TECHNICAL LETTER

17th October 2014

Ref: C/0023/A/002

Dear Resonics,

Re: 4th Floor Contact Centre, Affinity Sutton, Bromley, Kent – Reverberation Time & Internal Noise Level Re-tests post-installation of acoustic systems

Following our last site visit on the 24th September 2014, please find below the results of our Reverberation Time (RT) and Internal Noise Level (INL) re-tests conducted within the 4th Floor Contact Centre at the above address and following post-installation of acoustic remedial systems, as follows:

1.0 Test Methodology

1.1 RT Re-tests

A number of Reverberation Time (RT) re-tests were conducted on the 4th Floor Contact Centre in accordance with the "Survey Grade" methodology detailed under *BS EN ISO 3382-2: 2008 Acoustics – Measurement of room acoustic parameters – Part 2: Reverberation Acoustics* using an interrupted pink noise signal and 1 no. decay per microphone position.

The following equipment was used to conduct RT tests:

1.1.1 A Brüel & Kjær Type 2250 Sound Level Analyser (serial no. 2699597) was used in conjunction with a Brüel & Kjær Type 4189 microphone (serial no. 2785433) and Brüel & Kjær Type ZC-0032 pre-amplifier (ID no. 15085) with the BZ7228 (Building Acoustics) module enabled. The Analyzer was calibrated before and after testing with a Brüel & Kjær Type 4231 Field Calibrator (serial no. 2022652) to a level of 94.0 dB (at 1 kHz) with no drifts in calibration detected.

1.1.2 In addition, a JBL EON15-G2(230) loudspeaker (serial no. P0353-72715) and an AKG SR-40(S) single-channel wireless transmitter/receiver kit (serial no. 599866T-55T02) were also used to reproduce the test signal.

Calibration certificates for the Sound Level Analyzer and Field Calibrator are presented in Appendix 2 of this Letter.

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1.2 INL Tests

The same instrumentation as 1.1.1 above was used for Internal Noise Levels.

Measurements were taken during the occupied (ie. operational) condition consisting of a 5-minute intervals on Wednesday 24th September 2014.

All measurements were taken using the "Fast" time weighting and presented in terms of the single-figure, A-weighted sounds pressure levels (re: $2x10^{-5}$ Pa).

To replicate as close as possible the same acoustic conditions as were observed during the Pre-Treatment survey conducted on the 30th April 2014, the same 4 no. positions were selected during the occupied tests (between 10.02 hrs and 10.47 hrs) for the Post-Treatment survey. Please refer to Appendix 1 for measurement positions relative to the 4th Floor space.

2.0 RT Re-test Room Conditions

Within the Contact Centre, no RT re-tests were conducted in the presence of any abnormal intrusive noise events. Any prevailing room ambient noise (eg. that due to operational HVAC systems and/or discrete equipment (ie. dot-matrix boards, lighting etc.)) was accounted for and test signal sound pressure levels increased accordingly.

3.0 Test Results

3.1 RT Re-tests

Results of the RT re-tests conducted as per the above methodology are summarised in Table 1 below and presented in terms of 1/1-Octave Band Centre Frequency times (in seconds) between 125 Hz and 4 kHz with the arithmetic average between all the 1/1-Octave Band Centre Frequency times presented overall.

Measurement Position	**1/1-Octave Band Centre Frequency (Hz)**					
	125	**250**	**500**	**1k**	**2k**	**4k**
RT1	0.61	0.55	0.32	0.26	0.37	0.43
RT2	0.51	0.53	0.28	0.30	0.32	0.37
RT3	0.41	0.33	0.26	0.22	0.27	0.32
RT4	0.50	0.41	0.25	0.33	0.31	0.36
RT5	0.38	0.54	0.29	0.32	0.27	0.27
RT6	0.65	0.53	0.34	0.33	0.35	0.35
RT7	0.71	0.35	0.25	0.33	0.29	0.30
RT8	0.59	0.58	0.31	0.30	0.36	0.35
RT9	0.72	0.43	0.32	0.23	0.32	0.32
RT(125 Hz-4 kHz)	**0.38**					

Table 1 4th Floor - Reverberation Time Re-test Results in seconds (s)

3.2 INL Re-Tests

Results of the Internal Noise Level Re-tests are presented in Table 2. The corresponding number of call-takers during the operational condition (ie. occupied) is noted against each measurement, as follows:

Measurement Position	Time (hrs)	Test Condition	Measurement Interval	$L_{Aeq,T}$ dB	No. Call Takers
SPL4	10.07	Operational (occupied)	5-minutes	53.4	30
SPL5	10.18	Operational (occupied)	5-minutes	54.7	32
SPL6	10.26	Operational (occupied)	5-minutes	50.3	32
SPL7	10.42	Operational (occupied)	5-minutes	49.7	25

Table 2 4th Floor – L_{Aeq} (A-Weighted) Sound pressure Levels (dB re: 2x10-5 Pa)

4.0 Control Scheme

Resonics carried out the installation of 65 m^2 of *Saint-Gobain Ecophon Akusto Texona* wall panels (dims: 2.7 x 1.2 m) and 45 no. *Saint-Gobain Ecophon Solo Square* (assumed; Finish Type "C"; 40 mm Overall Depth of System configuration) ceiling rafts (dims: 1.2 x 1.2 m) to the 4th Floor Contact Centre space.

The results of these acoustic performance re-tests therefore demonstrate the change in performance of the space and corresponding change in measured sound pressure levels between comparative operational conditions from when the space was acoustically un-treated (ie. prior to the Resonics installation) to the treated space.

5.0 Comparison of Pre and Post-Treatment Acoustic Performance

5.1 Internal Noise Level Assessment

Referring to the previous Technical Letter (ref: C/0023/A/001) dated 9th May 2014, the following historical (ie. "Pre-Treatment") internal noise level results were observed and summarised in Table 3 below. The summary also includes the results of the re-tests (ie. "Post-Treatment") to provide a "before and after" acoustic comparison and the numerical difference in the sound pressure levels; ΔL_{Aeq} (dB).

Measurement Position	Test Condition	Pre-Treatment		Post-Treatment		Diff. ΔL_{Aeq}
		$L_{Aeq,T}$ dB	No. Call Takers	$L_{Aeq,T}$ dB	No. Call Takers	Post-Pre (dB)
SPL4	Operational	65.5	35	53.4	30	-12.1
SPL5	Operational	65.6	31	54.7	32	-10.9
SPL6	Operational	64.7	35	50.3	32	-14.4
SPL7	Operational	58.3	32	49.7	25	-8.6
Average (Log)	Operational	64.3	33	52.5	30	-11.8

Table 3 Comparison of Pre and Post-Treatment measured sound pressure Levels (dB re: 2x10-5 Pa)

5.2 RT Assessment

Referring to the same previous Technical Letter (ref: C/0023/A/001) dated 9th May 2014, the following baseline (ie. Pre-Treatment) RT results were observed and summarised in Table 4 below. The summary also includes the results of the re-tests (ie. Post-Treatment) to provide a "before and after" acoustic comparison and the numerical difference in RT; ΔRT (seconds).

Measured Parameter	Pre-Treatment Measurement (seconds)	Post-Treatment Measurement (seconds)	Diff. ΔRT60 Post-Pre (seconds)
RT60	0.49	0.38	-0.11

Table 4 Comparison of Pre and Post-Treatment measured RT60 (seconds)

6.0 Post-Treatment Acoustic Performance Assessment

From the results presented in Table 3 in the previous section, it can be seen that the difference in measured sound pressure level between the Pre-Treatment and Post-Treatment condition varied by between -8.6 dB and -12.1 dB. This can be considered a significant reduction in overall sound pressure level relative to the same measurement positions between both test conditions.

Specifically, these reductions correspond broadly to the same number of call takers observed during both the Pre and Post-Treatment conditions (ie. between 31 and 35 call takers in the Pre-Treatment condition and between 25 and 32 no. call takers in the Post-Treatment condition, depending on spatial location). No attempt has been made here to standardise the measured sound pressure level results by number of call takers for either test condition but the general acoustic premise is that the magnitude of sound power propagating into the 4th Floor space, due to call takers alone (ie. omitting the contribution due to HVAC or external noise ingress components), does not represent a significant variation and probably insufficient to result in a large change in a theoretical standardised sound pressure level in any case.

Notwithstanding, it should be noted that the overall reduction in sound pressure level from the logarithmically-averaged sound pressure levels in all 4 no. measurement positions between the Pre and Post-Treatment conditions is a ΔLAeq -11.8 dB. From psychoacoustic theory, a reduction in sound pressure level of -10 dB is equivalent to a "halving of the perceived loudness of a sound". This premise is significant, because the variation in the log average sound pressure levels, results in a reduction in noise level which is greater than 10 dB. It is therefore apparent that the perceived loudness in the 4th Floor Contact Centre space would be deemed significantly improved by operators using the space, following more than a halving of the perceived sound level under the Post-Treatment condition compared with the Pre-Treatment condition.

Secondly, from the results presented in Table 4, it can be seen that the acoustic treatment installed has had the effect of reducing the measured RT60 by -0.11 seconds. Whilst this reduction appears small in magnitude, the reduction in reverberation time has resulted in a beneficial effect by reducing the reverberant component of the propagating sound power in the tested space (assuming broadly a similar number of call takers under both conditions), thereby resulting in the measured sound pressure levels shown in Table 2 previously.

Moreover, referring to Section 6.0 of the previous Technical Letter, it was surmised that a halving of the RT relative to the Pre-Treatment condition (ie. to result in around 0.25-0.30 seconds from a Pre-Treatment performance of 0.49 seconds) should result in at least a 3 dB reduction in the reverberant component of the measured sound pressure level and whilst it should be noted that measured sound pressure levels in this space (under either condition) are broadly influenced by the direct sound (ie. that propagated by call takers themselves), the Post-Treatment installation has shown that a much greater reduction than 3 dB has been observed between similar operational conditions but corresponding to a much lower reduction in RT than would have been expected (ie. a reduction equivalent to just 22% reduction in RT as opposed to a target reduction of 50% (ie. a halving) in RT following the acoustic installation).

6.0 Conclusions

From the results presented in Section 5.0 above, it can be seen that the acoustic installation carried out by Resonics has had the effect of significantly reducing both the measured sound pressure levels at a number of representative operative positions in the 4th Floor Contact Centre space, as well as the RT60 times between the Pre and Post-Treatment conditions.

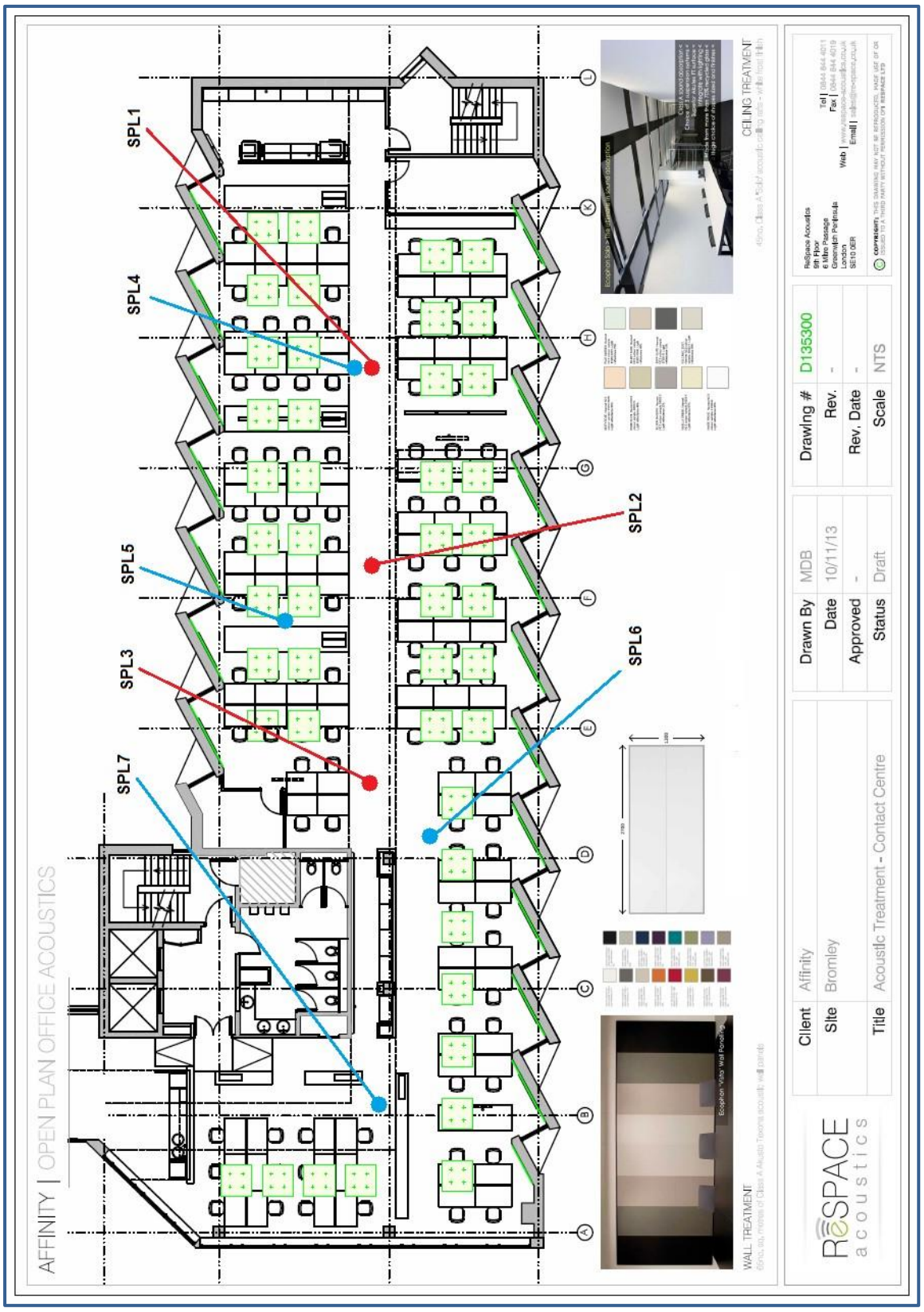
Specifically, sound pressure levels, where measured at comparative positions under both conditions, have now reduced to a level which would be considered to be equivalent to a halving of the perceived loudness and numerically greater than a 10 dB reduction in absolute terms. The significant reductions in measured RT and sound pressure level should now result in a much more acoustically comfortable environment relative to telephonic communication and a noticeable improvement in speech privacy relative to individual operative positions.

We trust that this Technical Letter comprehensively evaluates the beneficial difference in the Pre and Post-Treatment acoustic performance of the 4th Floor Contact centre space at the above premises at this time and we welcome further discussions regarding any of the content contained within this Technical Letter, as necessary.

Yours sincerely,

ALEX KRASNIC
BEng (Hons) MSc MIOA MInstSCE
Director

APPENDIX 1 INL Re-Test Measurement Positions



Note: Excluding Positions marked: SPL1, SPL2 or SPL3.

APPENDIX 2 Calibration Certificates

Brüel & Kjær

The Calibration Laboratory
Skodsborgvej 307, DK-2850 Nærum, Denmark

ilac-MRA DANAK CAL Reg.nr. 307

CERTIFICATE OF CALIBRATION No: CDK1309578 Page 1 of 10

CALIBRATION OF

Sound Level Meter:	Brüel & Kjær Type 2250	No: 2699597 Id: -	
Microphone:	Brüel & Kjær Type 4189	No: 2785433	
Preamplifier:	Brüel & Kjær Type ZC-0032	No: 15085	
Supplied Calibrator:	None		
Software version:	BZ7222 Version 3.5.3	Pattern Approval:	PTB1.63-4055843 / 1.63-4055845
Instruction manual:	BE1712-18		

CUSTOMER

Enfonic Ltd
Tecpro House, IDA Business & Technology Park, Clonshaugh
Clonshaugh
Dublin 17
Ireland

CALIBRATION CONDITIONS

Preconditioning:	4 hours at 23°C ± 3°C
Environment conditions:	*See actual values in **Environmental conditions** sections*

SPECIFICATIONS

The Sound Level Meter Brüel & Kjær Type 2250 has been calibrated in accordance with the requirements as specified in IEC61672-1:2002 class 1. Procedures from IEC 61672-3:2006 were used to perform the periodic tests. The accreditation assures the traceability to the international units system SI.

PROCEDURE

The measurements have been performed with the assistance of Brüel & Kjær Sound Level Meter Calibration System 3630 with application software type 7763 (version 4.9 - DB: 4.90) by using procedure 2250-4189.

RESULTS

Calibration Mode: **Calibration as received.**

The reported expanded uncertainty is based on the standard uncertainty multiplied by a coverage factor $k = 2$ providing a level of confidence of approximately 95 %. The uncertainty evaluation has been carried out in accordance with EA-4/02 from elements originating from the standards, calibration method, effect of environmental conditions and any short time contribution from the device under calibration.

Date of calibration: 2013-12-03 Date of issue: 2013-12-03

Steen Vodstrup Andersen
Calibration Technician

Susanne Jørgensen
Approved Signatory

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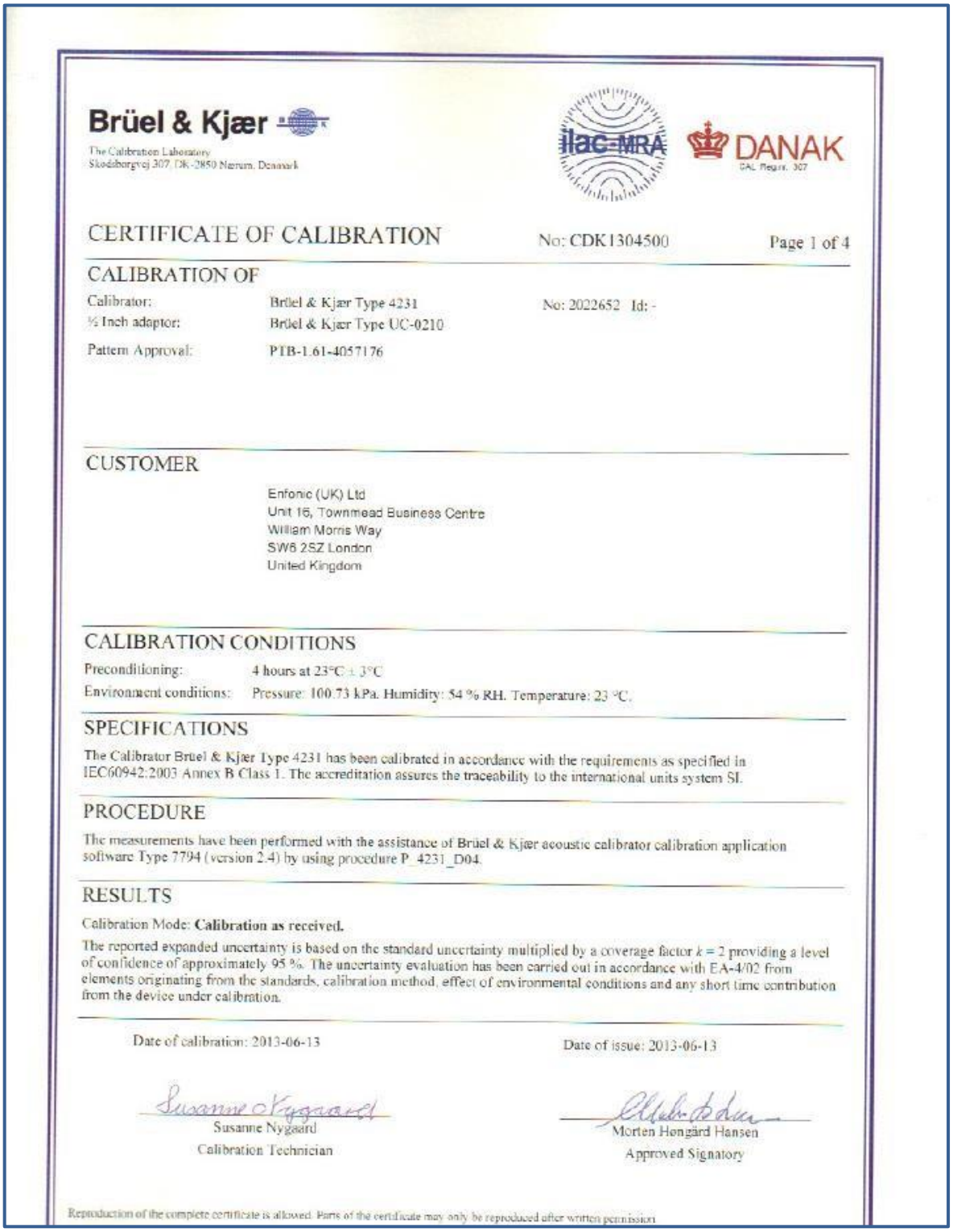

Brüel & Kjær

The Calibration Laboratory
Skodsborgvej 307, DK-2850 Nærum, Denmark

ilac-MRA DANAK CAL Regist. 307

CERTIFICATE OF CALIBRATION

No: CDK1304500 Page 1 of 4

CALIBRATION OF

Calibrator:	Brüel & Kjær Type 4231	No: 2022652 Id: -
½ Inch adaptor:	Brüel & Kjær Type UC-0210	
Pattern Approval:	PTB-1.61-4057176	

CUSTOMER

Enfonic (UK) Ltd
Unit 16, Townmead Business Centre
William Morris Way
SW6 2SZ London
United Kingdom

CALIBRATION CONDITIONS

Preconditioning: 4 hours at 23°C ± 3°C
Environment conditions: Pressure: 100.73 kPa. Humidity: 54 % RH. Temperature: 23 °C.

SPECIFICATIONS

The Calibrator Brüel & Kjær Type 4231 has been calibrated in accordance with the requirements as specified in IEC60942:2003 Annex B Class 1. The accreditation assures the traceability to the international units system SI.

PROCEDURE

The measurements have been performed with the assistance of Brüel & Kjær acoustic calibrator calibration application software Type 7794 (version 2.4) by using procedure P_4231_D04.

RESULTS

Calibration Mode: **Calibration as received.**

The reported expanded uncertainty is based on the standard uncertainty multiplied by a coverage factor $k = 2$ providing a level of confidence of approximately 95 %. The uncertainty evaluation has been carried out in accordance with EA-4/02 from elements originating from the standards, calibration method, effect of environmental conditions and any short time contribution from the device under calibration.

Date of calibration: 2013-06-13 Date of issue: 2013-06-13

Susanne Nygaard
Calibration Technician

Morten Hongård Hansen
Approved Signatory

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