

## **APPENDIX 11.5**

### **Calibration Certificates of LiDAR and Noise Instruments**



## ZX LIDARS FACTORY ACCEPTANCE CERTIFICATE

**System Variant:** ZX300  
**Serial Number:** ZX1527  
**Certificate Date:** 19-08-2022  
**Test station:** Zephyr Limited, The Old Barns , Fair Oaks Farm, Hollybush, Ledbury, HR8 1EU, UK

### FACTORY CALIBRATIONS AND PERFORMANCE VERIFICATION TESTS:

Velocity testing and system integrity tests provide a check of the performance of the lidar:

Test:	Criteria:	Result:
VELOCITY TEST*	VELOCITY ERROR < 0.5%	PASS
DIRECTION CALIBRATION*	DIRECTION ERROR < 0.5°	PASS
SENSITIVITY TEST*	BACKSCATTER RATIO > 1.0	PASS
FOCUS CALIBRATION**	RANGE ERROR < 1m	PASS

\*Velocity, Direction, and Sensitivity checked against calibrated moving belt at speeds up to 5m/s

\*\*Focus calibrated at 80m focus range

Additional factory functionality tests and checks carried out:

Power supply performance and safe	✓	Ingress protection and enclosure sealing	✓
Met station configuration	✓	Environmental control operation	✓
Window cleaning system	✓	Operating system configuration and checks	✓
Optical functionality	✓	External cable and connector integrity	✓
Rain sensor	✓	Mechanical level functionality	✓
Modem and communications	✓	Internal humidity	✓
Data collection and export	✓		

*This certificate warrants that the lidar unit detailed above has passed all relevant factory acceptance tests.*

*The performance of identical build level lidar units (which have passed the same factory assessment tests) have been verified against an IEC compliant meteorological mast with calibrated cup anemometry.*

*This document may not be reproduced other than in full without the written permission of Zephyr Ltd., and is invalid without signatures.*

### Authorised signatures:

Name: Gary Ellis

Dr. Andy Lewis

Title: Senior Engineer

Quality Manager

& Engineering Project Manager

Signature:

Date: 19-08-2022

19-08-2022

# Calibration Certificate

**Certificate Number 2021014391**

**Customer:**

Environmental Measurement  
Unit 12 Tallaght Business Centre  
Whitestown Business Park  
Dublin, 24, Ireland

**Model Number** LxT SE  
**Serial Number** 0006869  
**Test Results** **Pass**  
**Initial Condition** As Manufactured  
**Description** Sound Expert LxT  
Class 1 Sound Level Meter  
Firmware Revision: 2.404

**Procedure Number** D0001.8378  
**Technician** Ron Harris  
**Calibration Date** 10 Nov 2021  
**Calibration Due**  
**Temperature** 23.41 °C ± 0.25 °C  
**Humidity** 53.2 %RH ± 2.0 %RH  
**Static Pressure** 86.63 kPa ± 0.13 kPa

**Evaluation Method** Tested electrically using Larson Davis PRMLxT1L S/N 070113 and a 12.0 pF capacitor to simulate microphone capacitance. Data reported in dB re 20 µPa assuming a microphone sensitivity of 23.6 mV/Pa.

**Compliance Standards** Compliant to Manufacturer Specifications and the following standards when combined with Calibration Certificate from procedure D0001.8384:

IEC 60651:2001 Type 1	ANSI S1.4-2014 Class 1
IEC 60804:2000 Type 1	ANSI S1.4 (R2006) Type 1
IEC 61252:2002	ANSI S1.25 (R2007)
IEC 61672:2013 Class 1	ANSI S1.43 (R2007) Type 1
IEC 61260:2001 Class 1	ANSI S1.11 (R2009) Class 1

Issuing lab certifies that the instrument described above meets or exceeds all specifications as stated in the referenced procedure (unless otherwise noted). It has been calibrated using measurement standards traceable to the International System of Units (SI) through the National Institute of Standards and Technology (NIST), or other national measurement institutes, and meets the requirements of ISO/IEC 17025:2017. **Test points marked with a ‡ in the uncertainties column do not fall within this laboratory's scope of accreditation.**

The quality system is registered to ISO 9001:2015.

This calibration is a direct comparison of the unit under test to the listed reference standards and did not involve any sampling plans to complete. No allowance has been made for the instability of the test device due to use, time, etc. Such allowances would be made by the customer as needed.

The uncertainties were computed in accordance with the ISO Guide to the Expression of Uncertainty in Measurement (GUM). A coverage factor of approximately 2 sigma (k=2) has been applied to the standard uncertainty to express the expanded uncertainty at approximately 95% confidence level.

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Correction data from Larson Davis LxT Manual for SoundTrack LxT & SoundExpert LxT, I770.01 Rev O Supporting Firmware Version 4.0.5, 2019-09-10

Calibration Check Frequency: 1000 Hz; Reference Sound Pressure Level: 114 dB re 20 µPa

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1681 West 820 North  
Provo, UT 84601, United States  
716-684-0001



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D0001.8407 Rev F

**Certificate Number 2021014391**

# Calibration Certificate

**Certificate Number** 2022002441

**Customer:**

Environmental Measurement  
Unit 12 Tallaght Business Centre  
Whitestown Business Park  
Dublin, 24, Ireland

**Model Number** LxT SE  
**Serial Number** 0007030  
**Test Results** **Pass**  
**Initial Condition** As Manufactured  
**Description** Sound Expert LxT  
Class 1 Sound Level Meter  
Firmware Revision: 2,404

**Procedure Number** D0001,8384  
**Technician** Jacob Cannon  
**Calibration Date** 1 Mar 2022  
**Calibration Due**  
**Temperature** 23.54 °C ± 0.25 °C  
**Humidity** 51.1 %RH ± 2.0 %RH  
**Static Pressure** 87.07 kPa ± 0.13 kPa

**Evaluation Method**

**Tested with:**

Larson Davis PRMLxT1L, S/N 077596  
PCB 377B02, S/N 335772  
Larson Davis CAL291, S/N 0203  
Larson Davis CAL200, S/N 6768

**Data reported in dB re 20 µPa.**

**Compliance Standards**

Compliant to Manufacturer Specifications and the following standards when combined with Calibration Certificate from procedure D0001,8378:

IEC 60651:2001 Type 1	ANSI S1.4-2014 Class 1
IEC 60804:2000 Type 1	ANSI S1.4 (R2006) Type 1
IEC 61252:2002	ANSI S1.11 (R2009) Class 1
IEC 61260:2001 Class 1	ANSI S1.25 (R2007)
IEC 61672:2013 Class 1	ANSI S1.43 (R2007) Type 1

Issuing lab certifies that the instrument described above meets or exceeds all specifications as stated in the referenced procedure (unless otherwise noted). It has been calibrated using measurement standards traceable to the International System of Units (SI) through the National Institute of Standards and Technology (NIST), or other national measurement institutes, and meets the requirements of ISO/IEC 17025:2017.

Test points marked with a ‡ in the uncertainties column do not fall within this laboratory's scope of accreditation.

The quality system is registered to ISO 9001:2015.

This calibration is a direct comparison of the unit under test to the listed reference standards and did not involve any sampling plans to complete. No allowance has been made for the instability of the test device due to use, time, etc. Such allowances would be made by the customer as needed.

The uncertainties were computed in accordance with the ISO Guide to the Expression of Uncertainty in Measurement (GUM). A coverage factor of approximately 2 sigma (k=2) has been applied to the standard uncertainty to express the expanded uncertainty at approximately 95% confidence level.

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Correction data from Larson Davis LxT Manual for SoundTrack LxT & SoundExpert LxT, I770,01 Rev J Supporting Firmware Version 2,301, 2015-04-30

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D0001,8406 Rev F

# Calibration Certificate

**Certificate Number** 2022002771

**Customer:**

Environmental Measurement  
Unit 12 Tallaght Business Centre  
Whitestown Business Park  
Dublin, 24, Ireland

**Model Number** LxT SE

**Serial Number** 0007038

**Test Results** Pass

**Initial Condition** As Manufactured

**Description** Sound Expert LxT  
Class 1 Sound Level Meter  
Firmware Revision: 2.404

**Procedure Number** D0001.8384

**Technician** Jacob Cannon

**Calibration Date** 7 Mar 2022

**Calibration Due**

**Temperature** 23.56 °C ± 0.25 °C

**Humidity** 49.8 %RH ± 2.0 %RH

**Static Pressure** 86.66 kPa ± 0.13 kPa

**Evaluation Method**

**Tested with:**

Larson Davis PRMLxT1L, S/N 077600

Larson Davis CAL291, S/N 0108

PCB 377B02, S/N 336072

Larson Davis CAL200, S/N 9079

**Data reported in dB re 20 µPa.**

**Compliance Standards**

Compliant to Manufacturer Specifications and the following standards when combined with Calibration Certificate from procedure D0001.8378:

IEC 60651:2001 Type 1

IEC 60804:2000 Type 1

IEC 61252:2002

IEC 61260:2001 Class 1

IEC 61672:2013 Class 1

ANSI S1.4-2014 Class 1

ANSI S1.4 (R2006) Type 1

ANSI S1.11 (R2009) Class 1

ANSI S1.25 (R2007)

ANSI S1.43 (R2007) Type 1

Issuing lab certifies that the instrument described above meets or exceeds all specifications as stated in the referenced procedure (unless otherwise noted). It has been calibrated using measurement standards traceable to the International System of Units (SI) through the National Institute of Standards and Technology (NIST), or other national measurement institutes, and meets the requirements of ISO/IEC 17025:2017.

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Correction data from Larson Davis LxT Manual for SoundTrack LxT & SoundExpert LxT, I770.01 Rev J Supporting Firmware Version 2.301, 2015-04-30

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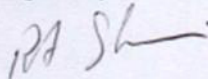


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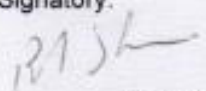
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A PCB DIVISION

D0001.8406 Rev F



 <div style="display: inline-block; vertical-align: middle; text-align: left;"> <b>MTS Calibration Ltd,</b>  <b>The Grange Business Centre,</b>  <b>Belasis Avenue,</b>  <b>Billingham TS23 1LG,</b>  <b>England</b>  <b>Telephone: 01642 876 410</b> </div>																																																																																						
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<b>The Device calibrated was:</b> <div style="display: flex; justify-content: space-between; align-items: center;"> <span><b>Larson Davis</b></span> <span><b>Model CAL200</b></span> <span><b>Serial Number 18140</b></span> </div>																																
The measurements were performed at Elvington Close, Billingham, TS23 3YS and the measured values were as follows:																																
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This measurement is valid only for the above device configured for calibration of a WS-2 microphone under the stated environmental conditions. For deviation of prevailing conditions, the manufacturer's literature for the calibrator should be referred to.																																
<b>Date of Measurements:</b> 02 March 2023 <b>Date of Receipt:</b> 23 February 2023																																
<b>Method of calibration</b> A Reference Calibrator was used to establish the sensitivity of the measurement chain. The same measurement chain is then used to determine the output level of the Object Calibrator by the difference between its output and that of the nominated Reference Calibrator. Four independent measurements of the third-octave band sound pressure levels produced by the Reference Calibrators and the Object Calibrator are averaged to minimise uncertainties of the calibration. The measurement chain consists of a calibrated, Reference Microphone, Reference Preamplifier and Reference Analyser.  As well as providing a traceable measurement of the sound pressure level in the cavity of the Object Calibrator, the Calibrator's frequency and total harmonic distortion are also measured. Frequency is determined from the average of four independent measurements using a multimeter. The total harmonic distortion is measured from the average of three independent measurements by third octave analysis, subtracting the level of the fundamental frequency from the sum of the combined harmonics in the frequency band to 20kHz. The complete procedure is detailed in the MTS Calibration Ltd work procedure WMP01.  The sound pressure level generated by the calibrator in its WS2 configuration was measured by reference to the reference Sound Calibrator as shown in the Test Equipment section below.  The reported expanded uncertainty is based on a standard uncertainty multiplied by a coverage factor k (individually calculated as above), providing a coverage probability of approximately 95%. The uncertainty evaluation has been calculated in accordance with the current version of UKAS publication M3003. The uncertainty quoted for the Distortion Measurement is the Distortion Percentage as measured, multiplied by our Uncertainty as calculated for the individual measurement or our CMC, whichever is the larger.																																
<b>Measurement Conditions:</b> <table style="width: 100%; border: none;"> <tr> <td style="width: 40%;">Temperature</td> <td style="width: 20%;">23 °C</td> <td style="width: 40%;">± 1 °C</td> </tr> <tr> <td>Atmospheric Pressure</td> <td>1027 mBar</td> <td>± 2 mBar</td> </tr> <tr> <td>Relative Humidity</td> <td>35 %</td> <td>± 5 %</td> </tr> </table>			Temperature	23 °C	± 1 °C	Atmospheric Pressure	1027 mBar	± 2 mBar	Relative Humidity	35 %	± 5 %																					
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<b>Test Equipment used during this calibration:</b> <table border="1" style="width: 100%; border-collapse: collapse; font-size: small;"> <thead> <tr> <th>Equipment</th> <th>Manufacturer</th> <th>Model</th> <th>Serial No.</th> <th>Traceability Ref.</th> <th>Calibration Due</th> </tr> </thead> <tbody> <tr> <td>Reference Calibrator</td> <td>Brüel &amp; Kjær</td> <td>4231</td> <td>2326247</td> <td>TE 129</td> <td>Nov-23</td> </tr> <tr> <td>Multimeter</td> <td>HP</td> <td>34401A</td> <td>36146A63804</td> <td>TE 105</td> <td>Oct-23</td> </tr> <tr> <td>Microphone</td> <td>B&amp;K</td> <td>4133</td> <td>810486</td> <td>TE 155</td> <td>Aug-23</td> </tr> <tr> <td>Real-Time Analyser (set 1)</td> <td>Larson Davis</td> <td>2900</td> <td>0492</td> <td>TE 108</td> <td>Jul-23</td> </tr> </tbody> </table>			Equipment	Manufacturer	Model	Serial No.	Traceability Ref.	Calibration Due	Reference Calibrator	Brüel & Kjær	4231	2326247	TE 129	Nov-23	Multimeter	HP	34401A	36146A63804	TE 105	Oct-23	Microphone	B&K	4133	810486	TE 155	Aug-23	Real-Time Analyser (set 1)	Larson Davis	2900	0492	TE 108	Jul-23
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End of Certificate																																

**APPENDIX 11.6****Candidate Turbine Manufacturer's Noise Emission Data****6.3 Sound Curves, Mode PO6000/PO6000-0S**

<b>Sound Power Level at Hub Height</b>		
<b>Conditions for Sound Power Level:</b>	<b>Measurement standard IEC 61400-11 ed. 3</b> <b>Maximum turbulence at hub height: 30%</b> <b>Inflow angle (vertical): <math>0 \pm 2^\circ</math></b> <b>Air density: 1.225 kg/m<sup>3</sup></b>	
<b>Wind speed at hub height [m/s]</b>	<b>Sound Power Level at Hub Height [dBA] Mode PO6000 (Blades with serrated trailing edge)</b>	<b>Sound Power Level at Hub Height [dBA] Mode PO6000-0S (Blades without serrated trailing edge)</b>
3	92.0	94.8
4	92.2	95.0
5	94.0	96.8
6	96.9	99.7
7	99.9	102.7
8	102.7	105.5
9	104.6	107.4
10	104.8	107.6
11	104.9	107.7
12	104.9	107.7
13	104.9	107.7
14	104.9	107.7
15	104.9	107.7
16	104.9	107.7
17	104.9	107.7
18	104.9	107.7
19	104.9	107.7
20	104.9	107.7



### 7.3 Sound Curves, Sound Optimized Mode SO0

Sound Power Level at Hub Height	
Conditions for Sound Power Level:	Measurement standard IEC 61400-11 ed. 3 Maximum turbulence at hub height: 30% Inflow angle (vertical): $0 \pm 2^\circ$ Air density: $1.225 \text{ kg/m}^3$
Wind speed at hub height [m/s]	Sound Power Level at Hub Height [dBA] Sound Optimized ModeSO0 (Blades with serrated trailing edge)
3	91.3
4	91.8
5	94.1
6	96.9
7	100.0
8	102.6
9	103.7
10	103.9
11	104.0
12	104.0
13	104.0
14	104.0
15	104.0
16	104.0
17	104.0
18	104.0
19	104.0
20	104.0