



## ***Tramway Audible Warning Acoustic Test Guidance***


  
**CALL**  
0121 214 7107

  
**EMAIL**  
[info@lrssb.co.uk](mailto:info@lrssb.co.uk)


  
**WEB**  
[www.lrssb.org](http://www.lrssb.org)

  
**TWITTER**  
[@LightRailSSB](https://twitter.com/LightRailSSB)


  
**LINKEDIN**  
[@lightrailssb](https://www.linkedin.com/company/lightrailssb)

	<b>TRAMWAY AUDIBLE WARNING ACOUSTIC TEST GUIDANCE</b>		<b>LRSSB - LRG - 5.0</b>	
			Issue	3
			Revision	0
			Date	25/11/2022
			Page	1 of 16

TITLE:		TRAMWAY AUDIBLE WARNING ACOUSTIC TEST GUIDANCE			
REF:		LRG 5.0		STATUS:	FINAL
ISSUE:	03	REVISION:	00	DATE:	25/11/2022
DEPT:	LRSSB Safety Assurance			REVIEW DUE:	25/11/2027
DOCUMENT OWNER:				DISTRIBUTION:	
LRSSB				ALL UK TRAMWAYS	
DESCRIPTION:					
THIS DOCUMENT PROVIDES GUIDANCE IN TRAMWAY AUDIBLE WARNING ACOUSTIC TESTS.					
EXPLANATORY NOTE:					
LRSSB is not a regulatory body and compliance with this guidance document is not mandatory. This document reflects good practice and is advisory only. Users are recommended to evaluate this guidance against their own arrangements in a structured and systematic way, noting that parts of this guidance may not be appropriate to their operations. It is recommended that this process of evaluation and any subsequent decision to adopt (or not adopt) elements of this guidance should be documented. Compliance with any or all of the contents herein, is entirely at an organisation’s own discretion.					
SOURCE / RELATED DOCUMENTS:					
LRG 1.0 Tramway Principles and Guidance (TPG) (LRSSB) LRG 2.0 Non-Motorised Tramway Crossing Guidance (LRSSB) LRG 4.0: Signing and Marking of Tramways (LRSSB) LRG 19.0 Cycle Tramway Interface Guidance (LRSSB) LRG 24.0 Pedestrian Safety Guidance (LRSSB) EN 15153-2:2019: Railway Applications - External Visible and Audible Warning Devices - Part 2: Warning Horns for Heavy Rail EN 15153-4:2019: Railway Applications - External Visible and Audible Warning Devices - Part 4: Audible Warning Devices for Urban Rail EN 61672-1:2013: Electroacoustics. Sound Level Meters. Specifications BS EN 61672-2:2013+A1:2017: Electroacoustics. Sound Level Meters. Pattern Evaluation Tests BS EN IEC 60942:2018: Electroacoustics. Sound Calibrators RAIB Report 19/2013: Fatal Accident at Bayles and Wylies Footpath Crossing, Bestwood, Nottingham					
RELATED TRAINING COURSES:				RELATED LEGISLATION:	
N/A				Health and Safety at Work Act etc. 1974 Management of Health and Safety at Work Regulations 1999 Railways and Other Guided Transport Systems (Safety) Regulations 2006 (as amended) (ROGS) 2006 Vehicles (Construction and Use) Regulations 1986 Control of Noise at Work Regulations 2005	

	<b>TRAMWAY AUDIBLE WARNING ACOUSTIC TEST GUIDANCE</b>	<b>LRSSB - LRG - 5.0</b>	
		Issue	3
		Revision	0
		Date	25/11/2022
		Page	2 of 16

CHANGE NOTES:				
Date of Issue	Issue No.	Revision No.	Reviewer	Details of Revision
16/11/2020	02	01	Colin Kerr	Amendments to text / format
24/11/2022	03	00	LRSSB	Amendments to text / format
<b>UNCONTROLLED WHEN PRINTED</b>				

	<b>TRAMWAY AUDIBLE WARNING ACOUSTIC TEST GUIDANCE</b>		<b>LRSSB - LRG - 5.0</b>	
			Issue	3
			Revision	0
			Date	25/11/2022
			Page	3 of 16

## LRSSB

**DOCUMENT CODE: LRG 5.0**

# TRAMWAY AUDIBLE WARNING ACOUSTIC TEST GUIDANCE

## CONTENTS


1. Introduction
2. Scope
3. Test Conditions
4. Test Equipment
5. AWD Limits
6. Test Procedure
7. Report

### Figures

- Figure 3.1 Open Test Site  
Figure 6.1 Lateral Measurements

### Tables

- Table A Terms  
Table B Abbreviations

	<b>TRAMWAY AUDIBLE WARNING ACOUSTIC TEST GUIDANCE</b>		<b>LRSSB - LRG - 5.0</b>	
			Issue	3
			Revision	0
			Date	25/11/2022
			Page	4 of 16

### Revisions from Previous Issue

New LRG document template and other formatting.

Changes to Page 1: removal of the named preparer, reviewer and authorising person and insertion of an explanatory note in relation to the status of this guidance document.

Reference made to LRG 2.0 Non-Motorised Tramway Crossing Guidance, LRG 19.0 Cycle Tramway Interface Guidance and LRG 24.0 Pedestrian Safety Guidance.


Amendments to text in section 6.11 and amendments to Figure 6.1.

Additional abbreviations added to the Terms and Abbreviations table (from existing text).

Additional paragraphs and changes to the Introduction Chapter to be consistent with other LRG documentation.

Link to actual RAIB report inserted into footnote.

Numerous minor presentation, minor factual and typographical changes.

	<b>TRAMWAY AUDIBLE WARNING ACOUSTIC TEST GUIDANCE</b>	<b>LRSSB - LRG - 5.0</b>	
		Issue	3
		Revision	0
		Date	25/11/2022
		Page	5 of 16

## TERMS AND ABBREVIATIONS


**Table A – Terms**

<b>Term</b>	<b>Definition</b>
<b>A-weighted sound pressure level</b>	A sound pressure level that is weighted by a set of curves.
<b>Class 1 Sound Calibrator</b>	The highest of the reference standards in the calibration of sound i.e. is appropriate for calibrating high-precision analytical sound.
<b>Instrumentation System</b>	System for taking measurements.
<b>Line of Sight</b>	Operating mode where a tram should be able to stop before a reasonably visible stationary obstruction ahead, from the intended speed of operation using the service brake.
<b>Measuring System</b>	A set of measuring devices where the operator receives the necessary information simultaneously.
<b>Type 1 Instrument</b>	Type of instrument used for precision measurements in the field.
<b>Urban Guided Transport</b>	For this document, tramway / Light Rail system.

	<b>TRAMWAY AUDIBLE WARNING ACOUSTIC TEST GUIDANCE</b>	<b>LRSSB - LRG - 5.0</b>	
		Issue	3
		Revision	0
		Date	25/11/2022
		Page	6 of 16

**Table B – Abbreviations**


<b>Abbreviation</b>	<b>Definition</b>
<b>AWD</b>	Audible Warning Device
<b>BS</b>	British Standard
<b>BS EN</b>	British Standard (BS) adoption of a European (EN) Standard
<b>D</b>	Distance
<b>dB</b>	Decibel
<b>dB<sub>pAFmax</sub></b>	
<b>EN</b>	European (EN) Standard
<b>Hz</b>	Hertz (cycles per second)
<b>KHz</b>	Kilo-hertz (thousand cycles per second)
<b>L<sub>pAFmax</sub></b>	The maximum Sound Level with 'A' Frequency weighting and Fast Time weighting during the measurement period
<b>LRSSB</b>	Light Rail Safety and Standards Board
<b>M</b>	Metres
<b>MR</b>	Medium Range
<b>Ms</b>	Milli-Seconds
<b>PPE</b>	Personal Protection Equipment
<b>RAIB</b>	Rail Accident Investigation Branch
<b>ROGS</b>	Railways and Other Guided Transport Systems (Safety) Regulations 2006 (as amended)
<b>SR</b>	Short Range
<b>TPG</b>	Tramways and Principles Guidance
<b>UK</b>	United Kingdom

	<b>TRAMWAY AUDIBLE WARNING ACOUSTIC TEST GUIDANCE</b>		<b>LRSSB - LRG - 5.0</b>	
			Issue	3
			Revision	0
			Date	25/11/2022
			Page	7 of 16

## 1. Introduction

- 1.1. This guidance supports the high level principles set out in LRG 1.0 Tramway Principles and Guidance (TPG) published by the Light Rail Safety and Standards Board (LRSSB).
- 1.2. This document provides high level guidance for tramway audible warning acoustic tests for those delegated this responsibility in relation to tramways (Light Rail systems) based on 'line-of-sight' operations only.
- 1.3. As with all guidance, this document is not prescriptive and is intended to give advice not to set a mandatory industry standard, and it is based upon goal setting principles as best practice. Much of this guidance is based on the experience gained from existing tramways and from published documents. It does not prescribe particular arrangements adopted by any existing tramway and is intended to give guidance and advice to those involved in Tramway Audible Warning Acoustic Tests. It does not provide a process for type approving audible warning devices (AWDs).
- 1.4. This guidance is not intended to be applied retrospectively to existing Tramway s. However, owners and operators should consider and assess any implementation of this guidance and / or any subsequent revision, to ensure continual improvement, so far as is reasonably practicable.




	<b>TRAMWAY AUDIBLE WARNING ACOUSTIC TEST GUIDANCE</b>		<b>LRSSB - LRG - 5.0</b>	
			Issue	3
			Revision	0
			Date	25/11/2022
			Page	8 of 16

## 2. Scope

- 2.1. Tramways systems do not have to be segregated from general road and pedestrian traffic. They share their right of way with general road and / or pedestrian traffic and are therefore embedded in their relevant national road traffic legislation (for example highway codes and specific adaptations etc).
- 2.2. The test procedure in this document is based on EN 15153-4:2019<sup>1</sup> and designed to be used by Light Rail systems and maintainers in order to validate that the Light Rail system meets the essential requirements as defined in the LRG 1.0 TPG.
- 2.3. As stated in LRG 1.0, AWDs should be installed at both ends of a Light Rail system to ensure that they provide sufficient sound pressure outputs in keeping with the environment in which the Light Rail system runs.
- 2.4. In general, a Light Rail system operating on-street must conform to the current Road Vehicles (Construction and Use) Regulations 1986<sup>2</sup> for road vehicles as far as appropriate. Although not subject to the mandatory requirements for road vehicles, a Light Rail system should nevertheless include features in their construction and performance that make them safe for use on the highway and in other places where they share the infrastructure with other users.

<sup>1</sup> EN 15153-4:2019 – Railway Applications - External Visible and Audible Warning Devices - Part 4: Audible Warning Devices for Urban Rail

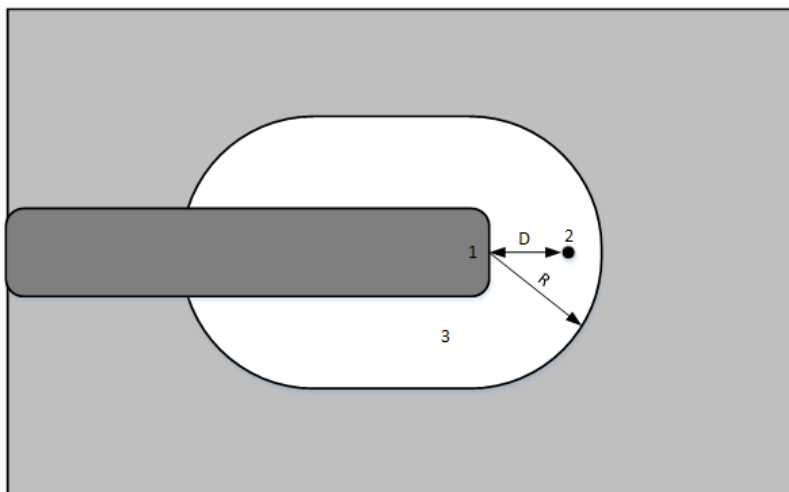
<sup>2</sup> The Road Vehicles (Construction and Use) Regulations 1986 SI 1986/1078  
<https://www.legislation.gov.uk/uksi/1986/1078/made/data.pdf>

	<b>TRAMWAY AUDIBLE WARNING ACOUSTIC TEST GUIDANCE</b>		<b>LRSSB - LRG - 5.0</b>	
			Issue	3
			Revision	0
			Date	25/11/2022
			Page	9 of 16

### 3. Test Conditions

- 3.1. The test requirements of EN 15153-2<sup>3</sup> Clause 6 should apply, with the following modifications as specified in EN 15153-4:
- 3.2. The test environment should be representative of the operating environment, i.e. it is not required to be ballast.
- 3.3. The measurement distance ('D') is 7m (as illustrated below in Figure 3.1) with a relative tolerance of  $\pm 2\%$ . This measurement is from the front of the tram vehicle along the centre-line of the track at a height of  $1.6\text{ m} \pm 3\%$  above the top of rail.

Figure 3.1: Open Test Site



**Key:**

D= 7m

$R \geq 2D$


1 = Front of tram vehicle

2 = Measurement of position

3 = Open Area

- 3.4. For sound pressure level tests, three measurement samples should be taken. In each case, the arithmetic mean value of the three measurement results should be used. If the frequency results vary by more than 5%, or the sound pressure level results vary by more than 3 dB, then the three measurement results should be discarded, and the measurements repeated.

<sup>3</sup> EN 15153-2:2019 – Railway Applications - External Visible and Audible Warning Devices - Part 2: Warning Horns for Heavy Rail

	<b>TRAMWAY AUDIBLE WARNING ACOUSTIC TEST GUIDANCE</b>		<b>LRSSB - LRG - 5.0</b>	
			Issue	3
			Revision	0
			Date	25/11/2022
			Page	10 of 16

#### 4. Test Equipment

- 4.1. The test equipment should conform to the following:
- 4.2. Each component of the instrumentation system should meet the requirements for a type 1 instrument, as specified in EN 61672-1<sup>4</sup>.
- 4.3. A suitable microphone windscreen should always be used during the tests.
- 4.4. The calibration of the measuring system should be verified before and after each series of measurements. The adjustment of the measurement equipment should use a class 1 sound calibrator that meets the requirements set out in EN 60942<sup>5</sup>, and should include the calibration at least at one frequency in the range of frequencies of interest. The measurement results should be rejected and retested if the difference between the adjusted results before and after calibration is greater than 0.5 dB.
- 4.5. As a minimum, the calibrator should be verified against the requirements of EN 60942 every 12 months.
- 4.6. As a minimum, all components of the measurement system should be verified against the requirements of EN 61672-1 and EN 61672-2<sup>6</sup> every two years. The date of the last verification of the compliance of the calibrator with the relevant European Standards should be recorded.

<sup>4</sup> EN 61672-1:2013 - Electroacoustics. Sound Level Meters. Specifications

<sup>5</sup> BS EN IEC 60942:2018 - Electroacoustics. Sound Calibrators

<sup>6</sup> BS EN 61672-2:2013+A1:2017 - Electroacoustics. Sound Level Meters. Pattern Evaluation Tests

	<b>TRAMWAY AUDIBLE WARNING ACOUSTIC TEST GUIDANCE</b>		<b>LRSSB - LRG - 5.0</b>	
			Issue	3
			Revision	0
			Date	25/11/2022
			Page	11 of 16

## 5. AWD Limits

- 5.1. The sound pressure level of the background noise and wind noise must be at least 10 dB (A) below the sound to be measured (refer to BS EN 15153-4).

### Short Range (SR) AWDs

- 5.2. Tramway systems should be fitted with short range (SR) AWDs at each driving end of the tram vehicle (refer to LRG 1.0 TPG).
- 5.3. The types of permitted devices for providing audible alerts or drawing attention at short range are listed below and then explained in more detail in the following sections:
- SR soft bell - single sound;
  - SR soft bell - recurring sound;
  - SR whistle; and
  - SR warning horn.

### SR Soft Bell - Single Sound

- 5.4. When actuated, the single sound SR soft bell AWD should emit an impulse sound with a decay having the following characteristics:
- Total audible duration not less than 500 ms;
  - Rise time not greater than 100 ms;
  - Fundamental frequency of the sound should be within the range from 1 kHz to 4 kHz; and
  - Sound pressure level of the emitted sound should be  $76 \text{ dB} \pm 5 \text{ dB}_{\text{pAFmax}}$ .
- 5.5. It should be noted that in the case of SR soft bells with a non-harmonic character, the decision for relevant frequency content should be based on the difference in level between peaks outside the specified spectrum and the level for the highest frequency peak.
- 5.6. When assessing suitability, frequency peaks at least 4 dB below the highest frequency peak should be considered to be not relevant.

### SR Soft Bell - Recurring Sound

- 5.7. A SR soft bell AWD with a recurring sound should meet the criteria as for a SR Soft Bell AWD with a single sound, with the following additions:
- Recurring time-base with the following characteristics:
    - 1.5 to 4 Hz in the case of single-stroke bells; or
    - 20 to 40 Hz in the case of motor driven bells.

### SR Whistle

- 5.8. A SR whistle AWD should meet the following criteria:
- Maximum peak frequency of  $1.3 \text{ kHz} \pm 300 \text{ Hz}$ ; and
  - Sound pressure level of the emitted sound should be  $76 \text{ dB} \pm 5 \text{ dB}_{\text{pAFmax}}$ .

### SR Warning Horn

	<b>TRAMWAY AUDIBLE WARNING ACOUSTIC TEST GUIDANCE</b>		<b>LRSSB - LRG - 5.0</b>	
			Issue	3
			Revision	0
			Date	25/11/2022
			Page	12 of 16

5.9. A SR warning horn AWD should meet the following criteria:

- Maximum peak frequency of 1.3 kHz  $\pm$  300 Hz; and
- Sound pressure level of the emitted sound should be 76 dB  $\pm$  5 dB<sub>pAFmax</sub>.

### Medium Range (MR) AWD

5.10. As with SR AWDs above, tram systems are also required to be fitted with a medium range (MR) AWD at each driving end of the tram vehicle. When actuated, AWDs should emit a continuous, uniform sound or a series of short, urgent, danger warnings.

5.11. The criteria for devices permitted in providing audible alerts or drawing attention at medium range are listed below and then explained in more detail in the following sections:

- MR bell - single sound;
- MR bell - recurring sound;
- MR whistle; and
- MR warning horn.

### MR Bell - Single Sound

5.12. When actuated, a MR bell AWD with a single sound should have the following characteristics:

- Total audible duration in the range 500 ms to 1 second;
- Rise time not greater than 100 ms;
- Fundamental frequency of the sound should be within the range from 1 kHz to 4 kHz; and
- Sound pressure level of the emitted sound should be 96 dB  $\pm$  5 dB<sub>pAFmax</sub>.


5.13. It should be noted that pursuant to the RAIB report into the Bayles and Wylies incident<sup>7</sup>, the recommended working of the AWD is to provide a series of short, urgent danger warnings.

5.14. It should also be noted that in the case of MR bells with a non-harmonic character (as with SR soft bells), the decision for relevant frequency content should be based on the difference in level between peaks outside the specified spectrum and the level for the highest frequency peak.

5.15. When assessing suitability, frequency peaks at least 4 dB below the highest frequency peak should be considered to be not relevant.

### MR Bell - Recurring Sound

<sup>7</sup> RAIB Report 19/2013 - Fatal Accident at Bayles and Wylies Footpath Crossing, Bestwood, Nottingham - <https://www.gov.uk/raib-reports/fatal-accident-at-bayles-and-wylies-footpath-crossing-bestwood-nottingham>

	<b>TRAMWAY AUDIBLE WARNING ACOUSTIC TEST GUIDANCE</b>	<b>LRSSB - LRG - 5.0</b>	
		Issue	3
		Revision	0
		Date	25/11/2022
		Page	13 of 16

5.16. A MR bell AWD with a recurring sound should meet the criteria as for a MR bell AWD with a single sound, with the following additions:

- Recurring time-base with the following characteristics:
  - 1.5 to 4 Hz in the case of single-stroke bells; or
  - 20 to 40 Hz in the case of motor driven bells.

#### **MR Whistle**

5.17. A MR whistle AWD should meet the following criteria:

- Maximum peak frequency of 1.3 kHz  $\pm$  300 Hz; and
- Sound pressure level of the emitted sound should be 96 dB  $\pm$  5 dB<sub>pAFmax</sub>.

#### **MR Warning Horn**

5.18. A MR warning horn AWD should meet the following criteria:

- Fundamental frequency:
  - 370 Hz  $\pm$  20 Hz; or
  - 660 Hz  $\pm$  30 Hz; and
- Sound pressure level of the emitted sound should be 96 dB  $\pm$  5 dB<sub>pAFmax</sub>.

5.19. It should be noted that is desirable for a warning horn AWD to provide a spectrum which is rich in harmonics to optimise audibility for persons with partial hearing loss.

	<b>TRAMWAY AUDIBLE WARNING ACOUSTIC TEST GUIDANCE</b>		<b>LRSSB - LRG - 5.0</b>	
			Issue	3
			Revision	0
			Date	25/11/2022
			Page	14 of 16

## 6. Test Procedure

- 6.1. When testing AWDs, consideration should be given to the location of the AWD, noting the above limits and also taking into account the possible exposure of staff to excessive noise.
- 6.2. It should be noted that this test should not be carried out in snow conditions.

### Safe System of Work

- 6.3. The risk of accidental hearing damage to any person working close to the Light Rail system when an AWD is sounded must be considered. All AWD testing must be carried out safely in accordance with the Control of Noise at Work Regulations 2005<sup>8</sup>.
- 6.4. In order to minimise any environmental impact, the AWD should be orientated along the longitudinal axis of the tram vehicle. It is permissible for additional AWDs to be fitted, for example bells.
- 6.5. The associated testing schedule for these tests should make appropriate allowance for the exposure to noise limits and provision of any necessary personal protection equipment (PPE):
  - Workers exposed to daily or weekly average noise exposure levels between 80 and 85 dB must use hearing PPE, and
  - Workers must not be exposed to noise exposure levels in excess of 87 dB (taking into consideration any hearing PPE).

### AWD Installation

- 6.6. On installation, a visual inspection of the AWD and its control systems should be carried out to confirm that they are adequately protected from impact and any potential subsequent blockage by airborne objects such as debris, dust, snow, hail and birds etc as far as is reasonably practicable.
- 6.7. Where any such protection features are used, the acoustic requirements should apply, taking into account any protection features that have been installed.

### Operation

- 6.8. As a minimum, functionality of the AWD should be checked each time the tram vehicle is handed back from maintenance to operation.
- 6.9. Although it is not required for a tram vehicle installed AWD to be included in regular maintenance activities, it is good practice for this to be part of the maintenance regime.

### Frequency Measurement

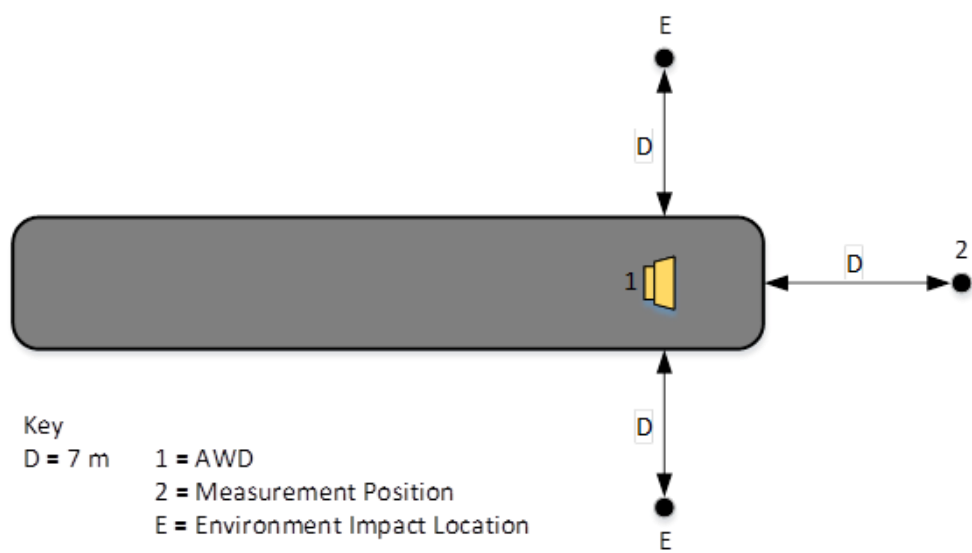
<sup>8</sup> Control of Noise at Work Regulations 2005  
<https://www.legislation.gov.uk/uksi/2005/1643/made/data.pdf>

6.10. Although a frequency measurement test is not required for a tram vehicle installed AWD, it is good practice for this to be undertaken and the AWD data sheet appended to the test report.

**Sound Pressure Levels**

- 6.11. The A-weighted sound pressure level  $L_{pAFmax}$  produced by each AWD sounded separately (or in a group if designed to sound simultaneously) should be between 91 dB and 101 dB when measured and verified at location 2 as illustrated in Figure 3.1.
- 6.12. In order to minimise the environmental impact of the AWD, the A-weighted sound pressure level  $L_{pAFmax}$  from the mounted AWD when measured should be at least 5 dB lower than the level measured at location 2 in front of the tram vehicle as illustrated in Figure 6.1 below.
- 6.13. In order to minimise the environmental impact of the AWD, the A-weighted sound pressure level  $L_{pAFmax}$  from the mounted AWD when measured should be at least 5 dB lower than the level measured at location at location E is at least 5 dB lower than the level measured at location 2 in front of the vehicle. This is illustrated below in Figure 6.1

Figure 6.1: Lateral Measurements



**Energy**


- 6.14. The tram vehicle electrical supply voltage to the AWDs should be recorded both before and after the suite of tests. The AWD should be operated using the normal energy supply on the tram vehicle.
- 6.15. The AWD should meet the technical requirements of the Standards referred to in this guidance for the full range of energy levels encountered on the tram vehicle in its normal operational condition.
- 6.16. Where agreed between tram vehicle supplier, owner and operator, the AWD should be operational over an extended range of energy levels.



# TRAMWAY AUDIBLE WARNING ACOUSTIC TEST GUIDANCE

## LRSSB - LRG - 5.0

Issue	3
Revision	0
Date	25/11/2022
Page	16 of 16

	<b>TRAMWAY AUDIBLE WARNING ACOUSTIC TEST GUIDANCE</b>		<b>LRSSB - LRG - 5.0</b>	
			Issue	3
			Revision	0
			Date	25/11/2022
			Page	17 of 16

## 7. Report

7.1. The test results should be documented in a test report and should as a minimum include the following details (not exclusively):

- Reference to EN 15153-2, including any deviations;
- Description of the environmental conditions of the test site location;
  - acoustical environment (presence of obstacles, ground cover);
  - meteorological conditions:
    - ambient temperature;
    - humidity;
    - wind speed and direction; and
    - precipitation;
  - background sound pressure level;
- Description of the AWD (type and serial number(s), and mounting arrangements of the AWD);
- Description of the AWD test conditions:
  - conditions of energy source;
  - actuation device used; and
  - the duration of the evaluation time;
- Description of the measurement instrumentation:
  - type of acquisition system; and
  - type of microphone;
- Measurement positions;
- Number of sample measurements;
- Test results:
  - the frequency values and sound pressure levels of all measurement samples; and
  - the mean values of the test results; and
- Any other useful information applicable to the tests.

7.2. The above list is not exhaustive as the test report should include any relevant additional detail that is specific to the test and Light Rail system.

7.3. In the case of additional tests, all relevant information should be included in the report.