Proceedings of The Institute of Acoustics

AN APPLICATION TO BCS FOR ACOUSTICAL APPROVAL

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1. INTRODUCTION

The Ministry of Defence Electrical Calibration Centre at Aquila, Bromley, Kent is the Services Electrical Standards Centre also the Master Reference Standards Laboratory for electrical parameters for the MOD.

Measurements form a significant and essential part of design, production and maintenance processes for all military stores. These measurements must be based on well defined units and standards to establish beyond reasonable doubt that military stores are fit for the purpose.

It is therefore essential that:-

(a) All measurements are traceable to a common source.

(b) There is ready access to a National source of measurement facilities and expertise.

(c) Measurements made throughout the UK are compatible.

The responsibility for maintaining the National Standards of Metrology lies with the National Physical Laboratories at NPL Teddington and RSRE Malvern, but access to these National sources is, however, not always readily available.

It is primarily for this reason that the Services Electrical Standards Centre was established.

The Services Electrical Standards Centre (SESC for short) was in the first place established by the Ministry of Aviation in 1963 from a small nucleus of metrology expertise at Aquila at the request of the Ministry of Defence Administration Committee, acting on a report rendered by an inter-departmental committee.

Since then the SESC has grown in stature and progressively absorbed the metrology work of disseminating electrical standards to the Defence Sector previously carried out at the NPL and RSRE.

The traceable master reference metrology service is provided to the 3 armed Services MOD departments and other government establishments for all prime and derived electrical parameters in the frequency spectrum DC to 40GHz and currently extending up to 90GHz.

Over the years the detailed nature of the work at the SESC has varied enormously in response to the changing technological needs of the Defence sector, but broad objectives in the standards and metrology area have remained the same.

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In addition to supporting the Defence Sector the SESC gives a significant service to industry under the aegis of the BCS. Since 1969 when the BCS was established, over 300 self-accounting contractors organisations have referred to the SESC facilities for their traceability to National Standards.

In 1973 the SESC decided to set up an enquiry to see if there was a need for an acoustic noise standards and calibration laboratory. This involved sending a letter to all SESC customers to ascertain the need and the workload. Generally there had for some years been a growing demand for the control of noise which was steadily increasing due to the increase of cars and heavy lorries on to our highways, while overhead, aircraft noise had burst forth. The armed services had for some time been actively engaged in the measurement of acoustic noise in various forms, from impulse noise derived from gunfire to sustained noise associated with tanks and aircraft.

At this point in time there were only limited calibration facilities available within the United Kingdom, and most of these were set up to cover a specific requirement and were limited by either range of measurements or quantity of work that could be handled.

The results of the enquiry indicated an overwhelming need for an acoustic standards and calibration laboratory.

So the Services Electrical Standards Centre Acoustic Noise and Calibration Laboratory was established.

2. BRITISH CALIBRATION SERVICE

The British Calibration Service (BCS) was set up in 1966 and was the first of its type to be established in Europe.

Following its success many European countries modelled their own National Service on it.

BCS was set up to establish correct calibration procedures for all types of scientific instrumentation and to standardise certification of the results of the measurements. The BCS Certificate of Calibration gives an extremely high degree of assurance that the instrument has been calibrated correctly and gives traceability to the National Standards.

Recently the BCS added the field of acoustics to the range of measurements for which approval may be sought.

Eleven criteria documents have been produced outlining the requirement that a prospective laboratory applying for acoustic approval will be assessed on.

The first is the general criteria which all laboratories applying for approval must satisfy and the other ten are supplementary criteria covering the areas of greatest interest.

Some of the supplementary criteria cover the calibration of standard microphones, sound calibrators, sound level meters, pure tone audiometers, etc.

Any laboratory seeking approval for the calibration of instruments covered in the supplementary criteria must notify BCS headquarters detailing the areas for which BCS approval is sought.

BCS will then send full details of the approval scheme.

2.1. General Laboratory Requirements

Before compiling the application certain internal and external environmental factors have to be considered. These are covered in the BCS General Criteria Publication 1001 and although they are not mandatory it can be considered as a guide to good practice.

Some of the main points of the criteria are:-

(a) That the laboratory is solely used for the purpose of acoustic noise measurements and not shared with other unrelated activities.

(b) That the laboratory's construction, size and furnishings must allow measurements to be suitably undertaken.

(c) That the effects from the external environment on the laboratory are minimal, this means that they are not subject to external noise and vibration.

(d) That the environment inside the laboratory must be monitored and the results recorded.

Typically this would mean recording the ambient pressure, temperature and relative humidity.

(e) That cleanliness and good housekeeping must be maintained, this would involve setting up an operation rota for the day-to-day running of the laboratory, assuring that construction, repair and maintenance work was detached from the main laboratory, and that there was adequate storage space for instruments and other equipment when not in use.

3. SESC APPLICATION

The SESC was to seek approval for the calibration of sound calibrators and one inch standard condenser microphones. Under the BCS scheme laboratories are approved for specific measurements. The BCS supplementary criteria for calibrators calls for the calibration to be made with a calibrated microphone used as a working standard and a measuring system capable of measuring its open circuit sensitivity.

Alternatively using a calibrated calibrator with the microphone to compare the output of the calibrators under test with that of the working standard. The criteria also states that it is necessary to maintain independent traceability to NPL by means of a completely independent measuring system such as a microphone or calibrator which is maintained as a reference standard.

3.1. Sound Calibrators

The SESC method of calibration for the approval of sound calibrators was by the substitution technique using a working standard microphone.

Initial calibration of the measuring system using the insert voltage technique and a reference microphone traceable to the NPL was to establish the value of the working standard calibrator.

Once the value for the working standard had been established the test calibrator was calibrated against the standard using the substitution measurement technique.

To ensure repeatability of results, correct positioning of the microphone into the relevant calibrator was essential. For the calibration of the pistonphone calibrator it was found necessary to build a special housing to enable the microphone to locate centrally into the pistonphone, the whole assembly being mounted in the horizontal position on a sponge mat. The housing allowed the correct positioning of the microphone into the pistonphone each time the working standard and test pistonphone were interchanged. For the smaller configurations on the pistonphone, packing pieces provided the means to locate the microphone centrally into the pistonphone also providing support for the preamp.

For the acoustic calibrator the calibration was performed with the calibrator mounted in the vertical position resting on a sponge mat. The microphone and preamp assembly was lowered into the calibrator and once located was held in position using a retort stand. The calibration procedure involved interchanging the standard and test calibrators for a total of six times, the mean value of which was used to establish the value of the test calibrator. Calibration of these instruments had been in operation for some time during which calibration method sheets and stability record charts were produced.

3.2. Condenser Microphones

The BCS criteria for the absolute pressure calibration of laboratory standard condenser microphones is covered in the BCS publication 1003. The reciprocity method is a primary calibration procedure yielding the pressure sensitivity in terms of voltage ratio, but the basic requirements are an electrical system for measuring the ratio of the current passing through the microphone used as the transmitter to the open-circuit voltage appearing at the terminals of a microphone used as a receiver and a cavity of calculable acoustical impedance which is used to couple the two microphones together. This procedure yields a value for the product of the sensitivities of the two coupled microphones but, by repeating the procedure with three independent pair-wise combinations available from a group of three such microphones, the sensitivity of each may be determined.

The SESC application included a commercially available reciprocity calibration instrument to determine the microphone sentivities using three one inch standard microphones, one of which had traceability to the NPL.

The basic measurement performed was the measurement of U/I where 'U' the open circuit voltage from the receiver microphone and 'I' was the current through the transmitter when both were acoustically coupled.

The measurement procedure was relatively straight forward although certain measurement techniques did develop. The instrumentation required a long warm-up period before it was possible to repeat measurements to the required repeatability.

By using the 20cm coupler the corrections that are normally applied to the calibration result became less critical, the corrections were to compensate for such conditions as coupler volume, heat conduction, wave motion etc.

To monitor the temperature of the coupler it was found most suitable to stick the sensor to the side of the coupler using adhesive tape. To make a suitable acoustic seal when the microphone with the adaptor ring was slid into the coupler, vaseline was smeared onto a flat plate, then the face of the adaptor ring placed onto the plate.

When the adaptor ring was lifted the vaseline was found to have evenly covered the surface.

Variations in the measurement results due to environmental variations were evident. This became most pronounced if the instrumentation was subject to draughts.

Small vibrations also showed up as variation in the measurement result.

Placing the reciprocity instrument on a sponge mat tended to eliminate the effects of this.

4. SESC APPROVAL PROCESS

BCS at the National Physical Laboratory, were contacted and informed of our wish to obtain approval for our acoustical measurement facility.

BCS promptly replied by sending BCS publication 1000 which was the index of criteria for laboratory approval acoustical calibration of instruments.

The SESC application was compiled with guidance being taken from the supplementary criteria contained in the index. It contained all the information relative to the parameter for which approval was sought.

It showed the traceability of the standards to the NPL.

It provided information on the measurement systems and details of the frequency ranges covered.

The measurements were supported by stability and traceability records and results of the SESC/NPL audits.

Finally, uncertainty of measurement build-ups for the relative parameters, were given to substantiate our claims.

During the period that the application was being compiled an audit was arranged by NPL, this was to determine whether the laboratory was carrying out the measurements to within the limits of the claimed uncertainties.

Following the audit a meeting was arranged with SESC and BCS and a senior member of the Acoustics Branch at NPL to meet SESC Staff at Aquila to discuss the application in full.

At the meeting the measuring procedures were reviewed.

This resulted in the application being revised and resubmitted to BCS.

BCS next contacted the SESC to arrange another visit with a view to assessing the calibration procedures for each of the measurement parameters made by different members of the staff. The measurements were in strict accordance with the documented calibration procedure as shown in the application. The measurements were witnessed by a member of the BCS appointed assessment team who were in fact from the Acoustics Branch of the National Physical Laboratory.

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The standards used in the assessment were supplied by BCS and the results of the calibrations served as a post audit measurement to the revised application.

Throughout the approval process BCS and the appointed assessors were most helpful.

References

The General Criteria for laboratory approval for the acoustical calibration of instruments are given in BCS publication 1001.

Supplementary criteria are given in BCS publications 1002 to 1011.