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TESTING COMPUTER BASED INSTRUMENTS

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1. INTRODUCTION

Testing acoustic instruments for both pattern approval and periodic verification has reached a crossroads. For some instruments, traditional methods of testing are as valid as ever they were, but for some new forms of instrumentation, a new look must be taken at test methods.

If the instrument is of conventional form, looking and operating just like a traditional analogue instrument, it would seem that the traditional ways can be used in perpetuity. This suggests that there is no need to investigate the internal workings of the instrument, but just to treat it as a 'black box'. However, discussions at working group 4 of IEC TC29, show how this simple approach can lead to significant errors. For example, it is difficult the check the fall time of spl (F) response on many digital readout sound level meters, without measurement uncertainties greater than the stated tolerances.

If the instrument is totally different to a traditional analogue unit such as the computer based system 'ARIA', how the test is performed can have a very significant effect as to the acceptance or otherwise of the device. Clearly, it is not desirable to pass instruments which are deficient in some way, but equally, it is undesirable to limit technological change by ignoring the new ways of measurement which were never envisaged when IEC 651 and IEC 804 were written. While these concerns are mainly related to the pattern approval procedure, they also impinge on the periodic verification methods used at NAMAS approved laboratories.

2. BACKGROUND.

IEC 651 and IEC 804 are both in process of revision into a new combined standard. While current work can formally take note of what this new standard may mandate, it is reasonable to look at the expert opinion in the working group for guidance where the present standards are not clear.

The current draft of the new combined sound level meters standard says "Sound level meter configurations range from hand held instruments with an attached microphone, electronic analogue and/or digital signal processing, multiple analogue and digital outputs, and a display with multiple functions contained in one of or more enclosures. Sound level meters may include general purpose computers, recorders, printers, and other devices, which are required but not integral parts of the instrument".

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Clearly, older methods of testing find it hard to cope with such a wide variety of instrumentation and in addition, different test laboratories will not always agree on a 'correct' procedure with the result that one laboratory may 'fail' a unit while another will 'pass' it.

It is also a truism that the majority of members of an international working group are likely to include very senior and respected members of the profession, but almost by definition, some of these will not be 'skilled in the art' of current, that is computer, technology. Thus, it can be difficult to modify specifications and test methods when the finer details of some of the new devices are unknown to some 'experts'. This causes a gulf between practicing high technology engineers and mainly retired older members of the working group and this gap must be closed.

3. CURRENT SYSTEMS.

Current realisations of an acoustic measuring system include:-

Analogue instruments with exponential time constants having analogue or digital read-out. In other words apparently traditional devices, of which there are many examples.

'Short L_{eq}' meters measuring a linear integral and computing the exponential time constant etc. Cirrus Research CRL 243 and Norsonics 116 are typical of these.

Direct sampling meters where the ac signal from the microphone is digitised and a program produces the various metrics. 01dB 'ARIA' and CEL 593 are current examples.

Obviously, these are not separate categories and there are many instruments, such as the CRL 700, which may have a mixture of these technologies.

While any of these can be used with a computer, direct sampling meters are in effect totally computerised. On any unit, the computer can be an embedded device where the sound level meter has a conventional form such as the CEL 593, or it can be a conventional pc where that data is transferred from the digitiser to the external memory by some means, as in ARIA. While these are conceptually the same, they have very different test problems.

To try to formalise methods for any of these realisations is far beyond the scope of this paper, so just a few problems of software will be considered. In this context, 'software' will not fully include 'firmware' which is the program in the embedded computer chip inside the instrument, but a few minor aspects of this are relevant.

4. EMBEDDED CONTROLLERS.

In a modern embedded computer instrument, the function of the instrument is mainly determined by the firmware controlling the computer chip. Obviously, if the associated circuitry is inadequate and the conventional aspects of a meter such as dynamic span, frequency response etc. are not met, there is little that the firmware can do to improve the situation. However, if the basic hardware is adequate, the metric read on the display can be changed by modifying the internal program. Such modification may not require that the instrument is opened and a part changed. The new program can simply be sent to the computer chip via the external port of the unit. For example, the Cirrus CRL 700 series has over 100 metrics available for display. Only 15 of these are normally available on the keypad, although more are possible. The rest are selected by means of data transmitted to the instrument via the RS232 port, enabling a new keypad set. To pattern approve such a unit is fraught with difficulties. Does the test laboratory simply test the functions provided and limit the approval certificate to these functions? If so any slight change to the functions, such as from spl (S) to spl (F) may require a whole new pattern approval procedure. An alternative approach is to test the 'core' functions, such as sound exposure and then check the basic computations of the other metrics. This however can lead to obvious errors. A potential problem that test houses will have is where a manufacturer deliberately makes his firmware correct for a deficiency such as non linearity. While this may be possible on the five models submitted for pattern approval, it may not be possible in production.

It would therefore seem that the exact version of the firmware used, with a checksum or other unique identification, must be approved. Should the periodic verification at a NAMAS approved laboratory now only carry out procedures on instrument firmware correctly identified on the pattern approval certificate? If so, how can a manufacturer fix minor problems in the firmware without invalidating the pattern approval? It can be argued that the same situation has always applied where BASEFA of MESA approval has been sought. If this was granted, no component could be changed without a re-check of the instrument integrity. However, this is an inconsequential task compared with checking modified firmware, where a minor change to one part may cause unexpected and serious performance changes elsewhere.

5. EXTERNAL SOFTWARE.

The most obvious change in noise measuring instrumentation over the last few years is the proliferation of external software to provide additional data on the acoustic climate. Due to the history of various metrics, such as Sound Exposure, Sound Exposure Level, L_{eq}, Percentage Dose, Lepd, etc., it has become the norm for an instrument to read one of these and then have an external computer calculate the rest. Providing that the initial data was within the tolerances of the appropriate standard such as IEC 804, and there are no computational errors, the data should always be correct. This indeed is the rationale behind many simple pieces of software from 'non acoustic' sources of supply. If this were even remotely true, there would be no need for testing, we would all simply accept what the author of the software told us.

The first and most obvious point is that the use of an external computer is no reason not to carry out the normal prudent checks that would have been done before computers. This alone will demonstrate that several pieces of software are giving 'wrong' answers. In accounting, there is a perfectly good procedure where a new accounting program is submitted to a professional test house to have the output data validated. Many fail this hurdle at the first attempt. In acoustics there is no reason to think that similar errors will not occur. For example, a very early version of the Cirrus S22 suite for the BBC computer contained a gross calculation error which was not picked up by the Company or by any customer for over three years. At this time, over a decade ago, the use of a computer was so novel, that nobody thought to make simple checks to see if the data was 'reasonable'. 'The computer is always right' syndrome! Today, we would like to think that we would not make such fundamental errors.

The next obvious point concerns the machine on which the software is to be run. Should a particular machine be pattern approved? Software engineers laugh at this and claim that if it runs correctly on one MS-DOS machine, it will run exactly the same way on them all. Therefore, the computer is not part of the pattern approval. The reality is perhaps different. For example, to make screen updating quicker many programmers write directly to the screen locations, bypassing the DOS calls which slow everything down. A different manufacturer decides to use a different address for the screen start and we have an un-controlled situation, where anything might happen. If the user is lucky, only the screen will be affected, but in many cases, data is written to areas of memory where data is stored; the result can be wrong output.

A similar situation occurs where a manufacturer provides a 'test program' as part of the test procedure. Naturally they acclaim that this always under any circumstances gives the same data as the normal user suite. Again they can be wrong. A minor change to one of the two programs can result in very different data manipulation occurring. What then does the test house do? Validate both suites? If so, why write the test house program? At Cirrus, we provide test programs so that an instrument can be exercised fully. For example, the area noise monitor has a very large store which takes 7 days to fill. Clearly, to exercise this memory and to check that strange things do not occur, a special speeded up version of the firmware is useful to use with an external test program. While this is fine as a production control, it is probably not adequate for pattern approval, or even for periodic verification.

The view that the computer has to be considered carefully as part of the approval procedure can be taken to obvious extreme limits, where a test house will insist that the whole instrument, including the computer, are tested over the whole temperature and climatic range of IEC 651. This may not only cause damage to the computer, but many temperature controlled cabinets cannot cope with the huge thermal load that the computer presents, thus very large cooling units are needed. However, absurd this may seem, the text in IEC 651 clearly mandates this. Similarly, IEC 651 mandates that the whole instrument must meet the requirements of a plane wave response, where clearly this is not possible for some realisations of instrument. What then does the test house do? Ignore the requirements of the standard and use their professional judgement? This is fine if the company agrees with their decision, but can lead to problems if not.

6. CONCLUSION.

There are many problems associated with testing new technology instruments and we cannot wait for the new combined sound level meter standard before addressing them. No one test house, however competent, can alone answer the many new questions implicit in the use of a computer.

The national laboratories must give clear guidance to NAMAS approved laboratories as to procedures to adopt when periodically verifying instruments, even if this means a special procedure being adopted for each new realisation; a mammoth task for any group.