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TECHNICAL REPORT

ELECTRIC WHEELS

Off-road UTV noise measurements

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1 INTRODUCTION

1.1 Background

We have been appointed by Donelan Trading Ltd to measure noise levels from an electric off-road utility task vehicle (UTV) and compare these to noise levels from an equivalent diesel-powered UTV.

We have measured noise levels from a HiSun 'The Beast' electric UTV and a John Deere Gator 855D diesel-powered UTV under controlled conditions at the Electric Wheels Ltd premises in Watton, Norfolk. The test vehicles are shown in Figure 1. This report sets out the methodology and results of our measurements.

Figure 1 – Diesel (left) and electric (right) test vehicles

1.2 Structure of this report

The structure of this report is as follows:

- Section 2 describes the measurement methodology.
- Section 3 sets out the measurement results.
- Section 4 presents our conclusions.
- An explanation of the technical terms used in this report is given in Appendix A.
- Details of measurement equipment and personnel are set out in Appendix B.

2 MEASUREMENT METHODOLOGY

We took measurements at Neaton Business Park, Watton on 12 May 2022. We took measurements of the diesel and electric test vehicles driving in figure-of-eight circuits on coarse gravel and on grass. In each location, course markers were set 15 metres apart and the sound level meter was positioned 15 metres from the midpoint between the markers at a height of 1.2 metres. The test vehicles were driven in turn around the course at an average speed of 8 to 10 miles per hour. The average turning radius around the course markers was approximately 5 metres. A plan of the test arrangement is shown in Figure 2.

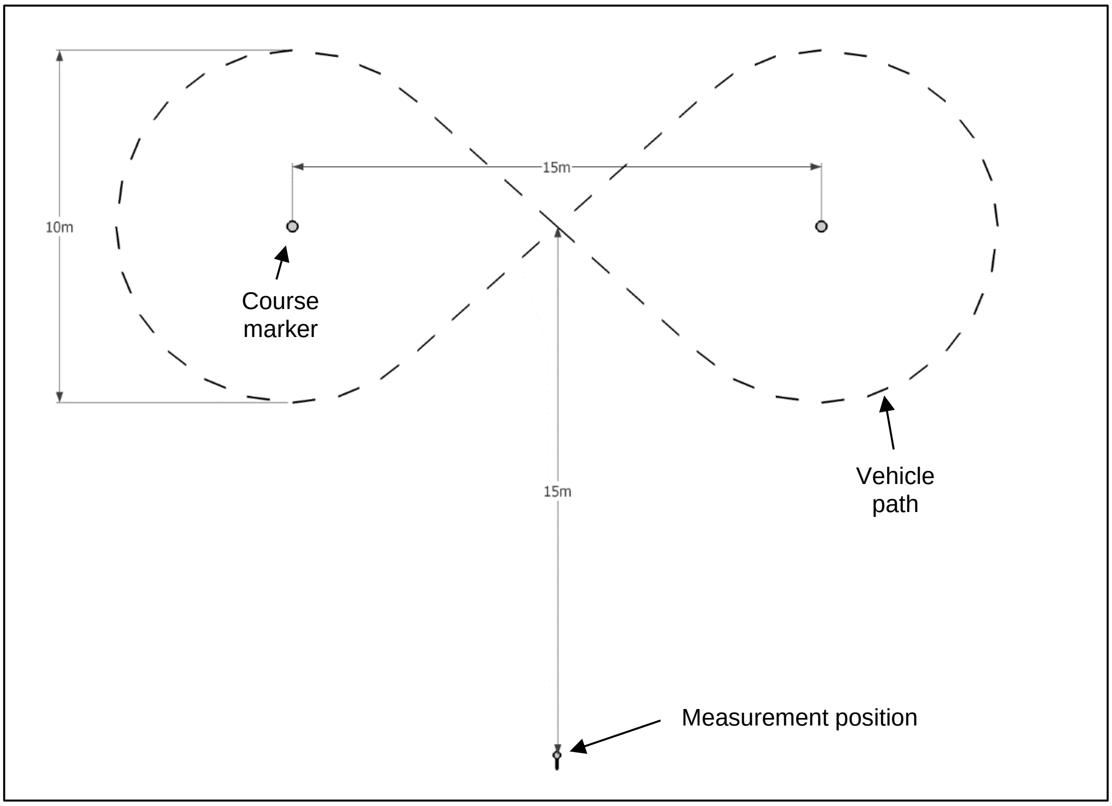

Figure 2 – Plan of test course and measurement position

Photographs of the gravel and grass test courses are shown in Figures 3 and 4.

Ambient noise level measurements were taken at the measurement position on each course over 1-minute periods without the vehicles running to assess the influence of noise from other sources on the measured results.

Measurements of vehicle noise were taken over 1-minute periods, during which time approximately four laps of the course were completed. We then took measurements within the vehicle cabs following the same course, again over 1-minute periods.

Finally, measurements were taken in each vehicle cab driving on tarmac roads at approximately 20 miles per hour.

Figure 3 – Photograph of electric UTV on gravel test course

Figure 4 – Photograph of diesel UTV on grass test course

3 RESULTS

3.1 Gravel surface

3.1.1 External measurements

The measured external noise levels from the test vehicles on a gravel surface are shown in Table 1. The measured ambient noise level in the absence of vehicle noise was 46dB $L_{Aeq,1min}$, which is 14dB(A) below the lowest measured vehicle noise level. The measured A-weighted levels are therefore not expected to be significantly affected by ambient noise from other sources. We have not corrected octave-band results for ambient noise but results within 6dB of the measured ambient level are indicated with an asterisk and are likely to represent a worst case.

Vehicle type	Octave band $L_{eq,1min}$, dB								$L_{Aeq,1min}$ dB
	63	125	250	500	1k	2k	4k	8k	
Electric	59.2*	57.1*	55.6	58.3	56.3	50.7	46.0	42.4	60
Diesel	72.4	70.5	66.2	65.5	61.8	58.3	54.4	48.1	67
Difference	-13.2	-13.4	-10.6	-7.2	-5.5	-7.6	-8.4	-5.7	-7

Table 1 – External vehicle noise measurements on gravel surface

3.1.2 Internal measurements

The measured internal noise levels within the test vehicle cabs on a gravel surface are shown in Table 2.

Vehicle type	Octave band $L_{eq,1min}$, dB								$L_{Aeq,1min}$ dB
	63	125	250	500	1k	2k	4k	8k	
Electric	87.8	80.2	75.8	74.2	68.6	60.4	56.2	51.2	75
Diesel	104.8	88.6	85.8	78.9	71.9	69.7	62.9	56	83
Difference	-17.0	-8.4	-10	-4.7	-3.3	-9.3	-6.7	-4.8	-8

Table 2 – Internal vehicle noise measurements on gravel surface

3.2 Grass surface

3.2.1 External measurements

The measured external noise levels from the test vehicles on grass are shown in Table 3. The measured ambient noise level in the absence of vehicle noise was 38dB $L_{Aeq,1min}$, which is 7dB(A) below the lowest measured vehicle noise level. The measured A-weighted levels are therefore not expected to be significantly affected by ambient noise from other sources. We have not corrected octave-band results for ambient noise but results within 6dB of the measured ambient level are indicated with an asterisk and are likely to represent a worst case.

Vehicle type	Octave band $L_{eq,1min}$, dB								$L_{Aeq,1min}$ dB
	63	125	250	500	1k	2k	4k	8k	
Electric	51.7*	48.3	41.3	38.3*	41.2	37.0	34.9	31.4	45
Diesel	72.3	68.2	61.6	52.3	51.5	55.8	50.9	43.1	61
Difference	-20.6	-19.9	-20.3	-14	-10.3	-18.8	-16	-11.7	-16

Table 3 – External vehicle noise measurements on grass

3.2.2 Internal measurements

The measured internal noise levels within the test vehicle cabs on grass are shown in Table 4.

Vehicle type	Octave band $L_{eq,1min}$, dB								$L_{Aeq,1min}$ dB
	63	125	250	500	1k	2k	4k	8k	
Electric	84.9	75.8	69.5	64.4	62.6	56.4	51.4	49.5	68
Diesel	104.6	87.6	84.6	75.8	69.4	67.8	63.4	55.4	82
Difference	-19.7	-11.8	-15.1	-11.4	-6.8	-11.4	-12	-5.9	-14

Table 4 – Internal vehicle noise measurements on grass

3.3 Tarmac road

3.3.1 Internal measurements

The measured internal noise levels within the test vehicle cabs driving at up to 20mph on a tarmac road are shown in Table 5.

Vehicle type	Octave band $L_{eq,1min}$, dB								$L_{Aeq,1min}$ dB
	63	125	250	500	1k	2k	4k	8k	
Electric	87.3	83.5	75.8	69.1	65.6	59.3	52.1	54.8	73
Diesel	103.1	91.5	85	77.5	71.1	70.1	66.1	55.6	83
Difference	-15.8	-8	-9.2	-8.4	-5.5	-10.8	-14	-0.8	-10

Table 5 – Internal vehicle noise measurements on tarmac road

4 CONCLUSIONS

- We have measured and compared noise levels from electric and diesel off-road UTVs at Electric Wheels Ltd premises in Watton. External and internal noise levels were measured with the vehicles driving in a circuit on gravel and grass surfaces. Internal noise levels were also measured driving on a tarmac road.
- On a gravel surface, the electric UTV was 7dB(A) quieter than the diesel UTV at 15 metres, and 8dB(A) quieter in the vehicle cab.
- On grass, the electric UTV was 16dB(A) quieter than the diesel UTV at 15 metres, and 14dB(A) quieter in the vehicle cab.
- Tyre noise contributed significantly to overall noise levels on gravel. This was the dominant source of noise from the electric UTV, as engine noise was significantly quieter than the diesel vehicle. On grass, tyre noise was not significant and the primary sources of noise from both vehicles was engine noise and intermittent bumps and rattles.
- On tarmac, internal noise in the electric UTV cab was 10dB(A) quieter than in the diesel UTV, primarily due to the difference in engine noise. Significant tyre noise was audible in both vehicles as these were fitted with off-road tyres. We would expect noise levels to be slightly lower in an electric UTV fitted with road tyres, although tyre noise may vary significantly depending on road surface condition.

APPENDIX A TECHNICAL TERMS AND UNITS RELEVANT TO THIS REPORT

Decibel (dB) - This is the unit used to measure sound level. The range of human hearing from the quietest detectable sound to the threshold of pain is very large. If a normal linear scale of measurement were used, it would have to range from 20 µPa to 200,000,000 µPa. Using such large figures would be unmanageable and for this reason sound pressure levels are expressed on a logarithmic scale, which corresponds to the almost logarithmic response of the ear and which compresses the range to a manageable 0dB to140dB.

Sound Pressure Level (L_p or SPL) - This is a function of the source and its surroundings and is a measure in decibels of the total instantaneous sound pressure at a point in space. The SPL can vary both in time and in frequency. Different measurement parameters are therefore required to describe the time variation and frequency content of a given sound. These are described below.

Frequency - This refers to the number of complete pressure fluctuations or cycles that occur in one second. Frequency is measured in Hertz (Hz). The rumble of thunder has a low frequency, while a whistle has a high frequency. The sensitivity of the ear varies over the frequency range and is most sensitive between 1KHz and 5KHz.

Octave and One-Third Octave Bands - The human ear is sensitive to sound over a frequency range of approximately 20 Hz to 20,000 Hz and is more sensitive to medium and high frequencies than to low frequencies. To define the frequency content of a sound, the spectrum is divided into frequency bands, the most common of which are octave bands. Each band is referred to by its centre frequency, and the centre frequency of each band is twice that of the band below it. Where it is necessary for a more detailed analysis octave bands may be divided into one-third octave bands.

'**A' Weighting** - The sensitivity of the human ear varies with frequency, some frequencies sound louder than others. The 'A'-weighting curve represents the non-linear frequency response of the human ear and is incorporated in an electronic filter used in sound level meters. Measurements using an 'A'-weighting filter makes the meter more sensitive to the middle range of frequencies, which approximates to the response of the ear and the subjective loudness of the sound. Sound level measurements using 'A'-weighting will include the subscript A, e.g. dB(A).

Statistical Analysis - These figures are normally expressed as LN, where L is the sound pressure level in dB and N is the percentage of the measurement period. The LN figure represents the sound level that is exceeded for that percentage of the measurement period. L_{90} is commonly used to give an indication of the background level or the lowest level during the measurement period. L_{10} may be used to measure road traffic noise.

L_{Amax} - The highest A weighted sound pressure level recorded during the measurement period. The time constant used (Fast or Slow) should be stated.

$L_{eq,T}$ - The equivalent continuous sound level is used to measure sound that varies with time. The $L_{eq,T}$ is the notional equivalent steady sound level, which contains the same acoustic energy as the actual varying sound level over the period of measurement. Because the averaging process used is logarithmic, the $L_{eq,T}$ level tends to be dominated by the higher sound levels measured.

APPENDIX B MEASURING EQUIPMENT AND CALIBRATION

Job reference and title:	13387 Electric Wheels – Off-road UTV noise measurements
Measurement location:	Neaton Business Park, Watton, Norfolk IP25 6JB
Measurement date(s):	12 May 2022

Measuring equipment used:

Equipment description / serial number	Type number	Manufacturer	Date of calibration expiration	Calibration certificate number
Precision sound level meter serial no. A2A-10758-E0	XL2-TA	NTi Audio	05/11/2023	39375
Microphone serial no. 6017	MC230	NTi Audio	05/11/2023	39374
Microphone pre-amplifier serial no. 5308	MA220	Neutrik	05/11/2023	39375
Microphone calibrator serial no. 34541	NOR-1251	Norsonic	05/11/2023	39373

Calibration level:	113.9 dB @ 1 kHz
Person in charge of measurements:	Ian Rees MIOA
Weather conditions:	Dry, clear, wind 1 – 2 m/s SW, temperature 12 °C
Principal sound sources:	Vehicles under test
Principal sources of ambient noise:	Distant road traffic and aircraft, birdsong, occasional industrial activity on business park.
Measurement parameters	Octave band $L_{eq,1min}$