage by the use of planning permission conditions or agreements. Where a process without such conditions gives rise to complaints then it is likely that BS 4142 would have been used to assess the situation. Although only intended to give an indication of the likelihood of complaints, this standard is often used to assess the validity of complaints received.

The assessment method of BS 4142 compares the noise from the source, rated for any characteristics, with the pre-existing background noise levels in absence of the source in question. The assessment method is only intended to consider the measured or calculated source noise level at the imission point.

The measurement methodology of BS 4142 has, through recent revision, in general followed more closely those methods defined in BS 7445, “Description and measurement of environmental noise”. [35], [36], [37]. This British Standard is identical to the International Standard ISO 1996. The manner in which BS 4142 defines source characteristics could however be problematic when dealing with process emissions. It is essential that noise emission limits are defined in a completely objective manner, otherwise there will be uncertainty in the demonstration of compliance. BS 7445 suggests objective methodology for dealing with noise that contains discrete tones and impulses, and, although a controversial issue, an objective criterion should be the ultimate aim. Hence, the procedures given in BS 7445 are probably those most applicable when considering the appropriate measurement methodology to employ when assessing emissions from an authorised process.

9 VIBRATION

9.1 General

The IPPC will also cover vibration monitoring, and in the UK the situation regarding standardization for vibration instrumentation and measurement differs considerably from that for noise monitoring.

Several manufacturers produce meters for the measurement of vibration. Often these are sound level meter manufacturers as the designs are similar, and in some cases may be provided in terms of an 'additional' kit for a meter normally used for noise measurement. However, due to the much lower frequency ranges and differences in frequency weightings and measurement parameters, sound level meters are not always suitable for the measurement of vibration. Many measurement systems are measurement chains, composed of separate components including an analyser, or are PC based, with vibration traceability normally attained through use of a calibrated accelerometer. However it is important that information about the complete instrumentation chain is available to ensure consistency of results from one occasion to another, and between measurements using different instrumentation.

For some years now, NPL has had no direct involvement in vibration measurement or in providing associated measurement standards, except in the medical application of bone-conduction audiometry. UK primary standards are derived from PTB in Germany (see www.ptb.de/english/ and search on "acceleration").

There are also currently two organizations in the UK which are UKAS accredited largely for calibrations of accelerometers and charge amplifiers. Full details of their scope of accreditation can be found on the UKAS Website, and their contact details are as follows:

Sira Test & Certification Ltd. South Hill Chislehurst Kent BR7 5EH Tel: 020 8467 2636	Endevco Bedford House Rutherford Close Herts SG1 2ND Tel: 01438 739100

9.2 Specification standards for vibration instrumentation

International specification for vibration instrumentation is, interestingly, dealt with by an International Organization for Standardization (ISO) committee, and again there is a parallel UK committee. The relevant committees are ISO TC 108 'Mechanical vibration and shock' and BSI Committee GME/21.

The main instrumentation standard is ISO 8041:1990 'Human response to vibration. Measuring instrumentation', which was amended in 1999 [38], but it should be noted that this is for measuring human effects, rather than vibration caused by a process. Currently ISO 8041 gives specifications for the complete measurement equipment chain and covers whole-body and hand-arm vibration instrumentation, including various frequency weightings. It specifies 2 classes of instrument. Electrical, vibration and environmental tests are described, but in very little detail which could lead to considerable differences in interpretation by different test houses. No specific recommendations are given for periodic testing, although as with sound level meters, there is an OIML Recommendation, R103 [39],which picks out key tests, although it gives no detailed test methods. There is no current work on vibration in the relevant OIML Technical Committee, TC13.

ISO 8041 is currently under revision with Paul Pitts of the UK's Health and Safety Laboratory being the Project Leader, within TC 108/SC3. It is a joint WG, JWG1 with the relevant CEN committee TC 231. Other UK members include Paul Brereton of HSE and Martin Armstrong of Brüel & Kjær (UK). The revision of the document is complicated, given that it is applicable to all human vibration effects.

Where appropriate the revision will follow IEC 61672 quite closely. The revised ISO 8041 which will retain the same publication number and is expected to have only one performance class. Uncertainties of measurement will be included in the document, and this requirement is currently posing a problem for the WG as little data is available, and it is really necessary for some of the WG members to actually perform the tests to provide such data. In addition to the specifications, the standard will contain detailed test methods for both pattern evaluation and periodic testing as well as in-situ testing. This in-situ test will use a 'vibration calibrator'. No specification standard exists for a vibration calibrator, so an annex with the basic specifications is to be included in ISO 8041. This will therefore parallel the use of a sound calibrator with a sound level meter.

The new document was circulated for vote earlier in 2001 as a CD, and although the final voting outcome is not known many comments have been received and it seems likely that there will be a negative vote. The UK voted against the document due mainly to concern over the uncertainty values involved, and the amount of testing required. It is therefore likely that another CD will be required.

As with noise measurement there are various other standards produced by ISO, giving guidelines for measurement and assessment of human exposure to vibration, but these are unlikely to be applicable for MCERTS work, where it is presumably more likely that measurements will be made directly with an accelerometer rather than with some type of 'vibration meter' which really is intended for measuring effects on humans.

9.3 Testing of vibration instrumentation within the UK

A recent study, performed on behalf of DTI by Higginson Acoustics Ltd. and A V Technology, considered the technical and commercial need for pattern evaluation, verification and calibration test services for instrumentation used in the assessment of health risks from vibration [40]. The study used various surveys to collect views from interested parties, such as public bodies, manufacturers, standards organizations and suppliers and users of vibration-measuring instrumentation. Although concentrating on the health risk aspects of vibration measurement the study also gives an overview of the current and foreseeable legislation requirements and considers the difficulty of making accurate measurements.

The study notes that instrument manufacturers may and do claim compliance of their products with ISO 8041, and may provide their own in-house 'checks' or 'calibrations'. However, the study states that there is currently no independent laboratory anywhere in the world which offers a routine service for pattern evaluation of instruments for human vibration, so there is no means at present for formal assessment of the performance of the meters. The UK Health and Safety Executive has some experience of assessing these meters against the existing ISO 8041, and found that the meters did not always conform, and they believe that PTB probably could perform the tests required by the existing ISO 8041.

The study found that that there are two main ways of routinely checking 'calibration'. Either the accelerometer can be subjected to a known vibration amplitude on a pre-calibrated vibration table, or it can be compared with a known reference, although little detail is available in terms of test protocol. The study concluded that with the specification of a vibration calibrator in the revised version of ISO 8041, there would be a need for a measurement service within the UK to calibrate the calibrator, in the same way that services are available to calibrate acoustical calibrators.

Pattern evaluation is not mandated for any measurement of vibration within the UK, and further, no

accredited verification services are available for vibration instrumentation. This may be due to lack of information on periodic testing within ISO 8041, which means that any laboratory who wished to seek accreditation for testing vibration instrumentation would also have to justify to UKAS that the tests they proposed to perform were reasonable. Of course, it is much simpler to demonstrate this if the tests have been decided upon by a group of experts in the field whether nationally or internationally, rather than by an individual. However the revision of ISO 8041 should address this requirement, so circumventing the need for a British Standard for vibration instruments. It is likely that, as with sound level meters, many of the tests to check the signal processing features of the instruments will be performed electrically, with a vibration 'calibration' at a few frequencies, probably using a reference accelerometer.

The study concluded that a sufficiently robust case could not be made for the development of a service for the pattern evaluation of vibration measuring instruments, with the market foreseen to be relatively small (no more than 300 units per year) and the fact that current and expected regulations for human vibration measurement do not mandate independent conformity testing. The authors felt that it was possible that such a service may be developed elsewhere in Europe, but it appeared that UK manufacturers would not be at a competitive disadvantage if they used such a service. However, the study had different conclusions on periodic verification. Here it appears there is a demand from users, whether to satisfy the requirements of their quality systems or, more importantly, to defend themselves in possible cases of civil litigation for damages due to injury. Any periodic testing service is likely to be well-subscribed, although the cost of testing must not be considered excessive by users. However, it is important to remember that this study considered exclusively instrumentation used in measuring the effects of vibration on humans.

10 IMPLICATIONS OF THE IMPLEMENTATION OF MCERTS

The Environment Agency will need to make decisions in several areas in deciding how to implement MCERTS in the field of noise and vibration. Particular issues are discussed below, with key recommendations given in *italic* type.

10.1 Instrumentation

For sound level meters and sound calibrators the pattern evaluation, periodic verification or calibration requirements will be clearly defined when the relevant Parts of IEC 61672 and the revised version of IEC 60942 are published. The question for the Environment Agency is what level of testing should be a requirement for MCERTS, and what class of meter should be used. Modern designs of sound level meters often perform much of their signal processing in software or firmware, and given that the instrument is not modified then these items are unlikely to change, other than by an obvious failure. This could be construed as an argument for requiring pattern evaluation of new models of instrument, and the Environment Agency may like to consider this course of action, although it should be made clear that pattern evaluation as such is not mandated for other measurements within the UK. Pattern evaluation does of course consider the performance of the meter when subjected to various environmental conditions, and this may also be an important consideration for MCERTS work, and is the only way to be certain that a particular model of instrument meets the full requirements of the international specification standard.

For mutual recognition of pattern evaluation measurements from different countries to be acceptable, it is important that that the testing rigorously follows the full requirements of the IEC standards. For such testing to be acceptable for MCERTS the following is recommended:

- *if pattern evaluation is mandated for instrumentation used for MCERTS, this should follow exactly the tests in IEC 61672 Part 2 for sound level meters and IEC 60942 Annex A for sound calibrators. Testing should be performed under the OIML Certificate System, including production of a Pattern Evaluation Report, for sound calibrators using the version given in Annex C of IEC 60942, and for sound level meters following the relevant Part of IEC 61672 when it is published*

- *it would be preferable to require the use of class 1 instruments for MCERTS work.*

Overall, this should lead to use of the OIML Certificate System within acoustics, and so provide a benefit to manufacturers as the need for pattern evaluation in several countries should gradually be removed.

A further issue is whether the laboratory performing the pattern evaluation tests should be formally accredited by the organization equivalent to UKAS in the relevant country. Other NMIs have not all embraced formal accreditation for their calibration and verification services in the way that NPL has, so such a requirement may be difficult to implement. However

- *as a minimum the Environment Agency could insist on ISO 9000 registration for the laboratory concerned.*

As there are now no plans for NPL to maintain pattern evaluation services for sound level meters and sound calibrators in the future, the Environment Agency would need to accept results from overseas laboratories if they chose to mandate pattern evaluation for instruments used for MCERTS. If the Environment Agency feels that pattern evaluation should be carried out within the UK and not overseas then

- *the Environment Agency should discuss with DTI a means of providing appropriate funding, perhaps via a joint Department initiative.*

The need for periodic verification is more clear-cut, as this looks at individual specimens of meters, and it is important such tests are performed on a regular basis, largely to check the acoustical performance of the meter. The microphone is certainly the most delicate and vulnerable part of the instrument and Part 3 of IEC 61672 is likely to place considerable weight on testing with the microphone in place. For those instruments that have not been pattern evaluated, periodic verification informs the user that the individual specimen is capable of passing certain prescribed tests, but clearly is unable to make any statement about conforming to all the specifications of the standard, although an assumption is made that the instrument was originally manufactured to the standard. This is the level of testing currently performed on many meters in the UK.

Most measurement standards that require verification of the instrumentation normally state an interval of a maximum of two years between verifications, although one year intervals are sometimes required. If truly independently assessed verifications are needed then use of a UKAS-accredited laboratory should be a requirement:

- *the Environment Agency should require regular periodic verification of individual specimens of sound level meter, using the tests of IEC 61672 Part 3 when published, and the tests should be performed by a UKAS-accredited laboratory*

- *a maximum interval of two years between sound level meter verifications should be required.*

The Agency may wish to consider whether it will only permit meters manufactured to IEC 61672 to be used. If, for a transition period, meters manufactured to IEC 60651 and IEC 60804 are permitted, then BS 7580 Part 1 is the appropriate verification standard.

It is very important that the sound level meter has a sound calibrator associated with it, operating at a single frequency and level, normally 1 kHz. Applying this calibrator before and after measurements are performed tells the operator that the sound level meter performance is consistent during the measurements, but also recording any adjustments necessary to set up the sound level meter to the required indication with the sound calibrator applied, gives the operator valuable information about the stability or changes in the sound level meter's performance.

The normal interval for calibration of a sound calibrator is annually. A calibration, with the Certificate including the sound pressure level, frequency and distortion is preferred and is more use than a simple pass/fail test, as the data can in any case be checked against the specifications in the standard. It also enables the sound level meter to be set-up before use more accurately, by basing the setting-up value on the true sound pressure level generated by the sound calibrator, rather than on the nominal level:

- *the sound level meter should have an individual sound calibrator associated with it, and the Environment Agency should make this a requirement*

- *the sound calibrator should be calibrated at least every year by a UKAS-accredited laboratory, and should meet the requirements of IEC 60942 for the appropriate class.*

In summary, the vast majority of users of noise measuring equipment have some form of calibration performed on the measuring set. This is usually driven by the requirements laid down in standards to which they are working. Adoption of MCERTS would formalise these requirements, and although any mandatory requirements will have a financial impact, there would be a benefit in terms of clarity and a standardised approach. For the users, the level of this financial impact would depend on the

level of verification and calibration of their equipment which they currently have performed, and could require purchase of a new sound level meter if their current model does not meet the requirements. For some manufacturers, the financial impact could be significant if pattern evaluation were mandated. However such a scheme would favour manufacturers who already submit their instruments for independent testing, and this should be a benefit from the user viewpoint and in the quest for reliable, accurate measurements.

For vibration instrumentation the situation is less clear, with the main instrumentation standard, ISO 8041 currently under revision, and dealing with meters used to measure the effect of vibrations on humans. The use of accelerometers alone may require the Environment Agency to write its own test protocol but

- *advice should be sought from the two UKAS-accredited laboratories and from the holder of the primary standard, PTB.*

10.2 Operator competency

10.2.1 General

Historically all aspects of noise control and enforcement of site noise emissions have been performed by Local Authorities. For the controlled industries the IPPC regulations move the direct emphasis away from local authorities as the body considering and approving process authorisations. They will, however, continue to playing a vital role as the major consultee over the acceptability of noise emissions. Local authorities are often seen as expressing the impartial view and have a wealth of experience in dealing with noise issues.

If the MCERTS scheme were to be adopted to cover the noise aspects of IPPC it raises the issue of whether local authorities would also need to meet MCERTS requirements in order to continue to participate in the authorisation process. It could be argued that, as the IPPC regulations promote the 'polluter pays' principle, any actual monitoring of the process emissions would be performed by the process operator, or consultants acting on their behalf. This may well be satisfactory in many cases, but there will always remain the need to verify the polluter's declarations by performing independent checks. It is therefore likely that either local authorities would have to comply with MCERTS or would need to employ consultants that comply with the scheme where checks of these declared emitted values are to be performed.

Whenever monitoring takes place the results should be as representative, repeatable and reliable as possible, imposing a requirement that the person performing that monitoring should understand the monitoring process, having sufficient knowledge to ensure the exercise is undertaken in an informed manner. There are currently no legislative requirements for persons making noise measurements to have undertaken any specific training, or to hold any particular qualifications. For most measurement practitioners however, the ability to demonstrate a sufficient level of competency is considered essential in order to avoid criticism in adversarial situations.

In recent years, the Institute of Acoustics (IoA) has developed both a 'Diploma in Acoustics and Noise Control' and a 'Certificate of Competence in Environmental Noise Measurement', these courses are popular with those wishing to establish a suitable level of competency. More traditional educational qualifications such as a BSc, MSc and PhD covering the subject of acoustics and noise control are still quite common and are also generally considered to demonstrate sufficient competency.

If the current MCERTS scheme is extended to cover noise under the IPPC regulations, there is likely to be a need to formalise the current situation, thereby ensuring that monitoring is performed appropriately and that any results are of high quality. It is therefore necessary to establish a minimum

acceptable standard of training.

10.2.2 Certificate of Competency

The IoA 'Certificate of Competence in Environmental Noise Measurement' could be regarded as the minimum training standard necessary to perform monitoring of authorised process emissions. This might be applicable where the authorised process operator wishes to perform their own monitoring of site emissions. This Certificate covers a number of topics ranging from the basic concepts such as sound pressure, the decibel, noise indices and noise effects, through instrumentation types and use, to how noise propagates and may be controlled. An important element of the Certificate is practical use, with a proportion of the course timetable allocated to performing measurements and reporting the results. The Certificate is usually taught as an intensive period of study over 5 days and totals around 31 hours of work. Annex A reproduces the IoA information sheet on the Certificate of Competence. It is recommended that:

- *where measurements are performed as part of routine monitoring of process emissions then the measurement operative must be trained to a minimum standard of the Certificate of Competency.*

10.2.3 Diploma in Acoustics

Where it is essential that a measurement practitioner be fully conversant with the theory and practice of performing environmental noise measurement then the IoA 'Diploma in Acoustics and Noise Control' should be obtained. The Diploma has a mandatory module, the 'General Principles of Acoustics' followed by two elective specialist modules chosen from a list of around seven. Of these seven modules the following are felt to be of relevance, with the two chosen only from these:

- Law and Administration
- Measurement and Instrumentation
- Noise Control Engineering
- Vibration Control

Annex B reproduces the IoA information sheet on the Diploma.

The Diploma would be essential when the practitioner was asked to participate in deciding appropriate measurement methodology, emission monitoring locations, or reasonable emission values, etc. If remedial noise control works were necessary to ensure an authorised process emission was met then the knowledge gained from the Diploma would also be essential, in particular the Noise Control Engineering module. The Diploma also satisfies the academic requirements for Corporate Membership of the IoA whereas the Certificate of Competency does not.

Measurement of the vibration emitted from a process will require knowledge of the methods and equipment, topics not covered in the IoA's Certificate of Competency. The IoA Diploma does cover vibration in the General Principles module but for measurement practitioners undertaking site vibration emission monitoring then one of the two elective modules should be Vibration Control. It is recommended that:

- *where a person is involved with setting emission limits, defining measurement methodology, establishing monitoring locations, monitoring vibration emissions or dealing with any noise control measures then they must be trained to a minimum standard of the Diploma in Acoustics and Noise Control (including the appropriate modules).*

10.3 Impact of the Competency Requirements

Any formalisation of the educational requirements for measurement practitioners is likely to impact upon those already performing these tasks. Where sufficient levels of competency exist, but those

persons do not hold the required qualification or training requirements, there will be pressure to undertake this training. This could be perceived as unnecessary and costly. It would be advisable therefore to adopt a flexible approach, requiring a minimum standard of knowledge which may be demonstrated either by undertaking the approved training, or allowing demonstration of competency by equivalent standards of education or training.

Some manufacturers of sound level meters run short (ie. 1 to 2 day) courses aimed at those performing environmental noise measurements. Although of value, these courses cannot provide sufficient coverage of the topic to satisfy the minimum training requirement. It would be impossible to describe every suitable course of study, but a general principle should be established. For a particular academic course to be considered equivalent to either of those discussed above the holder must be able to show that substantial parts of the subject material cover topics equivalent to either the IoA Certificate or Diploma as appropriate. It is recommended:

- *consideration should be given to allowing demonstration of the competency requirements of the MCERTS scheme by other equivalent academic means.*

In summary, there are many academic courses of study available which could satisfy the requirement of the MCERTS scheme in ensuring that measurement practitioners are sufficiently competent to perform the duties required, although the IoA Certificate and Diploma seem to offer the required standard. Providing two distinct skill levels should allow reasonable access to a minimum standard without overburdening the industry.

11 REFERENCES

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ANNEX A: IOA CERTIFICATE OF COMPETENCE IN ENVIRONMENTAL NOISE MEASUREMENT

Aims

The aims of the course are to:

- provide delegates with a basic knowledge of the methodology of environmental noise measurement including in particular the use and accuracy requirements of sound level meters and analysers.
- enable delegates to be aware of the significance of measurement data against the framework of standards and legislation for environmental noise.

Objectives

The course is intended for technical and scientific staff in local authorities, environmental consultancies and companies whose employment requires them to gain a working knowledge of noise measurement methodology and a basic appreciation of noise control methods.

After completing the course delegates should be able to:

- make reliable measurements of background noise and noise from a variety of sources, according to the requirements of the relevant British Standard or guidance document
- present and interpret measurement data in a form suitable for inclusion in a consultant's report
- demonstrate an ability to measure noise levels in a manner appropriate to established rating procedures, guidance documents and standards set by local authorities
- identify in outline the principle methods of noise control to mitigate the impact of noise on the community
- explain the measurement methodology, data and interpretation of reports and environmental appraisals and comment on proposals for noise impact mitigation

Syllabus

1. Basic Concepts and Noise Units (5 hours)

Sound pressure and sound power. Pure tones, frequency, the audible range, broadband noise octave and 1/3 octave-band frequency analysis of noise.

Sound pressure level and sound power level and the decibel scale. The range of decibel levels and the significance of level changes (3dB, 10dB, 20dB etc.) in terms of energy content and loudness.

The procedure for combining and subtracting decibel levels including background levels. The variation of hearing sensitivity with frequency and the A-weighting scale. Steady and time-varying noise levels. L_{Aeq}, SEL, and exceedance levels L_{A10}, L_{A90} etc.

The effects of noise on people: hearing damage, annoyance, activity interference and sleep disturbance.

2. Instrumentation for Environmental Noise Measurement (4 hours)

Types of sound level meters for measurement of steady noise levels (BS EN 60651 : 1994).

Integrating averaging sound level meters (BS EN 60804 : 1994) for the measurement of time-varying noise, and environmental noise analysers for L_{A10} and L_{A90} measurements and frequency analysis.

Time weighting ('Fast', 'Slow', 'Impulse' and 'Peak' averaging times) and frequency weighting: A-weighting, C-weighting and Linear.

Types of microphone and their directionality. Accuracy of Types 1, 2 and 3 instruments. Field and laboratory calibration of sound level meters, including traceability. Electronic noise floor. Electrical interference.

Chart and tape recording of time-varying noise levels.

3. Noise Indices and Measurement Methodology for Environmental Noise Measurement (4 hours)

Standard methodology for the measurement of transportation, industrial, recreation and construction site noise and non-specific background noise levels, according to BS 7445.

Noise indices and specific measurement methodology, rating and assessment methods for:

- Industrial noise and BS 4142 : 1997, Method for Rating industrial noise affecting mixed industrial and residential areas.
- PPG 24, 'Planning and Noise' (Scottish Office, PAN 56, 'Planning and Noise' - Scotland only) for guidance on noise sensitive developments near existing noise sources, and new noise sources near noise sensitive property.
- Road traffic noise - the measurement method in 'Calculation of Road Traffic Noise' and the requirements for compensation under the Noise Insulation Regulations.
- An elementary introduction to:
    - Construction site noise - BS 5228 : 1994 guidance on prediction and control of noise
    - Aircraft noise and railway noise and appropriate sound insulation schemes
    - Control of noise at surface mineral workings, Planning guidance MPG 11 (Pan 50 Annex: A Scotland only)
    - Noise from leisure activities and associated codes of practice

4. Environmental Noise Measurement in Practice (10 hours including field work)

The use of sound level meters in typical practical environmental noise situations. Choice of microphone position. The use of wind shields, and the effect of wind and other environmental conditions on measurement accuracy. The influence of screening and reflecting surfaces. The nature and causes of other uncertainties in measurement. Choice of sampling periods for time-varying signals - averaging of L_{Aeq}, and the use of L_{A10}, L_{A90} etc.

Limitations on accuracy and tolerance limits associated with sampling.

Data interpretation and report preparation. Comprehension of noise issues in environmental assessments and consultant's reports.

5. Basic Understanding of Noise Propagation and Control (3½ hours)

The effects of distance, reflection, air absorption, ground absorption, wind and temperature gradients (ISO 9613). Attenuation by barriers, earth banks, vegetation. Propagation from point, line and planar noise sources.

Consideration of noise reduction at source and standard noise control techniques (enclosures, barriers, use of absorption and insulation). The source-path-receiver model. Planning to control external noise, for dwellings. (BRE report BR238 'Sound Control for Homes', and BS 8233 : 1999 'Sound insulation and noise reduction for buildings - Code of practice' are recommended references.)

6. Written Examination (2½ hours) Practical Test and Report Preparation (2 hours)

The practical test will include an objective measurement of an environmental noise source to demonstrate the use of suitable instrumentation and assessment of the noise using an appropriate measurement methodology.

Acquired data will then be presented in a written report of no more than 3 sides. The report must be laid out to include the following: date/time, description of noise source, subjective response, purpose of report, prevailing environmental conditions, instrumentation used and calibration, measurement location and proximity to noise source, measurement procedure, results, interpretation of results and conclusions.

Courses are offered on up to two occasions per year depending upon demand at Accredited Centres. Information on the Centres and dates of examinations may be obtained from the Institute.

ANNEX B : IOA DIPLOMA IN ACOUSTICS AND NOISE CONTROL

The status of the Diploma
The Diploma satisfies the academic requirements for Corporate Membership of the Institute.

What you need for the award of the Diploma

- Completion of an approved course of study.
- A pass in the written paper for the General Principles of Acoustics module.
- Passes in the written papers for two of the Specialist Modules.
- A satisfactory performance in laboratory and course work assignments.
- The satisfactory completion of the project.

What you need to embark upon a course of study
You should hold an HNC, HND or Degree in the general areas of engineering, science, construction or environmental studies. Other qualifications may also be acceptable.

What specialist modules are available

- Architectural and Building Acoustics
- Law and Administration
- Measurement and Instrumentation
- Noise Control Engineering
- Sound Reproduction
- Transportation Noise
- Vibration Control
  (these may not all be available with a particular tuition arrangement)

How the Diploma arrangements are regulated
Accredited tuition centres are inspected periodically. The written examinations are externally set by the Institute operating through a Chief Examiner and an Examination Board.

Where you can study
There are 10 centres accredited by the Institute for tuition which offer, subject to demand, part-time courses to various patterns. There is also an Institute Tutored Distance Learning programme, see opposite

The Tutored Distance Learning Programme

To whom this should be of Interest
Anyone who satisfies the general entry requirements set out opposite but finds it impossible to attend a part-time course in the usual way.

Programme structure
The material for the General Principles of Acoustics paper has been prepared as ten units and the two specialist papers a further four units each. The work package for each unit comprises of course notes supported by a three-hour face-to-face tutorial organised on a regional basis.

Laboratory Work
The laboratory programme is held at the University of Liverpool in two, two day sessions held in November and February.

Course Work
Four set course work assignments will be sent to each student for completion by a required date.

The Project
This is undertaken under the guidance of the your tutor.

Tuition Programme
Regional tutorial groups form from January of each year to commence their studies in October for the examination In the following June.

Fees
Tuition fees amount to £1,500.
Examination fees are £225.00

It may be necessary to restrict the availability of tuition for the specialist papers in line with the number of students involved. Anyone who already holds the Diploma may study in this mode for an additional specialist paper.