Appendix A8.2 Calibration Certificates

NSAI

National Metrology Laboratory

Certificate of Calibration

Issued to	TMS Environment Ltd. 53 Broomhill Drive Tallaght Dublin 24
Attention of	Martin Kearns

Certificate Number	**151658**
Item Calibrated	Bruel and Kjaer 2250 Light Sound Level Meter, complete with Type 4950 Microphone and Type ZC0032 Preamp
Serial Numbers	2625696 (Sound Level Meter), 2621489 (Microphone) and 8606 (Preamp)
Client ID Number	--------
Order Number	D158325
Date Received	23 Sep 2015
NML Procedure Number	AP-NM-09
Method	The above sound level meter was allowed to stabilise for a suitable period in laboratory conditions. It was then calibrated by carrying out the verification tests detailed in IEC 61672-3 (2006), *Periodic tests, specification for the verification of sound level meters*. This standard specifies a procedure for the periodic verification of conformance of a sound level meter or integrating-averaging meter to IEC 61672-1 (2003).
Calibration Standards	Norsonic 1504A Calibration System incorporating: SR DS360 Signal Generator, No. 0735 [Cal. Due Date: 30 Sep 2015] Agilent 34401A Digital Multimeter, No. 0736 [Cal Due Date: 20 Jul 2016] B&K 4134 Measuring Microphone, No. 0742 [Cal Due Date: 13 Jan 2016] B&K 4228 Pistonphone, No. 0741 [Cal Due Date: 13 Jan 2016] B&K 4226 Acoustical Calibrator, No. 0150 [Cal Due Date: 06 May 2016]

Calibrated by	David Fleming	**Approved by**	Paul Hetherington
Date of Calibration	28 Sep 2015	**Date of Issue**	28 Sep 2015

CIPM MRA

This certificate is consistent with Calibration and Measurement Capabilities (CMC's) that are included in Appendix C of the Mutual Recognition Arrangement (MRA) drawn up by the International Committee for Weights and Measures. Under the MRA, all participating institutes recognize the validity of each other's calibration certificates and measurement reports for quantities, ranges and measurement uncertainties specified in Appendix C (for details see www.bipm.org)

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Ambient laboratory conditions :

Barometric Pressure :	102.9 kPa ± 0.5 kPa
Temperature :	22.0 °C ± 1 °C
Relative Humidity:	47 % ± 5 %

Summary of Results:

The following table summarises the results of the verification tests. The detailed results are given in the subsequent tables.

IEC 61672 Test	Test Title	Status
10	Self-generated Noise (Electrical)	See Notes
11	Acoustical Signal	PASS
12	Frequency Weighting	PASS
13	Frequency and Time Weighting @ 1 kHz	PASS
14	Level Linearity Test on Reference Level Range	PASS
15	Level Linearity including Range Control	Not Applicable
16	Toneburst Response	PASS
17	Peak C	PASS
18	Overload Indication	PASS

Detailed Results.

Prior to carrying out the verification tests the sound level meter was checked ensure it was reading correctly using its associated calibrator (Brüel & Kjær 4231, Serial Number: 2623773).

Self-generated Noise Test (Electrical Input) (Test #10) [1]

Range: 140 dB
Mode: Leq

SLM Configuration	Freq. Weighting Network	SLM Reading[2],[3]
Microphone installed	A	21.5 dB
Microphone replaced by electrical signal device and Fitted with a short-circuit	A	13.9
	C	15.3
	Z (Linear)	20.9

Acoustical signal test of a frequency weighting (Test #11) [1]

Range: 140 dB
Frequency Weighting setting: A
Time Weighting response: Slow

Input Level[4]	Input Freq.	SLM Error of Indication[5]	Tolerance[6] (±)	Uncertainty of Measurement (±)
94.0 dB	1000 Hz	0.0 dB	1.0 dB	0.3 dB
	125	0.0	1.0	0.3
	4000[7]	+0.3	1.0	0.5
	8000[7]	+0.8 £	1.5, -3.0 dB	0.9

Electrical signal tests of frequency weightings (Test #12)[1]

Range: 140 dB

Freq. (nominal)	Input Level[4]	SLM Reading	SLM Error of Indication[5]	Tolerance[6] (±)	Uncertainty of Measurement (±)
A-Weighting					
63 Hz	95 dB	95.0 dB	0.0 dB	1.5 dB	0.20 dB
125	95	95.0	0.0	1.5	0.20
250	95	95.0	0.0	1.4	0.20
500	95	95.0	0.0	1.4	0.20
1000	95	95.0	0.0	1.1	0.20
2000	95	95.0	0.0	1.6	0.20
4000	95	94.9	-0.1	1.6	0.20
8000	95	94.7	-0.3	2.1, -3.1	0.20
16000	95	95.6	0.6	3.5, -17	0.20
C-Weighting					
63 Hz	95 dB	95.0 dB	0.0 dB	1.5 dB	0.20 dB
125	95	95.0	0.0	1.5	0.20
250	95	95.0	0.0	1.4	0.20
500	95	95.0	0.0	1.4	0.20
1000	95	95.0	0.0	1.1	0.20
2000	95	95.0	0.0	1.6	0.20
4000	95	94.9	-0.1	1.6	0.20
8000	95	94.7	-0.3	2.1, -3.1	0.20
16000	95	95.5	0.5	3.5, -17	0.20
LIN Weighting					
63 Hz	95 dB	94.9 dB	-0.1 dB	1.5 dB	0.20 dB
125	95	95.0	0.0	1.5	0.20
250	95	95.0	0.0	1.4	0.20
500	95	95.0	0.0	1.4	0.20
1000	95	95.0	0.0	1.1	0.20
2000	95	95.0	0.0	1.6	0.20
4000	95	94.9	-0.1	1.6	0.20
8000	95	94.7	-0.3	2.1, -3.1	0.20
16000	95	95.6	0.6	3.5, -17	0.20

Frequency and time weightings at 1 kHz (Test #13)[1]

Range: 140 dB

Time Weighting Setting	Frequency Weighting Setting	Input Level[4]	Deviation from Reference	Tolerance[6] (±)	Uncertainty. of Measurement (±)
Fast	A	94.0 dB	Ref.	-	0.20 dB
	C		0.0 dB	0.4 dB	0.20
	Z		0.0	0.4	0.20
Slow	A	94.0 dB	0.0	0.3	0.20
Leq.	A	94.0 dB	0.0 dB	0.3 dB	0.20 dB
SEL	A	114.0 dB	0.0 dB	0.3 dB	0.20 dB

Linearity level on the reference range (Test #14)[1]

Input Frequency: 8 kHz
SLM Measuring Mode: SPL

Range	Input Level[4]	SLM Reading	SLM Error of Indication[5]	Tolerance[6] (±)	Uncertainty of Measurement (±)
140 dB	94 dB	94.0 dB	0.0 dB	1.1 dB	0.20 dB
	99	99.0	0.0	1.1	0.20
	104	104.0	0.0	1.1	0.20
	109	109.1	0.1	1.1	0.20
	114	114.1	0.1	1.1	0.20
	119	119.1	0.1	1.1	0.20
	124	124.1	0.1	1.1	0.20
	129	129.1	0.1	1.1	0.20
	134	134.1	0.1	1.1	0.20
	137	137.1	0.1	1.1	0.20
	138	138.1	0.1	1.1	0.20
	139	139.1	0.1	1.1	0.20
	140	140.1	0.1	1.1	0.20
	141	141.1	0.1	1.1	0.20
	94	94.0	0.0	1.1	0.20
	89	89.1	0.1	1.1	0.20
	84	84.0	0.0	1.1	0.20
	79	79.1	0.1	1.1	0.20
	74	74.0	0.0	1.1	0.20
	69	69.0	0.0	1.1	0.20
	64	64.0	0.0	1.1	0.20
	59	59.0	0.0	1.1	0.21
	54	54.0	0.0	1.1	0.21
	49	49.0	0.0	1.1	0.21
	44	44.1	0.1	1.1	0.21
	39	39.1	0.1	1.1	0.21
	34	34.2	0.2	1.1	0.23
	28	28.2	0.2	1.1	0.25
	27	27.3	0.3	1.1	0.25
	26	26.4	0.4	1.1	0.25
	25	25.4	0.4	1.1	0.25
	24	24.5	0.5	1.1	0.25

Toneburst response (Test #16)[1]

Range: 140 dB

Burst Type	SLM Mode	Input Level[4]	SLM Error of Indication[5]	Tolerance[6] (±)	Uncertainty of Measurement (±)
200 ms	LAF	119.0 dB	0.0 dB	0.8 dB	0.3 dB
2.0 ms	LAF	102.0	-0.1	1.3	0.3
0.25 msec	LAF	93.0	-0.1	1.3, -3.3	0.3
200 ms	LAS	112.6 dB	0.0 dB	0.8 dB	0.3 dB
2.0 ms	LAS	93.0	-0.1	1.3, -1.8	0.3
200 ms	SEL	113.0 dB	0.0 dB	0.8 dB	0.3 dB
2 .0 ms	SEL	93.0	-0.1	1.3	0.3
0.25 ms	SEL	84.0	-0.1	1.3, -3.3	0.3

Peak C sound level (Test #17)[1]

Range: 140 dB

Pulse Type	Pulse Frequency	Input Level[4] (peak value)	SLM Error of Indication[5]	Tolerance[6] (±)	Uncertainty of Measurement (±)
1 cycle	8 kHz	138.4 dB	0.3 dB	2.4 dB	0.35 dB
Pos. ½ cycle	500 Hz	137.4 dB	-0.2 dB	1.4 dB	0.35 dB
Neg. ½ cycle	500 Hz	137.4 dB	-0.2 dB	1.4 dB	0.35 dB

Overload indication (Test #18)[1]

Range: 140 dB
SLM Measuring Mode: LAEq

Test description	Overload occurred at (±)	Meas. Diff. (Pos – Neg)	Tolerance[6] (±)	Uncertainty of Measurement (±)
Positive ½ cycle at 4 kHz	143.2 dB	-	-	-
Negative ½ cycle at 4 kHz	143.1 dB	-	-	-
Level difference of positive & negative pulses	-	0.1 dB	1.8 dB	0.30 dB

Notes :

(1) The test number, given in parentheses after the section heading, refers to the relevant clause in IEC 61672-3 (2006).

(2) SLM denotes Sound Level Meter

(3) The measured self generated noise was found to be marginal to specification. This is likely due to the influence of ambient noise levels.

(4) All input levels are given in dB relative to a 20 µPa reference level.

(5) The SLM Error of Indication is defined as follows :
SLM Error of Indication = (SLM Reading - Input Level)
Any error of indication that exceeds the relevant tolerance limits [see note (6)] is indicated using a $ symbol.
£ indicates a marginal-to-specification condition. That is, the measured value, extended by its associated uncertainty, overlaps the specified accuracy limit.

(6) The figures in the column labelled 'Tolerance' are the acceptance limits given in IEC 61672-1(2003). These tolerance limits include an allowance for the maximum expanded uncertainty of the test laboratory. The criteria for compliance with the tolerance is that the measurement result, extended by its associated uncertainty, lies within the specified limits.

(7) Microphone response at 4 and 8 kHz was measured using an electrostatic actuator. Free field corrections of +1.2 and +4.0 dB respectively were applied to the measured actuator response.
This measurement is not included in NML's tables of Calibration and Measurement Capabilities, approved under the CIPM MRA.
For information, the measured sensitivity and frequency response of the microphone is given in an addendum to this certificate.

Comments:

The above sound level meter was found to meet the requirements of IEC 61672-3 (2006), with the exception of the 8 kHz electrostatic actuator test, where it was found to be marginal-to-specification.

Uncertainty of Measurement:

The measurement uncertainty is reported as a standard uncertainty multiplied by a coverage factor k=2 which, for a normal probability distribution, corresponds to a coverage probability of approximately 95%. The given uncertainty refers to the measured values only and carries no implication regarding the long-term stability of the item calibrated.

Traceability:

The reported measurement results are traceable, via national standards maintained by NSAI National Metrology Laboratory (NML), to internationally accepted realisations of the SI units.

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Addendum to Certificate 151658

Brüel & Kjær
Type: 4950

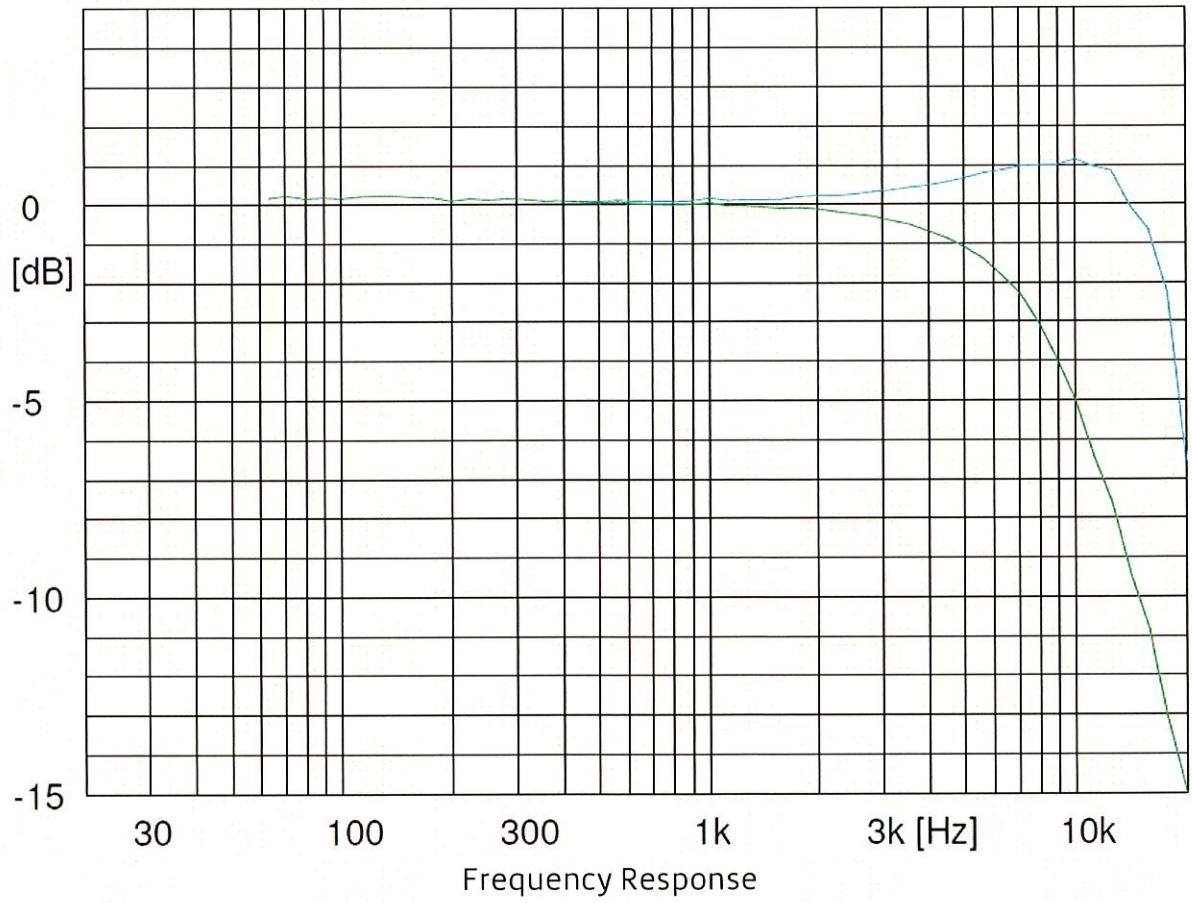
Serial no: 2621489

Sensitivity: 46.7 mV/Pa
-26.6 ±0.10 dB re. 1 V/Pa

Date: 28/09/2015

Measurement conditions:	
Polarisation voltage:	0.0 V
Pressure:	102.99 ±0.00 kPa
Temperature:	21.4 ±1.0 °C
Relative humidity:	46.9 ±2.1 %RH
Results are normalised to the reference conditions.	

Free field response
Pressure (Actuator) response



MSE-25-2.
14 Sept 16

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Certificate of Calibration

Issued to	TMS Environment Limited 53 Broomhill Drive Tallaght Dublin 24
Attention of	Graham Adams

Certificate Number	162928
Item Calibrated	Bruel & Kjaer Type 4231 Sound Level Calibrator
Serial Number	2623773
Client ID Number	None
Order Number	D168825
Date Received	30 Aug 2016
NML Procedure Number	AP-NM-13
Method	The above calibrator was allowed to stabilize for a suitable period in laboratory conditions. It was then calibrated by measuring the sound pressure level generated in its measuring cavity (half-inch configuration). The calibrator's operating frequency was also measured.
Calibration Standards	Norsonic 1504A Calibration System incorporating: Agilent 34401A Multimeter, No. 0736 [Cal due: 31 Aug 2016] B & K 4134 Measuring Microphone, No. 0743 [Cal due: 19 Jan 2017] B & K 4228 Pistonphone, No. 0740 [Cal due: 12 Jan 2017]

Calibrated by	David Fleming	Approved by	Paul Hetherington
Date of Calibration	30 Aug 2016	Date of Issue	31 Aug 2016

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Measuring Conditions:

Ambient Pressure:	(101.4 ± 0.5) kPa
Ambient Temperature:	(21.8 ± 1.0) °C
Ambient Rel. Humidity:	(52 ± 5) %RH

Results:

The measured sound pressure level(s) reported below refer to the reference conditions specified by the manufacturer. Corrections were applied using sensitivity coefficients provided by the manufacturer, where available. These reference conditions and sensitivity coefficients are listed below.

Parameter	Reference Value	Sensitivity Coefficient
Ambient Pressure	101.325 kPa	0.000 8 dB/kPa
Ambient Temperature	20 °C	0.000 dB/°C (1)
Ambient Relative Humidity	65 %RH	0.000 dB/%RH (1)

Calibrator Setting	Measured Parameter	Measured Value (2)		Tolerance (3)	Meas. Uncertainty (4)
		Before Adj.	After Adj.	(±)	(±)
94 dB	Sound Pressure Level	93.95 dB	*	0.40 dB	0.15 dB
	Frequency	999.97 Hz	*	10 Hz	0.25 Hz
114 dB	Sound Pressure Level	113.97 dB	*	0.40 dB	0.15 dB
	Frequency	999.97 Hz	*	10 Hz	0.25 Hz

Notes: (1) No sensitivity coefficient information was available for this parameter.
(2) * indicates that no calibration adjustment was made.
$ indicates an out-of-tolerance condition. Note that for acoustic calibrators which meet IEC 60942 (2003), the instrument is considered out of tolerance if the measured deviation from the set level, extended by it associated uncertainty, exceeds the specified tolerance limits.
(3) IEC 60942 (2003), Sound Calibrators, Class 1.
(4) The measurement uncertainty is reported as a standard uncertainty multiplied by a coverage factor k=2 which, for a normal probability distribution corresponds to a coverage probability of approximately 95%. The given uncertainty refers to the measured values only and carries no implication regarding the long-term stability of the item calibrated.

Comments:

The sound level calibrator was found to comply with the requirements of IEC 60942 (2003), Class 1, for sound pressure level and frequency measurements.
When using the calibrator with a sound level meter any manufacturer's guidelines regarding free-field corrections should be observed.

Traceability:

The reported measurement results are traceable, via national standards maintained by NSAI National Metrology Laboratory (NML), to internationally accepted realisations of the SI units.