Vibration Monitoring Assessment Report (November 2020)

Tweed Valley Hospital Project, Kingscliff NSW

Prepared for: Lendlease Group

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Executive Summary

ADE Consulting Pty Ltd (ADE) has been commissioned by the Delta Group to prepare an assessment of the vibration aspects of the construction phase for Tweed Valley Hospital Project located at 771 Cudgen Road, Kingscliff, located in the Northern Rivers region of New South Wales (NSW). The Site is bounded by Tweed Coast Road to the West, Cudgen Road to the South and Turnock Street to the East.

The Vibration Assessment consisted of the real time data observation and discussion to achieve the following:

- Compliance with regulatory requirements and standards for vibration management;
- Avoid excessive vibration generation through site planning and the adoption of appropriate work methods and practices; and
- Prevent or minimize to the greatest extent, the impact of construction vibration on neighbours and to establish and maintain positive relationships with project stakeholders.

This report details the outcome of the real time vibration assessment conducted by ADE Consulting Group Pty Ltd throughout the month of **November 2020**.

Results from vibration monitoring undertaken during the monitoring period [November 2020] displayed one (1) exceedance of DIN 4150 (Line 2) at monitoring location 002 on 25 November 2020 at 14:48 AEDT. All other vibrations were **below** the threshold used to assess the effects of short-term vibration on structures according to DIN 4150-3 and DIN4150-1.

Works were only conducted between 7am and 6pm, Monday – Friday for the month of **November 2020** and only data within this range should be considered.

DEFINITIONS

Vibration:	The mechanical oscillations occurring about an equilibrium point. The oscillations may be periodic such as the motion of a pendulum or random. Vibration is most commonly expressed in terms of displacement, velocity, acceleration and frequency, all of which are related.
Displacement:	The change in position of an object, is a vector quantity (Stress indicator).
Velocity:	The rate of change of displacement, is a vector quantity (Fatigue indicator).
Acceleration:	The rate of change of velocity, is a vector quantity. (Indicator of force).
Frequency:	The number of times a periodic function or vibration occurs or repeats itself in a specified time, often 1 second – cycles per second. Frequency is measured in Hertz.
Hertz (Hz):	The unit of frequency or pitch of a sound. One hertz equals one cycle per second.
Peak Particle Velocity (PPV):	The greatest instantaneous particle velocity during a given time interval if measurements are made in 3-axis. The resultant Peak Particle Velocity (PPV) is the vector sum i.e. the square root of the summed squares of the maximum velocities, regardless of when in the time history those occur.
Root Mean Square (RMS):	The RMS value of a set of numbers is the square root of the average of their squares. Best used when assessing building damage.
Vibration Dose Value (VDV):	The vibration dose value (VDV) is used for assessing intermittent vibration. A cumulative measurement of the vibration level received over an 8-hour or 16-hour period. Best used when structure is occupied.
Peak:	The peak is the maximum amplitude during a measurement period.
Peak to Peak (P-P):	The peak to peak (P-P) is the difference between the maximum positive and maximum negative amplitudes of a waveform.
Logarithmic Scale:	Comparing frequency with large amplitude differences can be accomplished using a logarithmic scale. Critical vibration components usually occur at low amplitudes compared to the rotational frequency vibration. These components are not revealed on a linear amplitude scale because low amplitudes are compressed at the bottom of the scale. But a logarithmic scale shows prominent vibration components equally well at any amplitude.
Zero Crossing Frequency:	Determining the apparent dominant frequency of a given sample can be achieved by using the Zero Crossing Frequency.
Primary Waves (P Waves):	Alternating compressions ('pushes') and dilations ('pulls') in the same direction as the wave is propagating. P waves are the first arriving energy, smaller and higher frequency than S waves.

Secondary Waves (S Waves):	Alternating transverse motions perpendicular to the direction of propagation. Slower than P waves.
Rayleigh Waves (R Waves):	Motion is both in the direction of propagation and perpendicular (in a vertical plane). R waves are also dispersive, and amplitudes decrease with depth.
Accelerometer:	A vibration sensor whose electrical output is directly proportional to the acceleration component of the vibration. The two most common accelerometer types are the traditional charge type and the IEPE, integrated electronic piezoelectric type with a built-in line-drive amplifier to enable the output signal to be transmitted over 'longer cable runs'.
Filter:	A device for separating components of a signal on the basis of their frequency. It allows components in one or more frequency bands to pass relatively unattenuated, and it attenuates components in other frequency bands. Modifies the frequency spectrum of a signal usually while it is in electrical form.
Short-term vibration	Vibration which does not occur often enough to cause structural fatigue, and which does not produce resonance in the structure being evaluated.
Long-term vibration	All types of vibration not covered by the definition of ‘short-term’ vibration.

1 Introduction

1.1 Project Background

ADE Consulting Group Pty Ltd (ADE) was commissioned by Delta Group (DLT) Pty Ltd to measure the levels of vibration caused by the Tweed Valley Hospital Project, located at 771 Cudgen Road, Kingscliff NSW hereafter referred to as 'the Site'. At the time of the vibration monitoring, Lendlease is completing substructure works on site.

The purpose of the Vibration Monitoring Assessment (VMA) report is to assess the impacts of piling, excavation and general construction works from the Tweed Valley Hospital Project upon the surrounding community.

Table 1. Project Specific Information.

Site Details	
Client Name:	Delta Group
ADE Project Number:	DLT-01-Q1013
Site Address:	771 Cudgen Road, Kingscliff NSW
Date of Report:	11/12/2020
Objectives:	▪ Comply with DIN 4150-3:2016 guidelines and conditions C21 - C24 of the consent. ▪ Avoid or minimise vibration impacts from activities which could affect the nearby buildings (Kingscliff Tafe and residential properties). ▪ To minimise the generation of vibration which could affect the neighbours of the Site, workers on the Site, associated buildings and other members of the public. ▪ Establish and maintain good relationships with the neighbours and wider community.
Key Legislation:	Protection of the Environment Operations Act 1997 (NSW) (POEO Act). The POEO Act is a key piece of environmental protection legislation and regulates activities via: Environmental protection licensing, as per schedule 1; Regulation of scheduled and non-scheduled activities; Environmental protection offences and penalties; and Establishment of a general duty of care to notify environment harm.

1.2 Scope of Work

The scope of work included the following:

- Completion of a Safety, Health & Environment Work Method Statement prior to undertaking any works;
- Real time continuous monitoring of vibrations in three (3) locations along the Southern boundary of the Site; and
- Preparation of a Vibration Monitoring Assessment Report outlining the Site data, conclusions and recommendations.

1.3 Whole Report

No one section or part of a section of this report should be taken as giving an overall idea of this report. Each section must be read in conjunction with the entire report, including its appendices and attachments.

1.4 Previous Report

Refer to the previous report (DLT-01-Q10103 / VIB15 / V1.1F) for details from earlier monitoring periods.

1.5 Monitoring Locations

The three (3) vibration monitors are located within the Site adjacent Cudgen Road. Monitoring locations were determined by the client (refer to ***Appendix I – Aerial Photograph***).

Vibrations were recorded at the above locations during the preparation and construction works of the Tweed Valley Hospital Project.

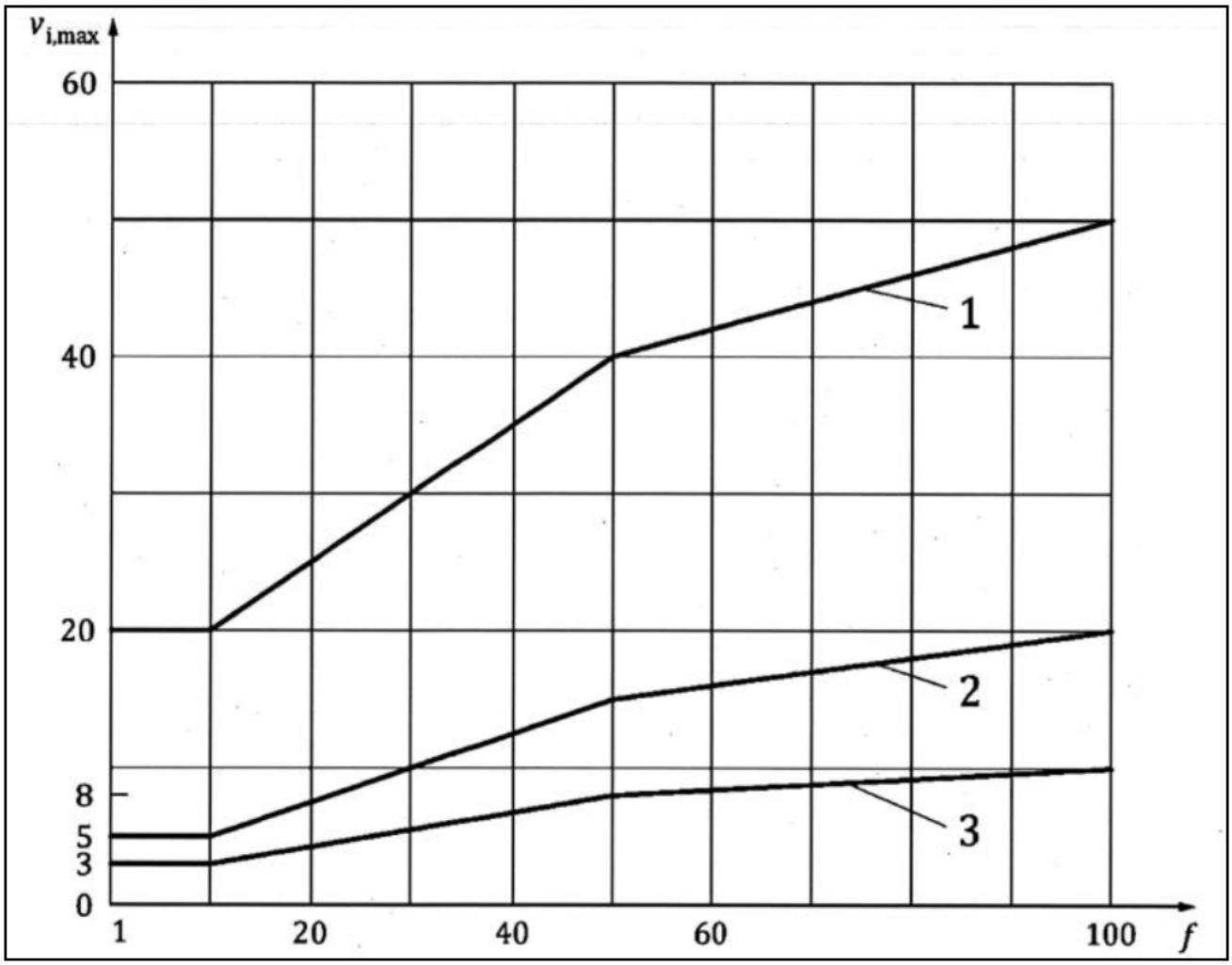
The vibration monitors were operational from 06:45 to 19:00, throughout the month of **November 2020.**

1.6 Limits for Vibration

The Peak Vibration Velocity (PVV) limits for the duration of work have been adopted from *Vibrations in buildings Part 3: Effects on structures DIN4150-3 February 2016.* Lines 1 and 2 in Table 2 on the following page apply to the surrounding structures of the Tweed Valley Hospital project, including the Kingscliff TAFE and nearby residences. A visual representation of Table 2 is also shown below in Graph 1 on the following page.

Table 2. Guideline Values for Vibration Velocity (Evaluating Effects of Short-Term Vibration on Structures).

Line	Type of Structure	Peak Vibration Velocity, mm/s				
		At foundation at a frequency of			Highest floor, horizontal direction	Floor Slabs, vertical direction
		1 to 10 Hz	10 to 50 Hz	50 to 100 Hz	All Frequencies	All Frequencies
1	**Buildings used for commercial purposes, industrial buildings and buildings of similar design**	**20**	**20 to 40**	**40 to 50**	**40**	**20**
2	**Dwellings and buildings of similar design and/or occupancy**	**5**	**5 to 15**	**15 to 20**	**15**	**20**
3	Structures that, because of their particular sensitivity to vibration, cannot be classified under lines 1 and 2 and are of great intrinsic value (e.g. listed buildings under preservation order)	3	3 to 8	8 to 10	8	20



Graph 1. Graph of the lines 1, 2 and 3 according to Table 2.

1.7 Monitoring Frequency

During this reporting period, vibration monitoring was conducted from 6:45am to 7:00pm every day, throughout the month of **November 2020** to determine the level of ground vibration that is experienced on the boundary of the Site before travelling off-site.

1.8 Survey Instrumentation and Methodology

The vibration measurements were recorded using Profound Vibra+ vibration monitors. These vibration monitors are enclosed in a tough case which is placed on the ground and covered with a tarp to aid in keeping temperatures below 60°C, to ensure continuous monitoring. The accelerometer is placed firmly against the soil surface and covered with a sandbag to minimize external interference. The monitors are positioned within the Site along the boundary adjacent Cudgen Road.

1.9 Existing Vibration Environment

The main on-going vibration source in the area prior to site establishment was:

- Car and trucks passing by on nearby Cudgen Road.

The main cause for vibration throughout this monitoring period (in addition to cars and trucks from nearby Cudgen Road) is:

- Substructure works being undertaken by Lendlease (i.e. the use of excavators and concrete pumps).

An alarm beacon was set-up with the vibration monitors in order to alert Lendlease and the Site Supervisor in the case of an exceedance (in real-time). If the alarm was triggered, Lendlease and the Site Supervisor would receive a text SMS and need to note the date, time and activity, then consider implementing controls and reviewing work practices before re-commencing works.

Lendlease has established a daily check list on site to ensure all monitors are operating in the field correctly, have adequate sunlight to power the units and that they are reporting consistently. Lendlease will report any issues immediately to ADE. Furthermore, ADE will conduct daily checks via telemetry to ensure the monitors are operating and recording correctly. ADE are to advise Lendlease of any issues immediately. Monitors will not be removed unless consultation with Lendlease, TSA and HI has occurred and alternative locations are agreed upon.

2 Results

The results of the **total velocity** in mm/s from the monitoring performed for **November 2020** are summarised in Figures 1 – 3 below.

If there is a day in which the velocity is above 5 mm/s, a graph of the velocity and the frequency will be added, and results will be compared against Line 1 and Line 2 of the DIN 4150 (refer to Graph 1, above). Velocities greater than 5 mm/s were detected at the following locations on the following days:

- Location 002:
  - 23 November; and
  - 25 November.

Works were only conducted between 7am and 6pm, Monday – Friday for the month of **November 2020** and only data within this range should be considered.

2.1 Data

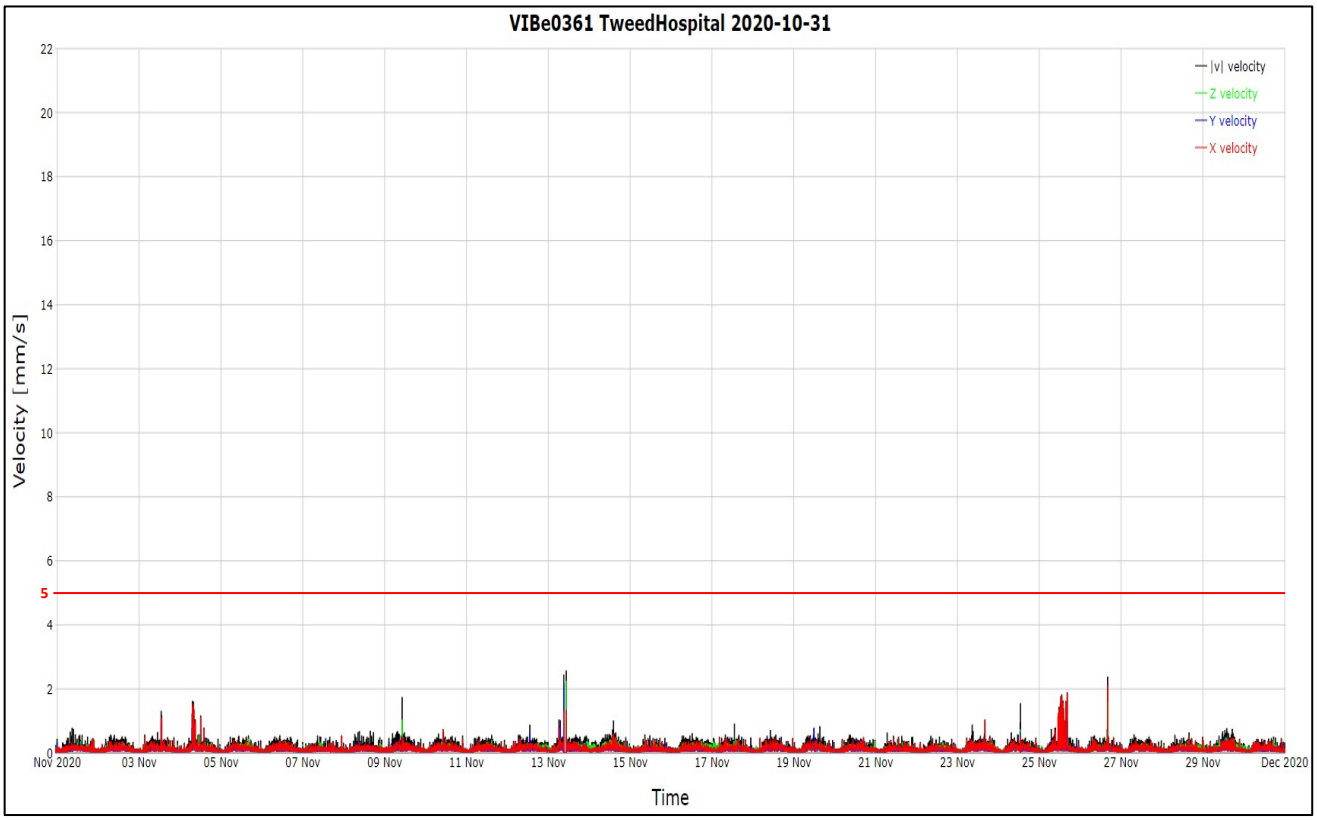


Figure 1. Results of the vibration monitoring from 1 – 30 November 2020 at monitoring location 001 – Adjacent carpark.

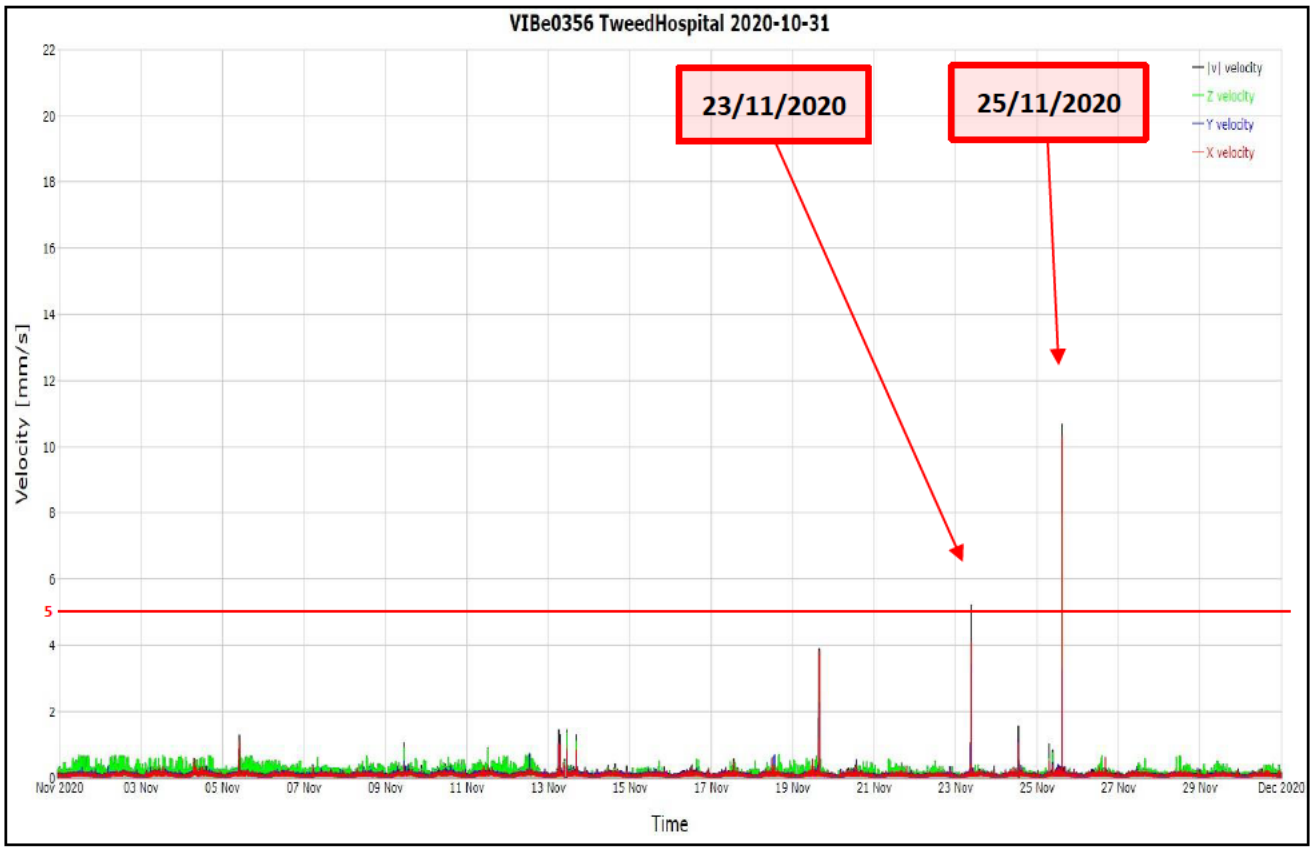


Figure 2. Results of the vibration monitoring from 1 – 30 November 2020 at monitoring location 002 – Central monitor.

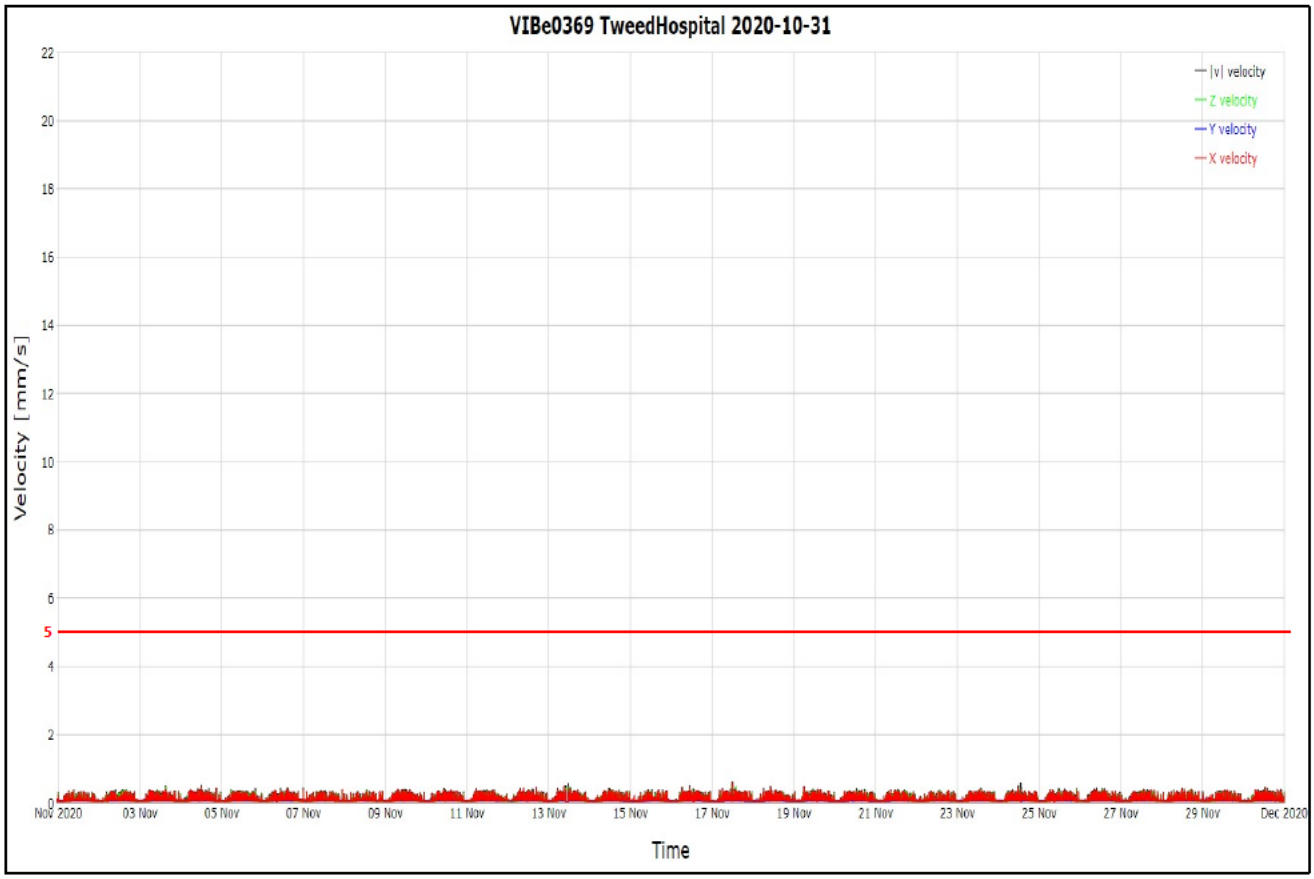


Figure 3. Results of the vibration monitoring from 1 – 30 November 2020 at monitoring location 003 – Eastern section.

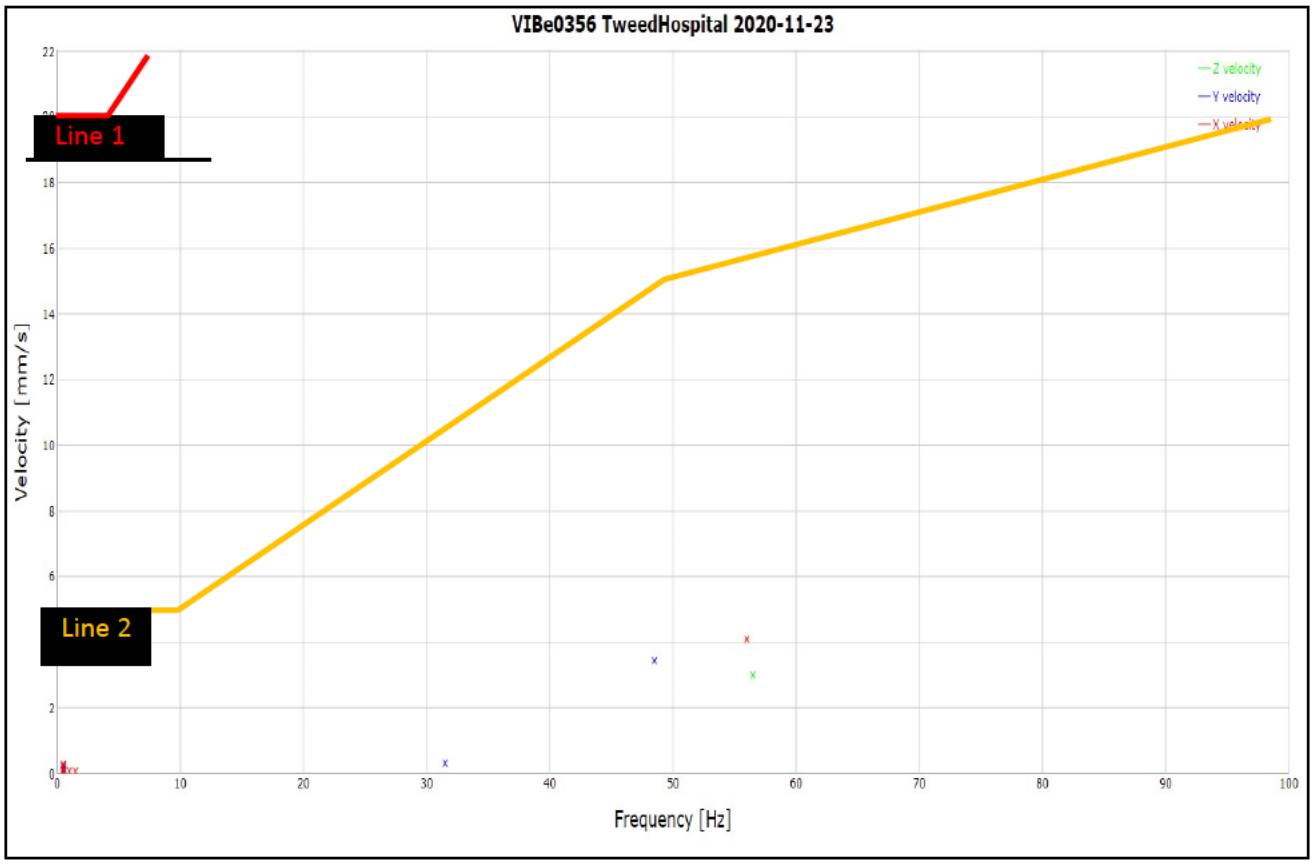


Figure 4. Velocity-Frequency results of the exceedance detected on Monday 23 November 2020 at monitoring location 002 – Central monitor. No Velocity-Frequency exceedance of Line 1 or Line 2.

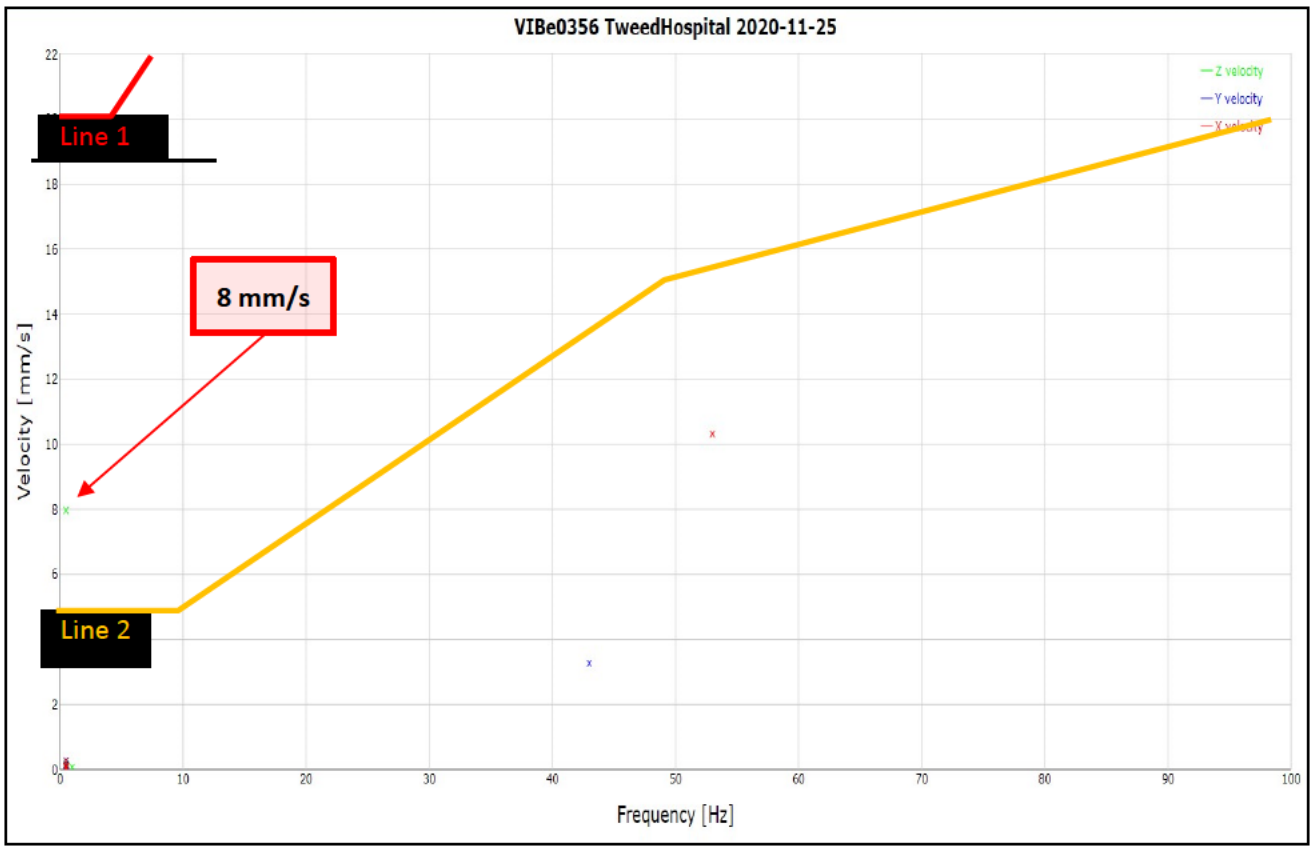


Figure 5. Velocity-Frequency results of the exceedance detected on wednesday 25 November 2020 at monitoring location 002 – Central monitor. Velocity-Frequency exceedance of Line 2.

3 Discussion

One (1) exceedance of DIN 4150 Line 2 occurred during this reporting period.

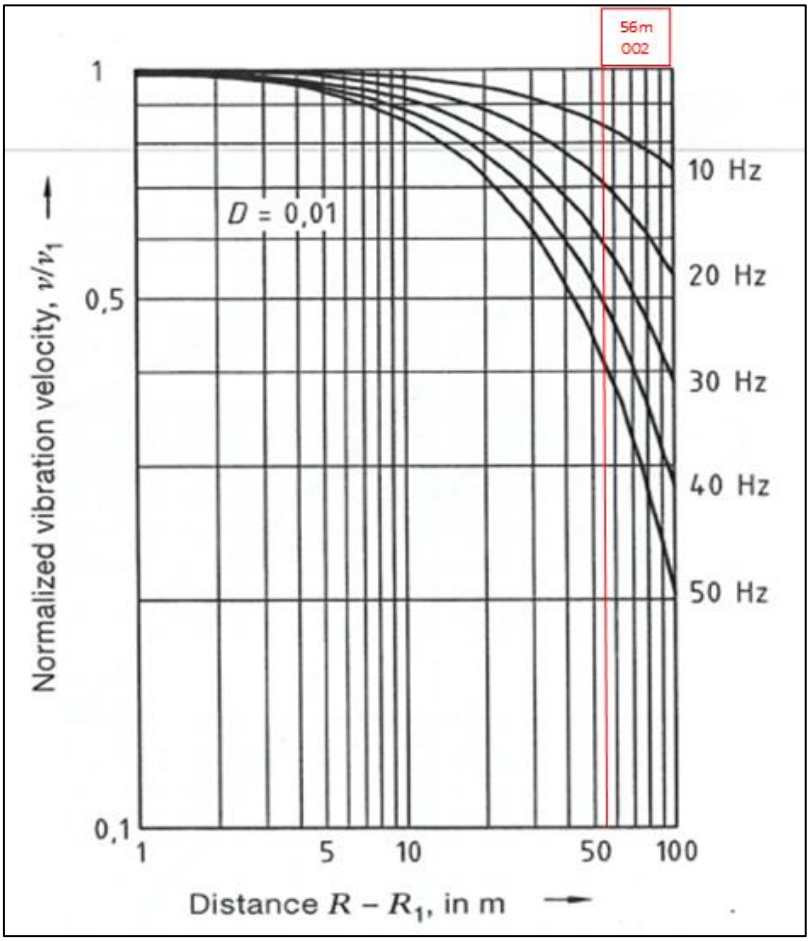
The exceedance occurred at Location 002 on Wednesday 25 November 2020, at approximately 14:48 (AEDT). The vibration had a maximum Z Velocity of approximately 8 mm/s at a frequency of 2 Hz.

The distance from the monitor at Location 002 to the nearest sensitive receiver is 56 m. As per DIN 4150-1:2001-06, a 2 Hz vibration will reduce to 95% of the initial velocity before reaching the receiver at 56 m (refer to **Graph 2**, below).

Therefore, the velocity of the vibration observed at the receiver at 14:48 (AEDT) would have been approximately **7.6 mm/s** (refer to **Figure 6** on the following page).

At a frequency of 2 Hz, a velocity of 7.6 mm/s is an exceedance of the DIN Line 2 threshold velocity of 5 mm/s.

On 25 November 2020, ADE was advised by Lendlease that the exceedance was caused by an 8 tonne excavator being unloaded from a flat bed truck approximately 6 m from the monitoring location.



Graph 2. Effect of vibration energy absorption by the soil on amplitude attenuation with increasing distance, as a factor of frequency (for D = 0.01 and a shear wave propagation velocity of 200 m/s). (Adapted from DIN 4150-1:2001-06, page 6).

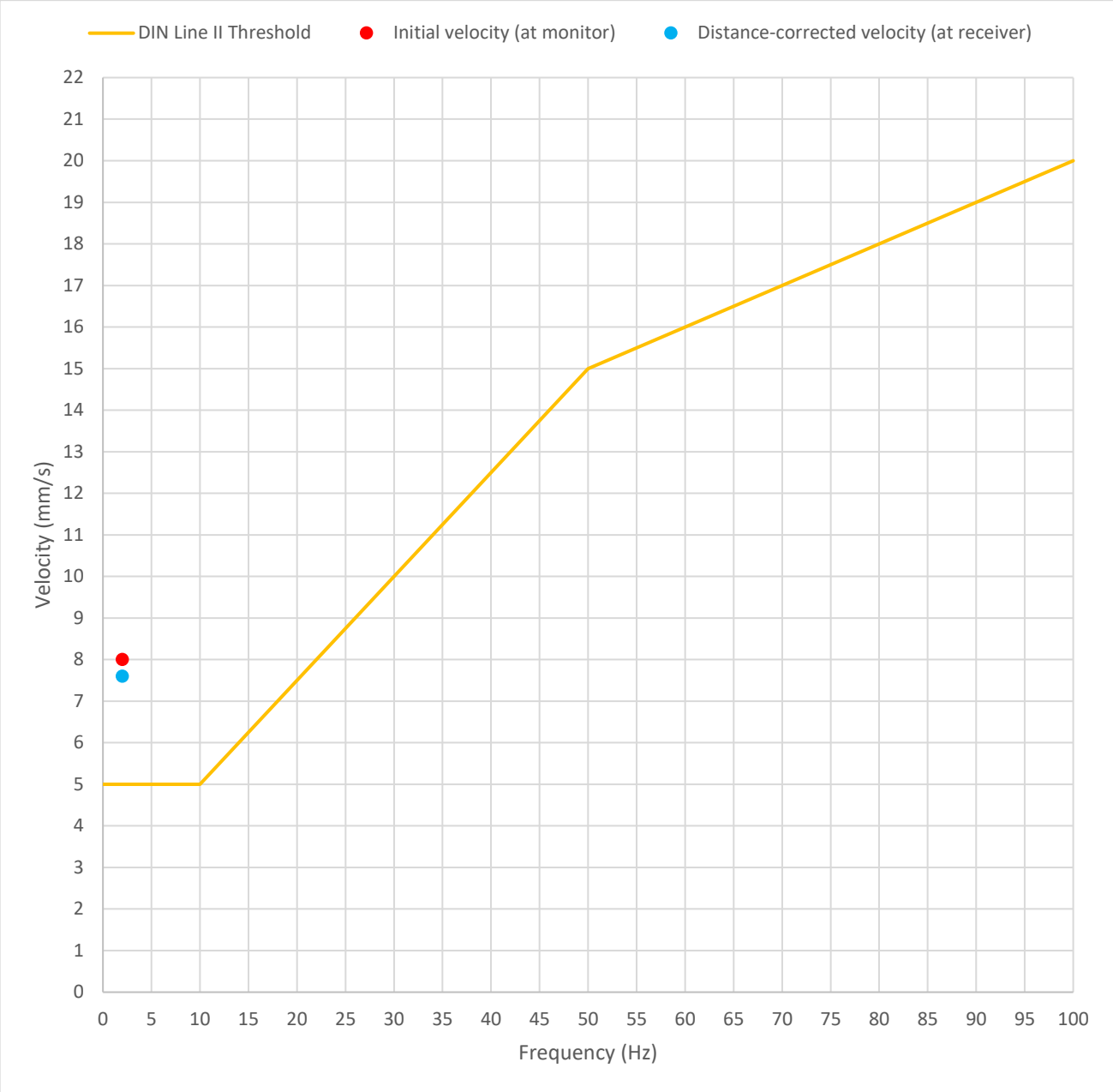


Figure 6. Distance based vibration velocity correction.

4 Conclusion

Results from vibration monitoring undertaken during the monitoring period [November 2020] displayed one (1) exceedance of DIN 4150 (Line 2) at monitoring location 002 on 25 November 2020 at 14:48 AEDT. Although the vibration occurred for less than 30 seconds. ADE notes that this was also an exceedance of DIN 4150 (Line 2) when vibrations were recalculated to account for the nearest sensitive receptor located approximately 56m away.

ADE recommends that careful consideration is given when loading and unloading of plant and/or machinery to reduce future vibration exceedances. This includes loading and unloading of plant and/or machinery as far as practicable away from the vibration monitor to minimise the chance of an exceedance.

All other vibrations were below the threshold used to assess the effects of short-term vibration on structures according to DIN 4150-3 and DIN4150-1

5 References

- Department of Environment and Conservation, Environmental Noise Management, Assessing Vibration: a technical guideline.
- NSW Government, Construction Noise and Vibration Guideline August 2016.
- Structural Vibration Part 1: Predicting vibration parameters DIN4150-1 June 2001.
- Vibrations in buildings Part 3: Effects on structures DIN4150-3 February 2016.

Appendix I – Aerial Photographs

Aerial photograph of the Tweed Valley Hospital Project at Kingscliff, NSW (as of 30 October 2020).

Appendix II – Monitoring Locations

Photograph 1. Representative photograph of monitoring location 001 – Adjacent Carpark location, as observed 24 November 2020

Photograph 2. Representative photograph of monitoring location 002 – Central location, as observed 24 November 2020

Photograph 3. Representative photograph of monitoring location 003 – Eastern Section of Site, as observed 24 November 2020.

Appendix III – ADE Site Visit Summary

Date of site visit	Time of site visit
13/11/2020	0845 – 1045 AEDT
24/11/2020	0930 – 1045 AEDT
25/11/2020	0900 – 1000 AEDT

Appendix IV – VIBRA Technical Specifications

VIBRA-series: *VIBRA*, *VIBRA*+

Profound *VIBRA*-series

Vibrations from pile driving, construction, road or rail traffic, demolition work and blasting can create nuisance or cause damage to buildings and sensitive equipment. These vibrations are accurately quantified with a system of the Profound *VIBRA*-series.

The *VIBRA*'s robust aluminium housing is IP65 watertight. The system is easily portable, lightweight and battery-operated which allows for up to 4 weeks of continuous and unmanned operation.

Depending on the chosen model *VIBRA* or *VIBRA*+, the system complies with national and international standards and is according to DIN 45669-1:2010. The specific characteristics of each model are further outlined in the *VIBRA* features overview.

Setting up the system on site is easy: attach the 3-dimensional sensor to the structure to be monitored, switch on the system and start measuring. While measuring the *VIBRA* displays date, time, time interval and the current peak vibration values including frequency in all 3 directions. In advance an alarm level can be set.

Peak values including dominant frequencies, are directly stored in memory. For full interpretation measurement signals are transferred via USB to a computer for further analysis. The *VIBRA* pc software automatically generates tables and graphs of peak values and signals for use in reports. The data can also be easily exported as a csv-file.

The *VIBRA*+ can be set up for wireless automatic data transfer including sms alerts via the integrated 3G modem. Data can also be continuously uploaded to any FTP server for real-time online monitoring. As an alternative Profound offers a turnkey online monitoring service.

Technical specifications *VIBRA*-series	
Velocity (PPV), frequency and acceleration (PPA)	In x, y, z-direction per time interval
Displacement (*VIBRA*+ only)	In x, y, z-direction per time interval
Sensor type	3-channel geophone
Geophone correction	Digital IR filter
Velocity range	0 – 100 mm/s
Resolution display	0.01 mm/s
Resolution AD-converter	0.001 mm/s (24 bits ADC)
Frequency range and accuracy	DIN 45669-1:2010-09 or SBR – part A, B 2002
Storage capacity	4 MB. Fixed or ring memory incl. buffer
Storage interval	1, 2, 5, 10, 20, 30, 60 s
Data save level	Adjustable between 0.01-100.00 mm/s (or always)
Alarm level	Adjustable between 0.01-100.00 mm/s (or none)
Data retention	10 years (minimum) at 25 °C
Clock stability	Within 5 minutes/year at 25 °C
Temperature range (operating)	- 20 °C to + 60 °C
Housing	Robust hard anodized aluminium case
Protection rating	IP65 according to DIN 40 050/IEC 529
Dimensions (l x w x h)	216 x 160 x 50 mm
Weight	2 kg
Display	≥ 4 Lines; display backlight; anti-reflex coating; anti-scratch
Batteries	3 x 1.5 V Alkaline D-size batteries
Battery life	≈ 28 days (continuous operation)
I/O functionality	Geophone, mini-USB
PC operating system	WIN10/WIN8/WIN7
Accessories	VIB.00320 Cable reel (50m) VIB.00407 Alarm beacon VIB.00420 USB adapter. External power via USB adapter: V_{mains} 100 ↔ 240 V, 47 ↔ 63 Hz

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