Attachment 30: Acoustic Conspicuity Assessment Protocol

1 Introduction

This document presents a procedure for objectively assessing the performance of Acoustic Vehicle Alerting Systems (AVAS) installed on a bus. TfL has designed a unique Urban Bus Sound to be used by quiet running buses in London and buses belonging to other organisations at TfL's discretion.

The aim of these systems is to make a vehicle fitted with a quiet running powertrain (e.g. hybrid or electric) as conspicuous to a pedestrian as a typical diesel engine.

For full understanding of this Attachment it should be read in conjunction with the Attachment 31: Acoustic Conspicuity Guidance Notes and New Bus Specification, Section 4.4.1.

Scope

This protocol applies to all new buses intended for service under contract to TfL that are passenger vehicles with a maximum mass exceeding 5 tonnes and a capacity exceeding 22 passengers. The passenger vehicles will be capable of carrying seated but unrestrained occupants and standing occupants. Such vehicles are categorised the Consolidated Resolution on the Construction of Vehicles (R.E.3) as M_3; Class I.

UNECE Regulation 138 requires the addition of an Acoustic Vehicle Alerting System (AVAS) on all new quiet running vehicles. The regulation came into effect for all new vehicle models of this type manufactured after 01/07/2019 and applies to all vehicles manufactured after 01/07/2021.

Purpose

The purpose of this protocol is to allow an assessment against the required level of performance for Acoustic Vehicle Alerting Systems (AVAS).

Normative References

The following normative documents, in whole or in part, are referenced in this document and are indispensable for its correct application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

- London Bus Services Limited New Bus Specification: Section 4.4.1
- London Bus Services Limited New Bus Specification: Attachment 31 Acoustic Conspicuity Guidance Notes

- UN ECE Regulation 138; Uniform provisions concerning the approval of Quiet Road Transport Vehicles with regard to their reduced audibility

Definitions

For the purpose of this Protocol:

- **Approval Authority** – The body within TfL that certifies that a bus is approved for use in the TfL fleet and assigns its score under the Bus Safety Standard for use in procurement processes.
- **AVAS** – Acoustic Vehicle Alerting System. This is the entire system including both hardware & firmware/software and the Urban Bus Sound when installed on a bus, as per Regulation 138.
- **AVAS Hardware** - Complete playback system used to reproduce the AVAS
- **Beacon sound** - Part of the Urban Bus Sound. A Distinct rhythmic pulse, intended to raise acoustic conspicuity
- **Core sound** - Part of the Urban Bus Sound. An underlying sound component that is played continuously when the bus is in operation
- **Front plane of the vehicle** - A vertical plane tangential to the leading edge of the vehicle
- **Intelligent Speed Assistance (ISA)** - Through TfL Digital Speed Map bus selects localised speed limits
- **$L_{AMAX, FAST}$** - The maximum sound pressure in a 5 second period, A-weighted, Fast time weighting
- **$L_{Aeq, 10\ seconds}$** - The equivalent continuous sound pressure level for a 10 second period, A-weighted.
- **L_{SIL}** – The Speech Interference Level of noise, calculated as the arithmetic mean of the $L_{eq,10\ seconds}$ in four octave bands 500 Hz, 1 kHz, 2 kHz and 4 kHz.
- **New Build** – A vehicle that has been built by the Vehicle OEM with the system to be assessed fitted during the assembly process prior to first registration of the vehicle.
- **Non-Responsive AVAS** – An AVAS configuration that has a fixed sound output level and is non-dependent on location and time of day.
- **Quiet running vehicle** - Any vehicle which does not require the continuous operation of an internal combustion engine to propel the vehicle
- **Rear plane of the vehicle** - A vertical plane tangential to the trailing edge of the vehicle
- **Responsive AVAS** – An AVAS configuration that adapts its sound output level depending on the vehicles GPS location and time of day via ISA.
- **Retrofit** – A vehicle as defined in the TfL AVAS Retrofit Programme.
- **Sound Pressure Level (L_{pA})** - The sound pressure expressed in Decibels, A-weighted

- **Test Service** – The organisation undertaking the testing and certifying the results to the Approval Authority.
- **Urban Bus Sound** - The uniquely identifiable AVAS sound designed and owned by TfL, consists of two components
- **VUT: Vehicle Under Test** – Means a vehicle that is being tested to this protocol.

Test Conditions

Requirements for testing as defined in Regulation 138.

Test Track (Outdoors)

Testing shall be conducted on a dry surface, free from absorbing materials (powdery snow, or loose debris)

The test track shall meet the requirements of ISO 10844:2014.

Test Track (Indoors)

The test facility shall meet the requirements of ISO 26101:2012.

Weather and lighting

Testing shall be conducted in dry weather conditions with no precipitation falling and temperatures no lower than 5°C and not higher than 40°C.

Wind speed shall be less than 5 m/s. As an alternative the tests may be conducted indoors.

The test track shall have a level of ambient light that will allow the driver and assessor to see if any people or objects move into positions where they could be a risk of being hit by the bus during testing.

Vehicle preparation

The AVAS shall have been installed during manufacture in the case of a new-build vehicle.

The VUT shall:

a) Have passed an annual MOT test at a DVSA test station within the last 12 months (if the vehicle is more than 12 months old), with the exception of prototype vehicles

b) Be within its scheduled maintenance period (unless it is a new vehicle that has not yet been required to have its first service)

c) Have no faults or damage that could interfere with the testing protocol

d) Be driven by a qualified driver. In the instances where the test procedure requires there be no seat pressure the driver shall remain within the drivers cabin to apply the brakes when the bus rolls

e) Be empty of passengers or any persons other than the driver

Test procedure

The assessment of the AVAS is carried out using the checklists found in Appendix A and B.

The AVAS checklist shall be assessed based on documentation submitted by the bus OEM.

Testing of the AVAS shall be conducted in a manner conforming to UN ECE Regulation 138.

All observed results shall be recorded in the checklist.

Assessment of results

The following criteria will be used to assess if the AVAS system has passed or failed the assessment.

In order to receive a “Pass” certification, the system must meet the expected outcome for each of the requirements on the assessment checklist.

The system shall be deemed to have failed the assessment if it does not meet any single expected outcome on the AVAS assessment checklist. A system that fails to meet these pre-requisites shall not be recommended.

Test report

The Test Service shall provide a comprehensive test report that will be made available to the Approval Authority. The test report shall consist of two distinct sections:

a) Completed AVAS checklist;

b) Reference information.

The reference information required shall include as a minimum:

a) Vehicle Make

b) Vehicle Model

c) Vehicle Model Variant

d) AVAS system installed (including unit serial number)

e) Evidence of meeting vehicle preparation requirements (e.g. technical inspection, service history)

f) Details of the Test Service

g) Test date(s)

Appendix A - AVAS checklist

Acoustic Vehicle Alerting System (AVAS)	**Expected Outcome**	**Actual Outcome**	**Outcome match? (Yes=1, No=0)**
Sounder/s located on the front of the vehicle below the windshield	True		
TfL Urban Bus Sound is in appropriate format	True		
The AVAS has a working functionality self-check with driver notification	True		
The AVAS sound is Regulation 138 compliant, and a valid test certificate submitted	True		
The reversing requirement of Regulation 138 is compliant	True		
The AVAS sound achieves the minimum frequency profile as defined in Appendix B for AVAS Step 1	True		
The AVAS sound achieves overall sound pressure levels for each AVAS Step as defined in Appendix B with a tolerance of ±1.5 dB (Step 3 only if a Retrofit vehicle)	True		
The AVAS sound does not exceed the maximum sound pressure levels in the Driver's cabin as defined in Appendix C	True		
The AVAS unit number is recorded in relation to the vehicle number and can receive local updates	True		
The AVAS can receive an updated sound file in the future	True		
	Total		
	Required Score		10
	Outcome		

Appendix B – AVAS Sound Level Requirements

Measurement Position: Front panes (left and right) – 2 meters from front centre (Regulation 138 front positions)

Vehicle Speed Operation: Performances shall be achieved at all speed operations below 22 km/h, tested as per Regulation 138.

Overall sound pressure levels for AVAS Steps 2-5 shall be achieved by a uniform increase across the frequency spectrum to achieve overall levels for each Step shown in Table B1. Sounder technologies for in harsh operating environments are continually evolving. Manufacturers are encouraged to develop improved frequency response at low and high frequencies for suitable weatherproof sounders in order to improve fidelity of the Urban Bus Sound operating across the TfL bus fleet. The minimum frequency profile in Table B1 shall be updated at regular intervals to respond to improvements in weatherproof sounder performance and improve fidelity of the Urban Bus Sound operating across the TfL bus fleet.

Table B1 – Minimum sound levels for the AVAS Step levels (may be subject to minor changes prior to final revision)

Frequency (Hz)		A-weighted Sound Pressure Level ($L_{AMAX, FAST}$ (dB))				
		Step 1	Step 2	Step 3	Step 4	Step 5
Overall amplitude		60	63	66	69	72
1/3 Octave bands	160	25				
	200	31				
	250	30				
	315	50				
	400	47				
	500	42				
	630	51				
	800	51				
	1,000	51				
	1,250	51				
	1,600	45				
	2,000	44				
	2,500	44				
	3,150	47				
	4,000	36				
	5,000	26				

Appendix C – Cabin Sound Level Requirements

Drivers Cabin

Measurement Position: 1.2m above the cab floor, directly between the steering wheel and the driver's seat.

Table C1 – Maximum sound levels in the Drivers Cabin as a result of AVAS Sounder operation only.

Frequency (Hz)	Sound Pressure Level ($L_{Aeq,10\ second}$ (dB))
	Maximum
Overall amplitude	60 (50 L_{SIL})

Manufacturers are encouraged to further reduce the level of sound ingress to the Cabin from the AVAS sounders by system configuration, placement, equipment, sound insulation, or other means, below the maximum levels set out in Table C1.

Attachment 31: Acoustic Conspicuity Guidance Notes

1 Introduction

This document sets out the guidance notes related to Acoustic Conspicuity. These guidance notes are aimed at bus operators and OEMs as a practical guide for implementation of the Bus Safety Standard.

These notes are for guidance only and are not legally binding. In all circumstances, the guidance provided by an OEM or system supplier shall take precedence, and these guidance notes are only for use in the absence of other information. These are not intended to be exhaustive, but to point the operators toward practical advice and questions to raise with OEMs/suppliers.

Selection of buses/systems

Buses requiring Acoustic Conspicuity measures

Regulatory requirements are in force for Whole Vehicle Type Approval (WVTA), in the form of Regulation 138[1]. This requires:

- From September 2019 all new bus models (new designs requiring type approval) in vehicle category
- #M3 and fitted with either a hybrid (HEV), pure electric (PEV), electrified vehicle (EV), fuel cell vehicle (FCV) or a fuel cell hybrid vehicle (FCHV) drivetrain will be subject to having acoustic conspicuity measures installed.
- From September 2022 all new registered buses with drivetrains listed above will also be subject to having acoustic conspicuity measures installed.

TfL requires all new buses conforming to the description above, to have an Acoustic Vehicle Alerting System (AVAS) installed in accordance with Regulation 138.

In particular the AVAS shall additionally meet some extra requirements, mainly around ability to emit the urban bus sound being designed by TfL, and that the noise should be updatable in the future.

Acoustic Conspicuity Measure

AVAS (Acoustic Vehicle Alerting System)

A solution has been defined as 'added sound', or what is currently referred to as an AVAS (Acoustic Vehicle Alerting System). This is an audible warning, active at low speed, indicating steady state acceleration and deceleration conditions. Currently, systems meeting Regulation 138 are required to active at speeds between 0 km/h to

[1] UN ECE Regulation 138; Uniform provisions concerning the approval of Quiet Road Transport Vehicles with regard to their reduced audibility.

22 km/h inclusive, and are intended to replace engine noise cues to pedestrians and vulnerable road users (VRUs) that a vehicle is approaching.

The sound sources should be installed at the front of the bus such that they provide a fuller directional component towards the kerbside (see Bus specification 4.4.1.5 for details of source height and direction). This should also be done in conjunction with the supplier of the AVAS equipment

TfL have developed a specific sound file which the vehicle will be required to generate, known as the Urban Bus Sound (UBS). Availability of the UBS will be provided by TfL upon request.

Vehicles using AVAS shall be shown to be compliant with UNECE Regulation 138 (Uniform provisions concerning the approval of Quiet Road Transport Vehicles with regard to their reduced audibility - QRTV). Regulation 138 lays out the requirements for the minimum sound and defines the testing protocol.

The pace/playback speed and frequency content of the Urban Bus Sound must increase and decrease as the bus accelerates and decelerates, at a rate of 0.8% per km/h.

The values defined in ‘Attachment 30, Appendix B - AVAS Minimum Sound Level Requirements’ are TFL’s minimum requirements for the playback of the Urban Bus Sound. TFL would encourage innovation and seek suppliers to develop AVAS sounders that exceed these minimum requirements to produce an enhanced low frequency presence and detailed high frequency to reproduce the highest quality Urban Bus Sound and have supplied ideal values in ‘Attachment 30, Appendix C Ideal Sound Level Requirements.’

Training

Once AVAS equipment is installed, there should be very little training required as the system is automatic and will operate between set speeds and adjust the sound for acceleration and deceleration via inputs from the CAN-Bus. However, individual suppliers of the equipment will advise if any training is required.

Maintenance

Once AVAS equipment is installed, there should be minimal maintenance required. However, as the system will be fitted within the front of the bus, regular inspection of the sound sources is recommended to keep them free of debris and to ensure that no damage has occurred.

Individual manufacturers of the equipment will advise if and what maintenance is required and will specify maintenance intervals.

Repair

Any repairs that are required to the AVAS will need to be done in conjunction with the supplier of the equipment.