INSTRUMENTATION CORNER

How much is our hearing actually worth?

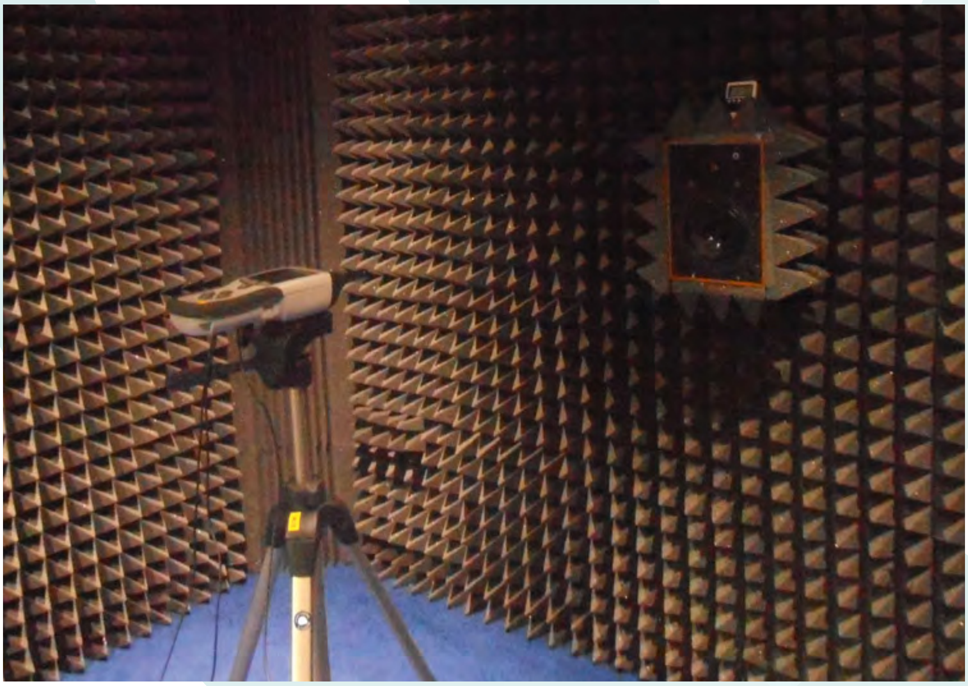
Are all meters equal? We subject a range of low-cost meters claiming to meet IEC61672 to a periodic test to see how well they performed.

By John Campbell and Martin Williams

It can be tempting to buy the cheapest tool for the job, especially if it claims to meet all the relevant requirements. But can these claims be trusted, should the buyer take these statements at face value or with a heavy pinch of salt? Six meters were randomly selected and tested at two independent, accredited ISO 17025 UKAS laboratories. All six meters failed at least one test, with a number failing multiple tests and basic requirements for providing the relevant information to perform a periodic test.

This may seem a bit strange as a contribution to a technical paper in a learned journal as they are not the tools that a professional would choose. They will, however, come across instruments in use by people who have acoustics as a secondary or tertiary job function who may well have chosen instrumentation that is marked with the established standard numbers because of price. With acoustic measurements, the important factor is that they are fit for purpose; if the objective is to set up a domestic hi-fi then any sound level indicator would do. However, if a meter is to support a statutory nuisance claim or part of a hearing conservation programme then the measurement must be to a certifiable standard with a specified level of accuracy to provide comfort and a reasonable level of uncertainty that the measured data is sampled accurately. The measuring instrument is a key element of this uncertainty so for any measurement that is in support of statutory or regulatory requirements its performance must be well understood. The International Standard BS EN IEC 61672 covers sound level meters; it specifies what they should do (the specification, part 1)tests that are design related (pattern evaluation, part 2) and tests that are use related (periodic verification, part 3).

- **1. Specification:** This sets out what the instrument must do and how accurately these objectives are to be realised. It allows for two classes of instruments, class 1(precision) and class 2 (general purpose). Both have the same design goals, but wider tolerances are allowed for class 2 instruments. It is the manufacturer's responsibility.
- **2. Pattern evaluation:** Here, fundamental matters are dealt with concerning how well the specification has been realised. In addition, the performance over the wide range of environments, i.e., anywhere humans live or work, as well as the effects of electromagnetic interference; all of these functions need very specialised facilities to verify. In addition, the acoustic effects of the instrument housing and front-end accessories such as windscreens need to be verified. This will provide the user with correction information to allow for regular calibration and give a full understanding of how the instrument performs in the field. Again, the manufacturer's responsibility but the data should be confirmed by testing at an independent national laboratory.
- **3. Periodic verification:** Sometimes referred to as 'calibration' is normally a biennial check based on a restricted range of parameters that are designed to show any drift or damage during use. These tests are carried out at close to reference conditions and make use of correction data confirmed during the pattern evaluation. This is the user's responsibility and for legal metrology applications carried out by an accredited laboratory. P52



Below: Free-field acoustic testing in an anechoic chamber

If both parts 2 and 3 have been carried out successfully then a calibration certificate becomes a certificate of conformance to the standard with results defendable in any court, tribunal or enquiry. If part 2 tests have not been carried out, any calibration certificate will be endorsed with a statement making it clear that the meter may not comply with all the requirements of the standard and that it was a snapshot of the instruments performance at the time of the part 3 tests.

The price of a sound level meter can range from a few tens of pounds to many thousands. The price may differ due to features within the instrument or because of the many expensive tests to confirm its ability to accurately measure noise have not been carried out.

This article reports on a project that looked at a range of low-cost meters that claimed compliance to BS EN IEC 61672 class 2 standard in their sales literature. Six meters were purchased, from five different manufacturers, and submitted for UKAS accredited periodic testing at Campbell Associates and Cirrus Research calibration facilities to see how they performed to the restricted range of tests at reference conditions. Testing was against the Edition of IEC 61672-3 with which each meter claimed conformance. Meters selected were priced between £75 to £375.

Results were mixed, with most failing to provide sufficient information to perform periodic test and all failing at least one test.

First impressions

First impressions of all instruments selected were good, each meter was well packed and built. Only two of the six had the required information within the user manuals to enable periodic testing to be performed. The other four manufacturers were approached for this missing information and none were able to provide this data. The information on the corrections, test points and reference data are mandated by the standards and hence if not available the meter immediately does not comply with the standard and testing should not be performed. However, for the purposes of this paper, it was decided that each of the test laboratories would make their own estimates on the required information based on previous experience so that testing could continue. For this exercise, each laboratory performed testing as best they could, one laboratory performed electrical and sound pressure testing, whilst another also performed free-field tests. This resulted in greater variance in results between the two calibration facilities than would be expected if all relevant information was available.

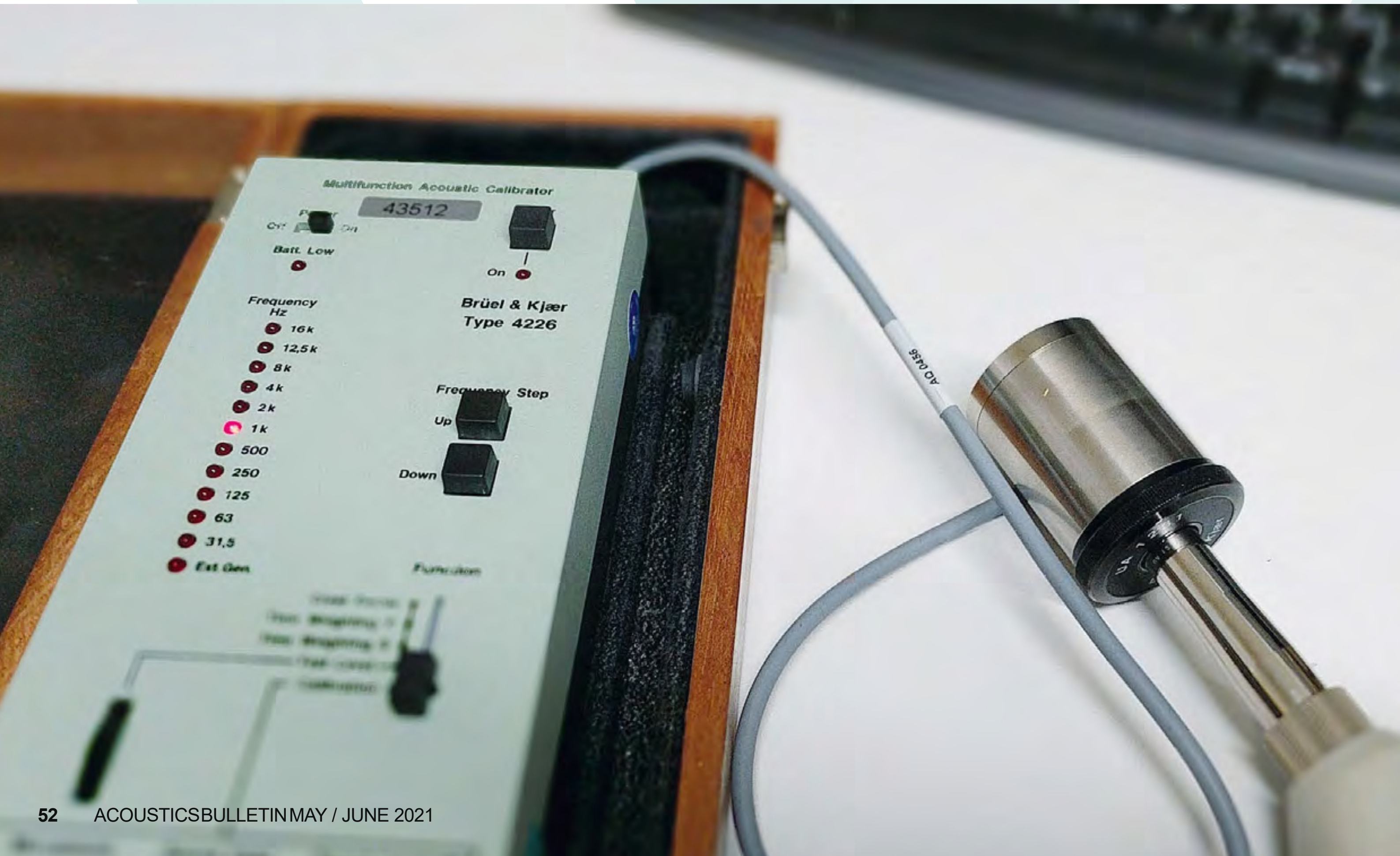
Method of testing

A number of the periodic tests are based on an electrical signal being applied to simulate an acoustic response. This is typically applied by removing the microphone and fitting an adaptor to the preamplifier. Some of the meters had fixed microphones, and, as no test point was provided, the electrical signals were directly input into the meter as appropriate. IEC 61672 requires a sound level meter to have a removable microphone so any meter that does not have this capability immediately fails to conform to the standard.

Other tests performed include sound pressure testing using a multi-frequency acoustic calibrator, measurement of the microphone self-noise and free-field testing in an anechoic chamber.

Test results

The following tables provide a summary of the results for each instrument at both test facilities. Instruments have been labelled A to F. P54



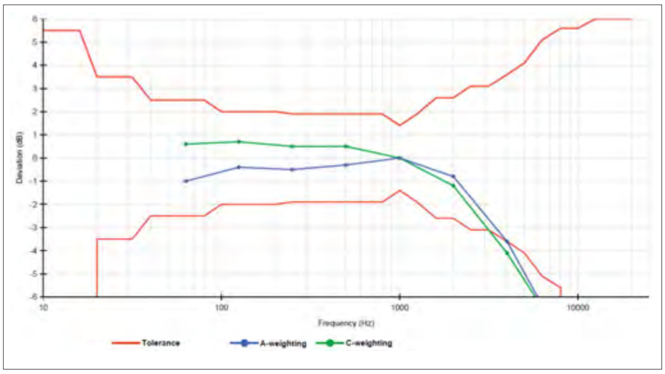
Below: Acoustic pressure testing using a B&K 4226 multifunction calibrator

Test per IEC 61672-3 (2006) Edition 1	Instrument A	Instrument D	Instrument E	Instrument F
Self-generated noise – clause10.2**	Failed (1)	Passed (1) Passed (2)	Passed (1) Passed (2)	Failed (1) Passed (2)
Acoustic frequency weightings – clause 11	Passed (1)	Passed (1)	Passed (1)	Passed (1)
Electrical frequency weightings – clause 12	Passed (1)	Failed (1) Failed (2)	Passed (1) Passed (2)	Passed (1) Passed (2)
Weighting at 1 kHz – clause 13	Failed (1) Failed (2)	Failed (1) Passed (2)	Passed (1) Passed (2)	Failed (1) Failed (2)
Linearity – clause 14	Passed (1)	Passed (1) Passed (2)	Passed (1) Passed (2)	Failed (1) Failed (2)
Linearity (all ranges) – clause 15	Passed (1)	Passed (1) Passed (2)	Passed (1) Passed (2)	Passed (1) Passed (2)
Tone burst response – clause 16	Failed (1)	Failed (1) Failed (2)	Failed (1) Failed (2)	Failed (1) Failed (2)
Overload indication – clause 18*	Passed (1)	Passed (1) Passed (2)	Failed (1) Failed (2)	Passed (1) Passed (2)

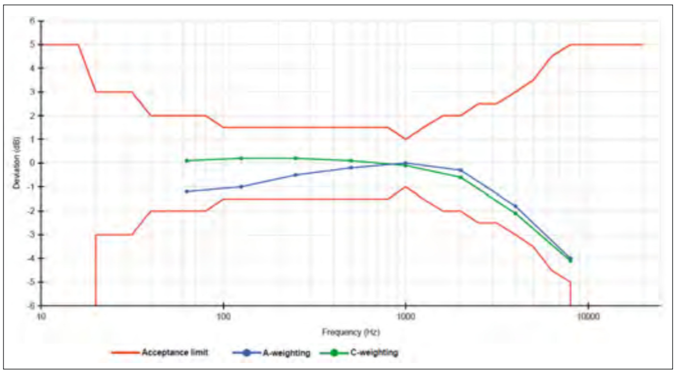
KEY:
*Overload is optional for non-integrating instruments
**Self-generated noise test is for indication and does not on its own, mean a meter does not comply, but may affect linearity
(1) Tests performed at Calibration facility 1
(2) Tests performed at Calibration facility 2

Test per IEC 61672-3 (2013) Edition 2	Instrument B	Instrument C
Self-generated noise – clause 11**	Passed (1)	Passed (1)
Acoustic frequency weightings – clause 12	Passed (1)	Passed (1)
Electrical frequency weightings – clause 13	Passed (1) Passed (2)	Passed (1) Failed (2)
Weighting at 1 kHz – clause 14	Passed (1)	Passed (1)
Long-term stability – clause 15	Passed (1)	Passed (1)
Linearity – clause 16	Failed (1)	Passed (1)
Tone burst response – clause 18	Failed (1)	Passed (1)
C-weighted peak – clause 19	Failed (1)	Passed (1)
Overload indication – clause 20*	Failed (1)	Passed (1)

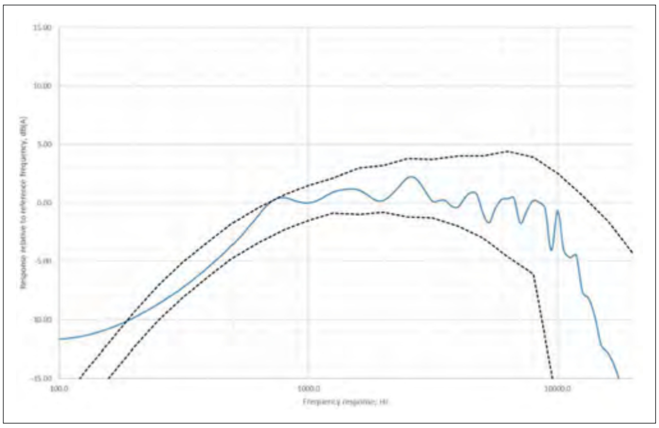
Typical results measured for frequency weighting are shown below. Typical failures recorded for units were failures above 2kHz and below 200Hz. Results are shown for electrical and free-field testing. Electrical testing should include manufacturers' correction data to correct to free-field which was typically not provided, whilst correction data is not required for free-field testing. P56



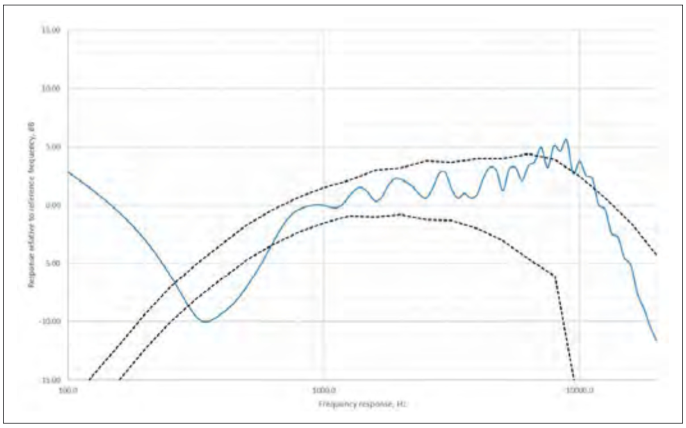
Electrical frequency A & C weighting for, instrument D – Fail
(no corrections provided)



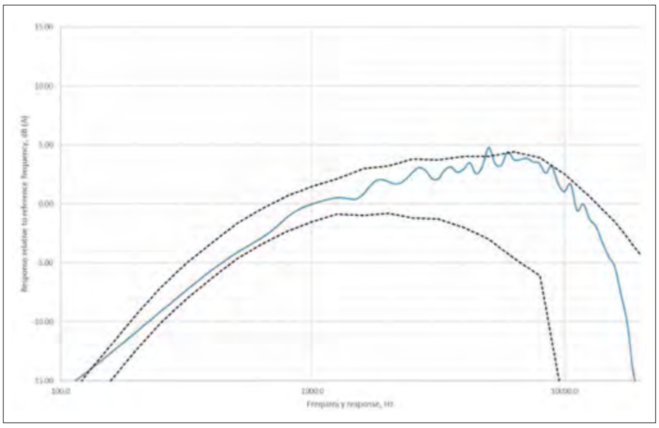
Electrical frequency A & C weighting, instrument A – Pass
(no corrections provided)



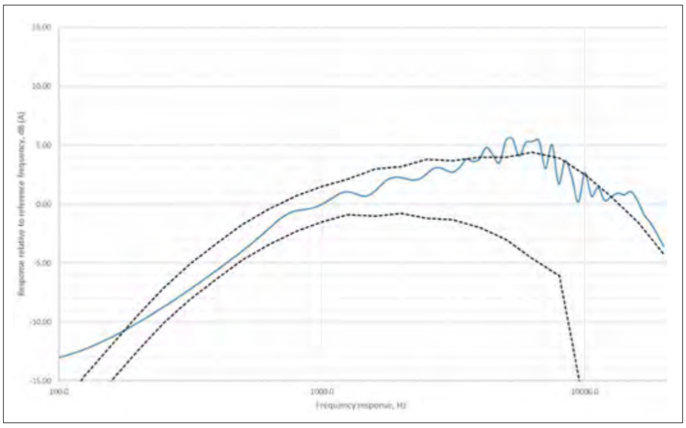
Free-field frequency A weighting, instrument D – Fail
(no corrections required for free-field testing)



Free-field frequency A weighting, instrument A – Fail
(no corrections required for free-field testing)



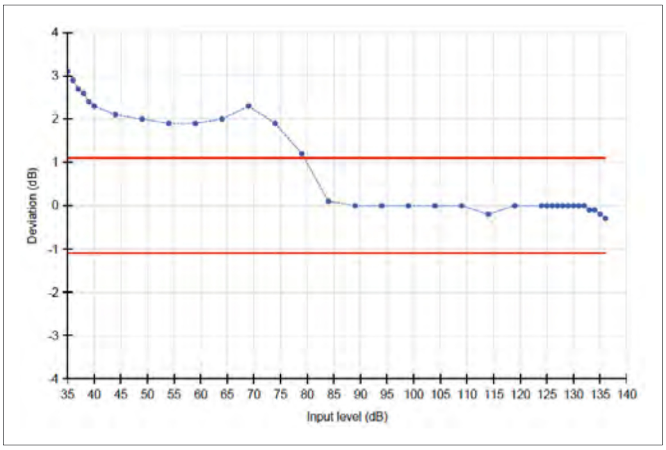
Free-field frequency A weighting, instrument E – Fail
(no corrections required for free-field testing)



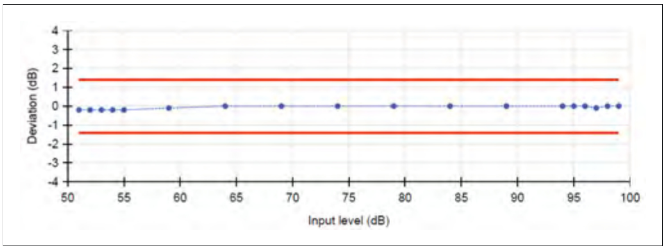
Free-field frequency A weighting, instrument F – Fail
(no corrections required for free-field testing)

Of the six units, two failed linearity testing. Linearity tests are performed at the reference level range for meters with multiple ranges. The results shown are for the reference range if identified in the manual. A second test is then performed at each range but limited to a single value in each range. Typical linearity failures at the low end of a range are due to noise floor of the instrument, however instrument A had an interesting step change halfway through the range. P58

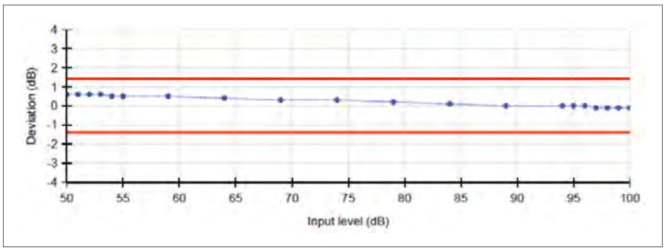
Most units failed tone burst tests, in many cases significantly. For example, a 2ms burst on meter D should have measured 79 dB, it measured 45.6 dB, giving a 33.4 dB error. Most tests performed by IEC61672 are based on stable sinusoidal test signals, whilst tone burst consist of a short burst of 4kHz sinusoidal signals, this test ensures the instrument measures complex signals correctly for fast and slow time weightings. A failure of this test will typically result in a meter reading low in real world situations and is typically the result of an over filtered front end or insufficient sampling to detect noise bursts.



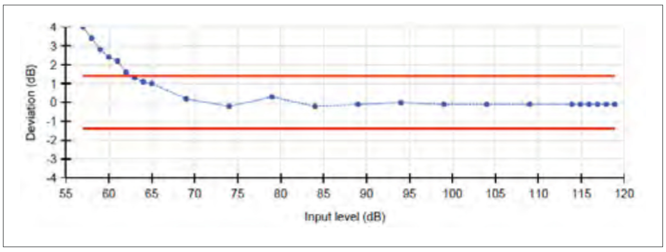
Electrical linearity – instrument A – Fail



Electrical linearity – instrument B – Pass



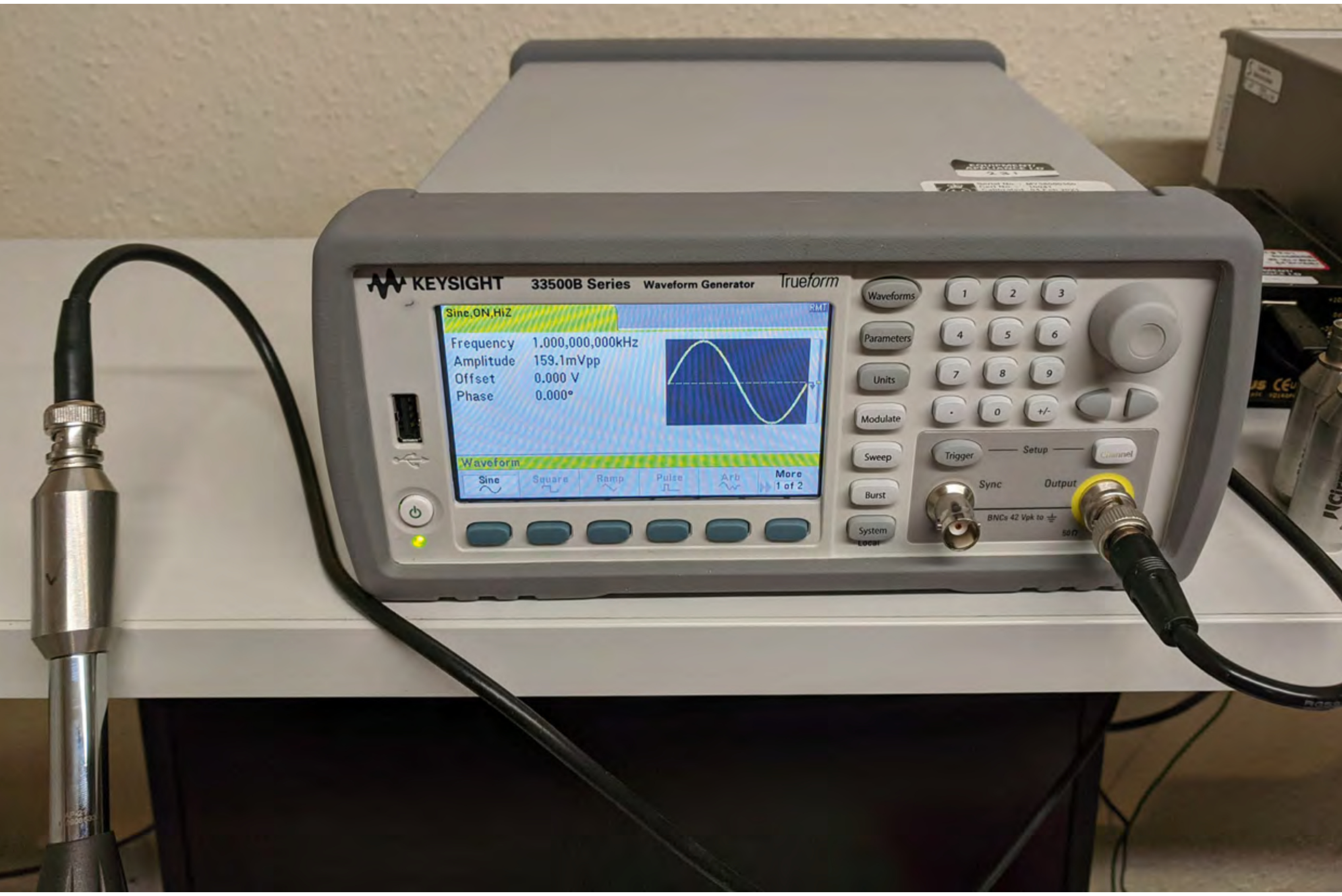
Electrical linearity – instrument E – Pass



Electrical linearity – instrument F – Fail

Burst Duration	Meter A			Meter B			Meter C			Tol (worst case)
	Exp	Act	Dev	Exp	Act	Dev	Exp	Act	Dev	
ms	dB	dB	dB	dB	dB	dB	dB	dB	dB	dB
200	96.0	91.7	-4.3	126.0	93.9	-32.1	116.0	116.0	0.0	+/-1.3
2	79.0	56.3	-22.7	109.0	58.8	-50.2	99.0	98.9	-0.1	+1.3/-2.8
0.25	50.0	45.4	-24.6	100.0	47.9	-52.1	90.0	89.8	-0.2	+1.8/-5.3

Burst Duration	Meter D			Meter E			Meter F			Tol (worst case)
	Exp	Act	Dev	Exp	Act	Dev	Exp	Act	Dev	
ms	dB	dB	dB	dB	dB	dB	dB	dB	dB	dB
200	96.0	96.8	0.8	96.0	88.0	-8.0	116.0	117.8	1.8	+/-1.3
2	79.0	45.6	-33.4	79.0	57.6	-21.4	99.0	80.0	-19.0	+1.3/-2.8
0.25	50.0	38.7	-31.3	50.0	41.1	-28.9	90.0	73.8	-16.2	+1.8/-5.3



Above: Electrical testing a meter by using an adaptor fitted to the preamplifier

Summary and conclusion

All meters failed at least one test. Whilst one meter was close to passing all tests; others failed several tests, including linearity, frequency weighting and especially tone burst, which five of the six failed.

Each meter was advertised as being compliant to IEC 61672, which would indicate it should meet the stringent requirements of this standard and should pass all the tests detailed of part 3. Meters were purchased new and immediately submitted to periodic testing per IEC 61672-3 at two test laboratories.

Four units failed to provide required information in the user manual to enable a calibration check to be properly performed. In each case the manufacturer was contacted to request this information, and none were able to provide the correct information, with one acknowledging the requirement and changing their marketing information to remove any claims to IEC 61672. According to the standard, as this information was not available, testing should not normally be performed, but for this exercise tests were made and failure of the manufacturer to provide this information will mean some of the tests performed will not be accurate as additional uncertainties will have been introduced, as shown by some variance between individual calibration facilities. However, it is unlikely the lack of this data would have resulted in failed tests becoming passes.

The results show that a low-cost meter is (as might be expected) capable of providing a noise level indication, but also that a number of instruments that claim IEC 61672 compliance are not compliant. If an instrument is required for accurate noise measurements it is recommended that any claims of compliance are confirmed. This can be established by asking for evidence of type approval, typically in the form of a certificate from a national metrology institute, and not by just relying on the marking on the sound level meter.