Waves Car Washes

Acoustics Report on the Noise Emissions from Waves Car Washing Operations

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1 CONTENTS

1 CONTENTS 3
2 INTRODUCTION 4
3 SPECIFIC SOUND LEVEL SURVEY 6
4 SUMMARY 12
APPENDIX A: TECHNICAL APPENDIX 13
APPENDIX B: FARFIELD DATA 14
APPENDIX C: TONE AUDIBILITY ANALYSIS (EXAMPLES) 15

2 INTRODUCTION

2.1 RPS (Acoustics) has been commissioned by Waves Consultancy Ltd. to carry out measurements of the sound emissions from its car washing operations. Waves car washes are typically located in supermarket car parks in former car parking spaces and the operations are identical from site to site.

2.2 A car washing site was selected by Waves Consultancy Ltd, Cannock Tesco Store, that would be suitable for the benchmarking exercise.

a) Typical Car Wash Operations

Layout

2.3 The car washing facilities consist of a:

- 'wet area' occupying three car parking bays;
- site cabin housing the water compressors occupying a single car parking bay; and,
- covered 'dry area' occupying four car parking bays.

2.4 Wet areas are always surrounded by 1.8m screens with signage. This is primarily to prevent water spray becoming a nuisance to other car park users but also helps to screen some of the noise. The dry area is covered with a canopy.

2.5 An illustration of the layout of a standard car wash operation is given in Figure 1. This layout can sometimes change so that the wet and dry areas are back-to-back but the three areas and their uses remain the same.

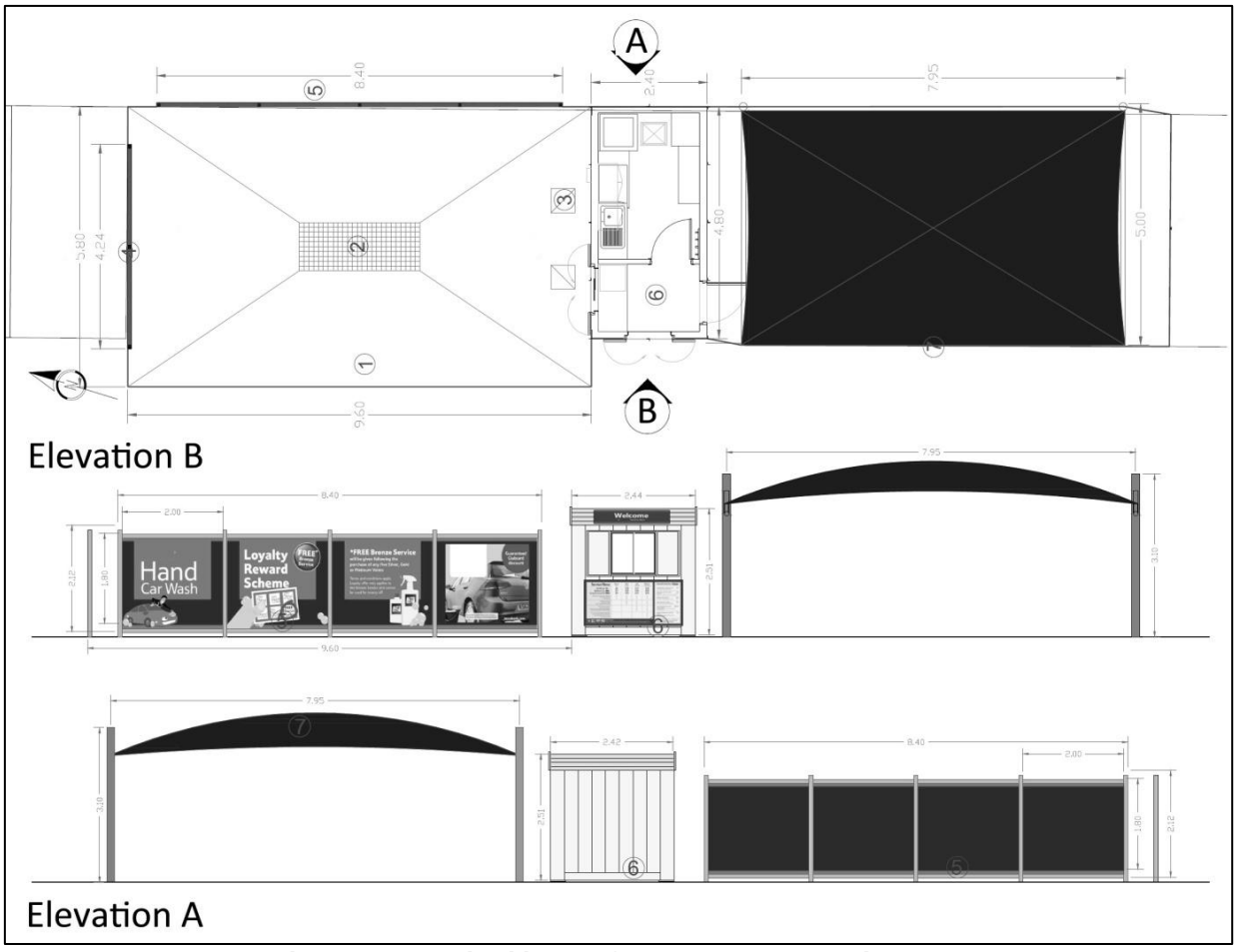


Figure 1 - Standard layout for a Waves car wash

2.6 The Waves car washes typically operate between 9am and 5pm, Monday to Friday with more restricted hours on Sundays.

Specific Sound Sources

2.7 The mechanical equipment used at Waves hand car wash operations are identical from site to site, this includes:

- two jet washers; and,
- two vacuums cleaners.

The jet washers have two visible nozzles in the wet area, which have fixed plumbing to compressors in the site cabin. The vacuum cleaners are on casters and are moved around as part of the operation.

2.8 At some older Waves hand car washes (for example: Tesco Store Tetbury) there are three vacuum cleaners and a third jet wash compressor; however, these are for redundancy only and only two units are ever used at one time. This is reinforced by the fact that there are only two pressure washer nozzles at each site. At newer Waves car washes, these redundancies appear to have been removed completely.

2.9 These specific sound sources are described in Table 1.

Source	Photograph	Description
Vacuum cleaners		Numatic vacuum cleaner Model Number NTD570 Manufacturer's sound power level data = 89dB(A) re 1pW
Internal compressors		Internal compressors for the pressure washers. No manufacturer's sound data is available for this item.
Pressure washers		The pressure washers are normally located at either end of the wet area; however, they were often used in conjunction on the same car. No manufacturer's sound data is available for this item.

Table 1- Specific sound sources included in the survey

3 SPECIFIC SOUND LEVEL SURVEY

b) General

3.1 Manufacturer's sound level data was not available for the pressure washers; therefore, this information has been derived from nearfield measurements. Additional farfield measurements have been made to determine the likely on-time of each item and to determine acoustic feature corrections.

a) Site Description

3.2 The Cannock Tesco Store is located in a mixed-use (residential and commercial) area. The Waves car wash was located in eight former car parking spaces toward the south west of the car park. The location of the car wash in the Tesco Store car park is illustrated in Figure 2.

Figure 2 – Plan showing the location of the car wash (red)

b) Measurement and Timescale

3.3 Attended noise monitoring took place on Wednesday 26th June 2019. Monitoring was carried out between 10:30 and 12:00. The following quantities were measured:

$L_{Aeq,25ms,}$ Audio sampled at 48kHz

3.4 A combination of measurements were made to fully characterise the specific sound measurements. This included:

- nearfield measurements of equipment under controlled use; and,
- farfield measurements of typical car washing operations.

3.5 The Waves car wash was not trading during the survey and measurements were under the control of the survey technicians.

c) Monitoring Locations

3.6 The monitoring locations are illustrated in Figure 3

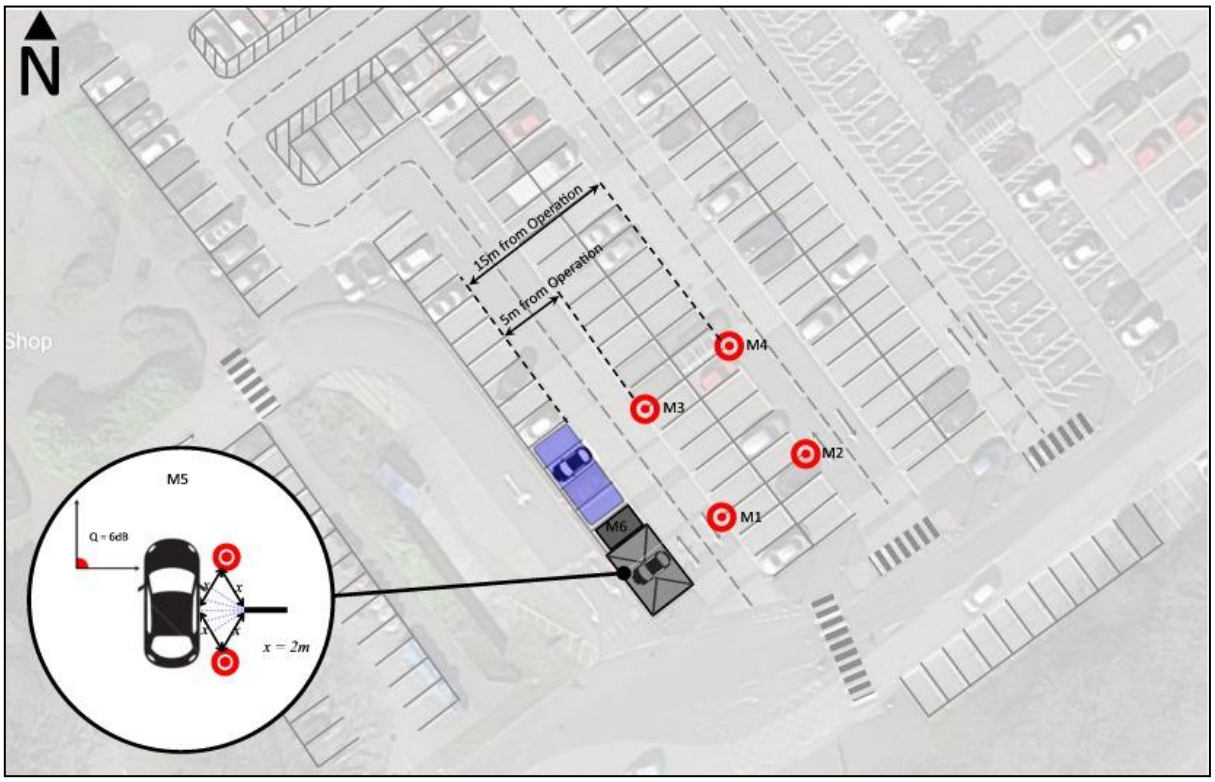


Figure 3 –Measurement locations during the specific sound survey. Q indicates directivity

3.7 External farfield measurements (M1-M4 in Figure 3) were made concurrently, 5m and 15m from the Waves car washing operation, during wet and dry operations separately. Measurements were made 1.5m from the ground and at least 3m from the next nearest reflecting surface. The situation was contrived in the sense that only a single car (5-door Honda Civic) was cleaned in order to isolate the separate wet and dry operations and to determine the typical time it takes to wash a single car. In all other respects, the car washing operations were normal.

3.8 External nearfield measurements (M5 in Figure 3) were made 1.5m from the ground and 2m from the sound source. Additional sound reflections may have been encountered from the car being cleaned, this has been accounted for by considering directionality.

3.9 Internal measurements (M6 in Figure 3) were made of the compressors in the site cabin because they were not subjectively dominant outside. Measurements were made 1.5m from the floor at three locations towards the centre of the room.

3.10 A single pressure washer was held stationary for the duration of the nearfield measurements. The source was on for 100% of the measurement period. The same was the case when the compressor was measured inside the site cabin.

3.11 The measurement of the external sources is illustrated in Figure 4.

Figure 4 – Photographs showing the measurement setup
(a) Nearfield measurements and activity
(b) Farfield measurement locations
(c) Activity during farfield measurements

d) Meteorology

3.12 During the survey the weather information was noted. This is shown in the following table:

	26th June 2019
Roads	Dry
Wind Speed	4m/s NE

Table 2 - Meteorological data noted during the survey

e) Measurement Results

Nearfield Measurements

3.13 The ambient sound level measurements are reported in Table 3. The corrections for residual sound have been illustrated.

Meter (Serial Number)	Ambient sound level in the absence of specific sound level, dB $L_{Aeq,1\text{-}min}$	Ambient sound level in the presence of specific sound, dB $L_{Aeq,1\text{-}min}$	
		Pressure Washer (external)	Compressors (internal)
1405559	56.5	80.1	79.9
1404965	54.2	81.2	78.8
1405557	56.9	80.2	80.7
Average	56.0	80.5	79.9
Plant sound level			
Correction for residual sound		0	0
Specific sound level, L_p dB(A) re 20µPa		80.5	79.9
Specific sound level, L_w dB(A) re 1pW*		91.5	N/A

Table 3 – Determination of the sound power levels of the sources. *Calculation takes into account directivity of measurements and distance from source

Farfield Measurements

3.14 Both the wet and dry parts of the car wash each took 10-minutes to complete. During these periods there were times when the specific sound sources were operating and periods when they weren't. These have been illustrated in plots provided in the appendix and the specific sound levels derived from these measurements have been summarised in Table 4.

Source	Distance from Operations	Ambient Sound Pressure Level, dB L_{Aeq}		Specific Sound Level, dB(A)	On-time
		With Specific Sound	Without Specific Sound		
Wet Operations	5m	70.7	57.1	70.5	≈50% of 10-minute period†
	15m	64.6	56.8	63.8	
Dry Operations	5m	61.1	57.4	58.7	≈100% of 10-minute period
	15m	57.5	55.6	53.0	

†During pressure washing cycle, both pressure washers were used on a single car for 50% of the time it took to wash the car, i.e. the actual on-time of the pressure washing would be 100%

Table 4 – Specific Sound Levels derived from far-field measurements

3.15 Taking into account the movement of the specific sound sources around the car washing operation during the measurement periods, the decay of the sound indicates that they are behaving as point sources. This allows for simple hemispherical sound propagation to be assumed.

f) Acoustic Feature Corrections

3.16 The prominence of the specific sound should be considered when assessing the likely impact at nearby noise sensitive receivers, based on the likelihood of any acoustically distinguishing characteristics of the specific sound which may attract attention, whilst considering the existing residual sound climate.

Tonality

3.17 The sound from most items of machinery with rotating or reciprocating components would be expected to contain tones. The reference method from BS4142 has been used to determine the tone audibility of the sound produced by the specific sources at 15m and apply an appropriate correction.

3.18 Autospectra were created from measurements made of the sources at a distance of 15m. However, it was clear that, during the use of the equipment, the operating speed varied by 50Hz. This resulted in a variation in tone frequencies of more than 10% of the critical band, contravening the spectral requirements of the reference method from BS4142.[1] It is recommended, in this situation, that the long-term average spectrum be subdivided into a number of shorter term averages. Comprehensive studies have shown that the lower limit for averaging time is approximately 3 seconds.[2] For this reason nine 2^{15} point FFTs were averaged with a 50% overlap, using a hanning window, providing an averaging time of 3.4 seconds. The resulting autospectra have a bin width of 1.46Hz and were A-weighted.

[1] Note 4, D.2.2, BS4142: 2014 "Methods for rating and assessing industrial and commercial sound"
[2] Section 5.1, ISO/PAS 20065 "Acoustics – Objective method for assessing the audibility of tones in noise – Engineering method"

3.19 The noise pauses have been identified in the spectra using an automated computer routine. The tones have been identified and evaluated, taking into account the appropriate half or quarter power bandwidths. Where two or more tones appear in the same critical band, their energies have been combined. The masking noise was evaluated using a regression line spanning ±0.75 of the critical frequency band, only noise lines within ±0.5 of the critical frequency band were included in the masking noise. Corrections for the effective analysis bandwidth have been taken into account. The threshold of hearing has been taken into account and tones identified below 20Hz have automatically been excluded.

3.20 The tone audibility assessment has been illustrated in Figure 5. Example outputs from a single time-segment have been reproduced in the appendix.

(a) (b)

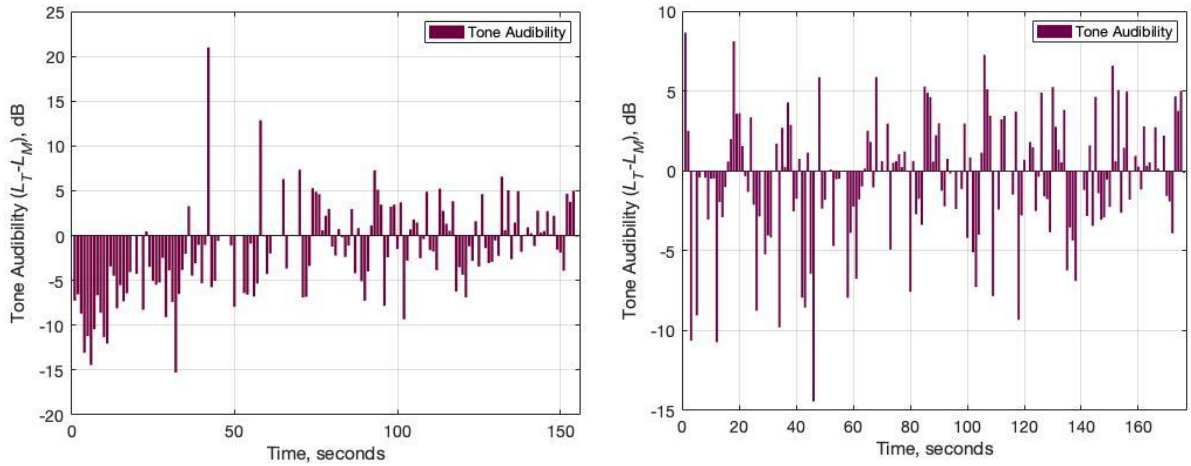


Figure 5 – Reference tone audibility assessment of (a) pressure washer and (b) vacuum cleaner

3.21 The extreme variability in tone audibility illustrated in Figure 5 reflects (a) the variability in the frequency of the tones being assessed, which are not fully captured by the shortening of the averaging time, and (b) the transitory nature of the residual sound, which was dominated by cars passing in the car park. It should also be noted that, for some of the 3.4 second segments, tones generated by cars using the car park will have been the most dominant tone in the assessed spectra, which are not of interest. Therefore, the tone audibility exceeded 90% of the time has been adopted as the figure that reflects the tones generated by the Waves car wash, these have been summarised in Table 5.

Operation	Tone Audibility, $\Delta L_{TA,90\%}$	Acoustic Feature Correction, K_T
Wet (Pressure Washer)	-3.8dB	0dB
Dry (Vacuum Cleaner)	4.6dB	+1dB

Table 5 – Acoustic feature corrections for tonality

3.22 It should be noted that these acoustic feature corrections were made based on measurements at 15m with direct line-of-sight to the sources. In real situations this is unlikely to be the case and the tone audibility would be less highly rated.

Impulsivity

3.23 The reference method from BS4142:2014 has been used to evaluate the impulsivity of the pressure washer starting, objectively. The short-term L_{Aeq} measurements during each event have been converted to an L_{pAF} time-series in 25ms intervals using a low-pass filter.

3.24 The sudden 'onset' of a sound is defined as an impulse and occurs when the rate of increase in sound exceeds 10dB/s. The start and end of the onset was determined using a combination of computer automation and expert listening. The worst case onset rate and level difference were determined and used to predict the subjective prominence of the impulse and calculate the acoustic feature adjustment, K_I, to be added to the L_{Aeq} to adjust for the acoustic feature. The results for the three events recorded during the survey have been presented in Table 6 with sample outputs provided in the appendix.

Operation	Prominence	Acoustic Feature Correction, K_I
Pressure Washer Switch-on 1	8dB	+5dB
Pressure Washer Switch-on 2	8dB	+5dB
Pressure Washer Switch-on 3	8dB	+5dB
Value used in assessment		**+5dB**

Table 6 – Acoustic feature corrections for impulsivity

Intermittency

3.25 Both the jet wash/compressors and vacuums are clearly 'on-off' activities and the periods of silence due to inactivity between washes have the potential to accentuate this. However; it is not thought that applying acoustic feature corrections for tonality, impulsivity **and** intermittency is appropriate given the mixed commercial and residential nature of the area. Therefore, no correction has been made for intermittency.

4 SUMMARY

4.1 RPS (Acoustics) has been commissioned by Waves Consultancy Ltd. to carry out measurements of the sound emissions from its car washing operations.

4.2 Nearfield measurements of the specific sound sources, for which there is no manufacturers' data, have been used to characterise the source levels. A summary of the source levels is given in Table 7.

Source	Source Level	Comment
Pressure Washer (Nozzle)	91.5dB(A) re 1pW	Sound power level determined by measurement
Pressure Washer (Compressor)	79.9dB(A) re µPa	Internal sound pressure level determined by measurement
Vacuum cleaner	89dB(A) re 1pW	Declared sound power level provided by manufacturer

Table 7 – Summary of source level data

4.3 The farfield measurements that were made indicate that the sound from the pressure washer nozzle and vacuum cleaner exhibits typical point source geometrical spreading. The sound from the compressors inside the site cabin was not subjectively audible in the farfield.

4.4 The farfield measurements 15m from the Waves car wash operation have been used to derive specific sound levels and to determine potential acoustic feature corrections at this distance. These have been summarised in Table 10 for two different scenarios:

- Light operations where a single car is cleaned (wet and dry) continuously. This situation is the one that was objectively measured during the survey.
- Heavy operations where four cars are cleaned at the same time requiring the measured sound pressure to be multiplied by a factor of two resulting in all equipment used 100% of the time

Source	Specific Sources	Specific Sound Levels, dB(A)	Acoustic Feature Corrections	Rating Level
Light Operations	Wet Operations	63.8	+5dB (Impulsivity)	69dB @15m
	Dry Operations	53.0	+ 1dB (Tonality)	
Heavy Operations	Wet Operations	66.8	+5dB (Impulsivity)	72dB @15m
	Dry Operations	56.0	+ 1dB (Tonality)	

Table 8 – Rating levels for car washing operations

4.5 These rating levels represent the worst-case direction of propagation, i.e. not benefitting from the screens around the wet area. Taking into account the decay with distance that was observed, if the operation were facing a residential receiver, the sound would decay at -6dB per doubling of distance.

APPENDIX A: TECHNICAL APPENDIX

Required ISO Test Report Information (cross referenced where required)			
		Measurements carried out to:	Analysed to:
A	Standards	BS 7445-1: 2003 BS 7445-2: 1991	BS 4142:2014
B	Organisation who performed the measurements	noise.co.uk Ltd, The Haybarn, Newnham Grounds, Kings Newnham Lane, Bretford, Coventry, CV23 0JU.	
C	Name of Client	Waves Consultancy Ltd	
D	Full site address	Tesco Store Cannock	
E	Date of surveys	Specific sound level survey: 26th June 2019	
F	Description & identification of proposed development	Assessment of the impact of the sound from a car washing facility on nearby residential receivers.	

Table 9 – Survey summary information.

a) Equipment

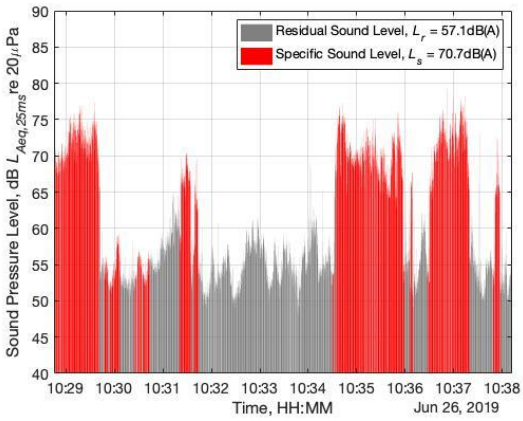
4.6 Measurements were made using the following equipment:

Monitoring	Sound Level Meter (Serial Number)	Calibrator (Serial Number)	Calibration	
			Before	After
M1, M3, M5, M6	Norsonic 140 1405559	Norsonic 1251 (33826)	114dB	114dB
M5, M6	Norsonic 140 1404965	Norsonic 1251 (31817)	114dB	114dB
M2, M4, M5, M6	Norsonic 140 1405557	Norsonic 1251 (33823)	114dB	114dB

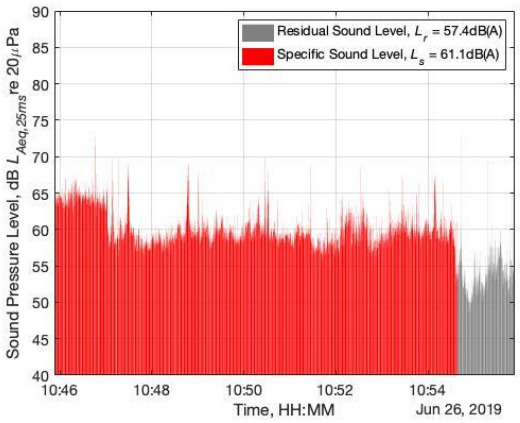
Table 10 – The measurement equipment used during the survey.

APPENDIX B: FARFIELD DATA

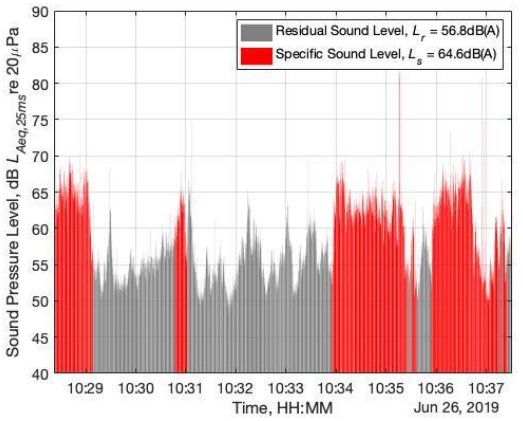
Wet Wash @5m



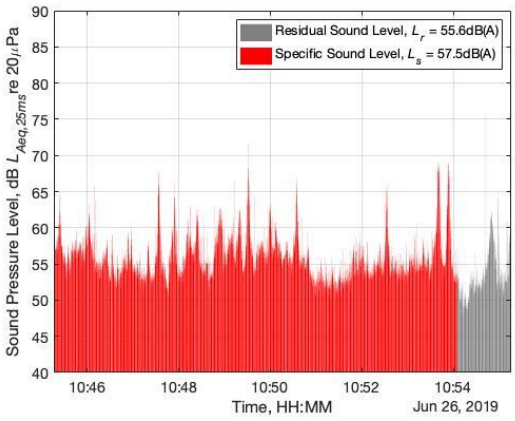
Dry Clean @5m



Wet Wash @15m

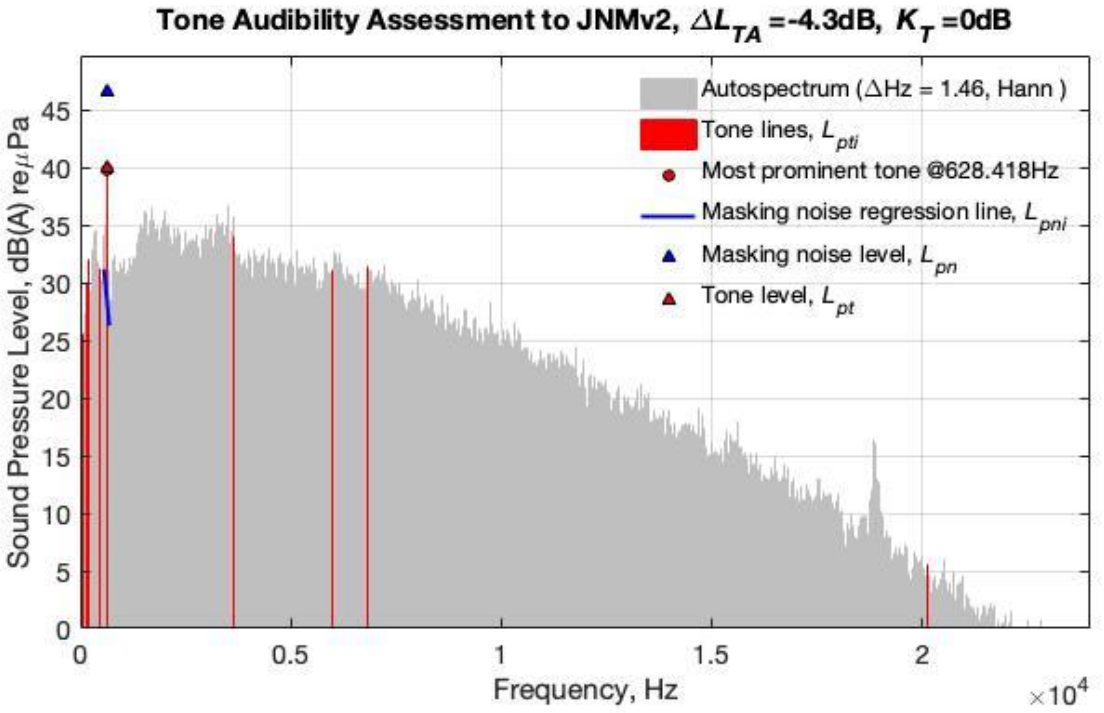


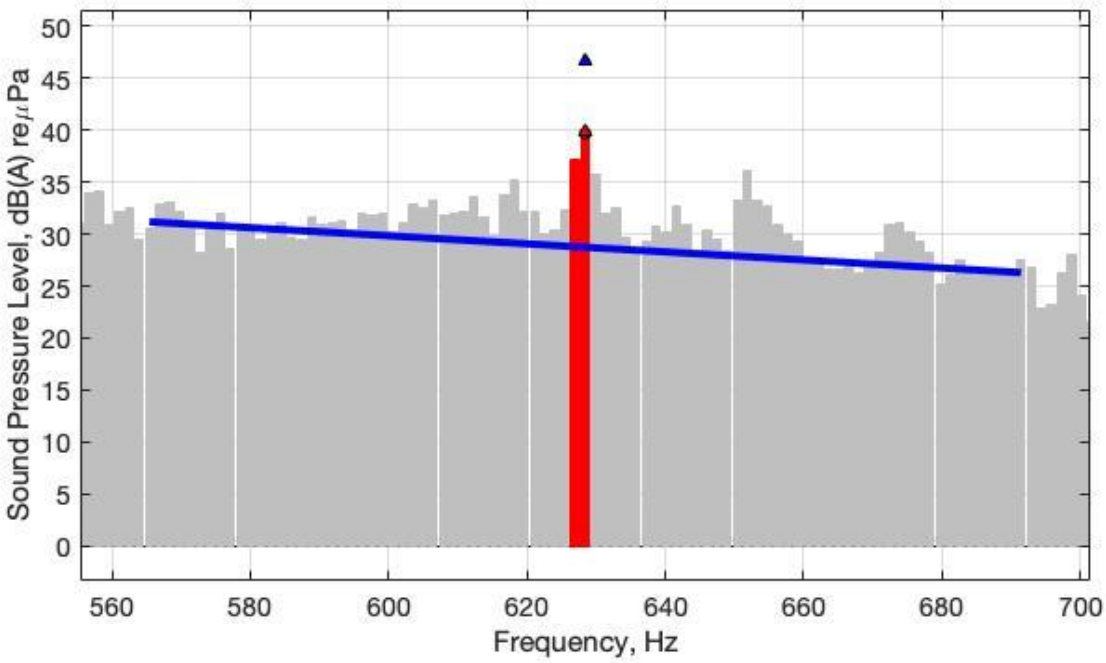
Dry Clean @15m



APPENDIX C: TONE AUDIBILITY ANALYSIS (EXAMPLES)

Pressure Washer





Vacuum Cleaner