INFRA C22

Triaxial Wireless Vibration Monitor

Art no. 080-05222-0

Manual ver. 7.0

Valid for firmware version 2.13.0

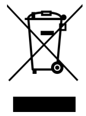
⚠ **IMPORTANT SAFETY INSTRUCTIONS – read this before use**

Operating conditions and limitations:

- The C22 shall not be submerged.
- Safe operating temperature range is -30 to +50 ºC (-22 to +122 ºF). Units have been internally tested functionally from -40 to 60 °C (-40 to 140 °F) but certain components are not rated for these temperatures.
- This instrument includes built-in radio transmitters and antennas. It should be installed away from the operator or third-party persons to be safe; a recommended minimum distance is 1 m (3 ft.).
- Before installing the instrument, make sure there are no restrictions of the use of radio transmitters at the intended site.
- Do not use the instrument in presence of flammable fumes or gases, or in explosive atmospheres.

Li-Ion batteries:

- Only use batteries and power supplies provided or recommended by Sigicom, see chapter 8 Accessories.
- Do not use C22 batteries in other products than applicable Sigicom products.
- A power source connected to the C22 must not be able to supply more than 20V and 3A. A solar panel with maximum 25W power and with an open-circuit voltage of 22V is allowed.
- Replacement and other handling of the batteries shall only be executed by persons who have carefully read the instructions in this manual.
- Never keep the batteries at temperatures above 50ºC (122ºF).
- Transportation of Li-Ion batteries by aircraft is regulated by UN and IATA. See Appendix B - Appendix D.
- Transportation by road or railway is exempt from dangerous goods transportation regulations. Care should still be taken with handling and packaging to avoid severe injury.
- If damaged, the batteries should be individually embedded into sand in a sturdy plastic drum container during transport. It is also recommended to affix a “Lithium Ion” label with an additional text: ‘Damaged batteries’ on the package. A worn-out battery, a battery with cracks or with signs of swelling or leakage, shall be replaced immediately.
  Note! Damaged or worn-out batteries are prohibited in air freight.
- Never incinerate, disassemble or expose the batteries in water.
- If the terminals of the battery are shorted, the battery may become very hot and permanently damaged.
- Prepare your warehouse and charging sites according to Appendix C and Appendix D.
- Use stand-alone chargers in a well-ventilated room, well away from flammable material, open fire and electric sparks.
- If the battery case is penetrated, it may burn with open flame.



This equipment falls under the Waste Electrical and Electronic Equipment Directive (WEEE directive) 2012/19/EU, category 9: monitoring and control instruments:

- Scrapped equipment should be sent back to the manufacturer of the equipment (Sigicom AB) for proper handling according to the WEEE directive.
- Sigicom uses a certified local partner for recycling of scrapped equipment.

The batteries used in this equipment falls under the Battery Directive 2006/66/EC:

- When the equipment is sold to customers in the European Union (EU), except Sweden, the customer is the importer of the battery. The customer must follow the rules and regulations as ratified by each individual European Union member state or send the battery/equipment back to the manufacturer of the equipment (Sigicom AB) for proper disposal.
- Swedish customers can recycle the battery in the national battery collection system.
- Users outside the EU may send the batteries back to the manufacturer of the equipment (Sigicom AB) for proper disposal.

Table of contents

1 Introduction

1.1 Infra System

The INFRA field measurement system consists of rugged sensors which sends data and status to INFRA Net, where it is processed, stored, and presented through a web interface. There are sensors which monitor several important quantities at construction sites and infrastructure projects, such as vibration, noise, and dust et cetera.

All data is sent to INFRA Net, using the built-in cellular modem, at various occasions:

- Monitoring is started or stopped
- A trigger event has occurred
- An error event has occurred, e.g., low battery
- Manual communication is performed by the operator
- At scheduled communication

1.2 INFRA C22 Vibration Monitor

The C22 instrument is a complete triaxial wireless vibration monitor measuring in three directions, vertical, longitudinal, and transverse. It consists of vibration sensor elements, analog measuring electronics, analog-digital converters, an embedded microcontroller/DSP for digital signal processing etc., a small color display, a six-button keypad, a memory card, a cellular modem, antennas and batteries.

The C22 instrument requires INFRA Net for full remote-control capability, data presentation, alarms/alerts configuration and setup, and instrumentation settings. However, most instrument settings can be changed directly at the unit using the keypad/display.

1.3 INFRA C22 Enclosure

The enclosure base is milled out of solid aluminum and includes:

- A horizontal hole for wall-mounting (M6 or ¼” bolt).
- A vertical hole for floor-mounting (M6 or ¼” bolt).
- A front lid covering the two batteries.
- A plug at the back of the enclosure covers a desiccant bag which needs to be replaced at regular intervals (see chapter 9).
- A plastic cap on the top covers the antennas. Removing this cap gives access to the microSD memory card and SIM card but will seldom need to be opened.
- A separate hole at the lower left side of the unit may be used for a wire to lock the unit to a fix and solid structure for theft prevention.
- Three mounting setoff screws, located on the back of the instrument enable sufficient, secure and plumb contact between instrument and uneven vertical (or near vertical) surfaces. These screws are not used for mounting (attachment) but used to ensure that the instrument is plumb in the vertical direction when attached (mounted) to a vertical surface.
- All lids, plugs and connectors are O-ring sealed.

Note! C22 instruments are not intended to be submerged in water.

1.4 Unpacking and Parts Identification

The INFRA C22 Vibration Monitor has been shipped in protective packaging. Please keep this and use it when transporting your equipment.

Verify the package content with the following list:

- C22 Vibration Monitor instrument.
- Foam (shock protection during transportation).
- Two (2) batteries, either inserted in unit or separate.
  Note! Because of shipping regulations, batteries are charged below 30% state of charge at delivery.
- Calibration document.

Any damage or omission should be reported immediately to Sigicom.

Keep record of the instrument's serial number. You will be asked to give this number in any C22 related communication you may have with Sigicom.

2 Product Description

2.1 Keypad

A six-button keypad is placed on the right-hand side of the unit.

- Display ON / Exit / Cancel / Display OFF
- Up / Increase
- Down / Decrease
- Monitoring start/stop
- Communication status
- Menu / Enter / Acknowledge / Activate

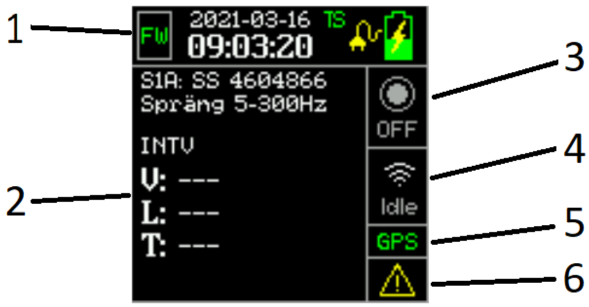
For more information about operation of the graphical user interface, see chapter 5 Operation.

Note! The LED indicator (the green circle in the picture above) is only used at firmware upgrade.

2.2 Display

A color display is used to show data and status. The start screen below presents product type, serial number and firmware version.

Press any key, or wait for a few seconds, to proceed to the main screen:



The main screen is divided in six sections:

1. STATUS: FW-files available; Date and time; GPS time sync enabled; external power; battery status and charging
2. DATA: Measurement standard. Vibration data; interval (INTV) or transient (EVT) values in three directions. Live values for three directions = maximum over the last three seconds.
3. MONITORING status
4. COMMUNICATION status
5. GPS position status
6. ERRORS and WARNINGS

See chapter 5 for more information about the display screens.

2.3 Batteries

The power supply of the C22 has two Li-Ion batteries and uses the battery with the highest voltage. The switch-over between the batteries is automatic.

If the unit is firmly mounted, the batteries can be replaced one at the time during normal operation without interrupting the measurement. A lock lever holds both batteries in place when the battery lid is removed. See the safety section at the beginning of this manual on how to replace the batteries. Voltage, current, temperature and a digital identity of both batteries are monitored to ensure safe use and charging.

Note! Make sure that both batteries are inserted.

2.4 External Power Connector

The external power connector is located at the left-hand side of the instrument. Input for a 12V power supply is supported. When the battery level is low, the external power will charge the batteries[1]. For a complete charge, the batteries must be removed from the instrument and charged separately.

Due to shortage of components, the instruments that were sold during the summer of 2022 did not include the function of being charged by external power.

Note! Use the plastic cap to protect the external power connector when not in use.

2.5 USB Connector (Micro-B Type)

A Micro-USB connector, mainly used for maintenance, is on the left-hand side of the unit. C22 is never powered through the USB interface. Do not ever monitor vibrations with the USB connected.

When set through the graphical user interface, the memory card can be accessible as a Windows drive via the USB interface. See section 5.8.5.

Firmware upgrade is normally performed remotely via INFRA Net but may also be done via the USB interface. See section 5.8.6.

Note! Use the plastic cap to protect the USB connector when not in use.

[1] Only charging up to battery level 60%, to extend battery life.

2.6 Memory Card

The C22 uses a microSD memory card to store recorded data, system logs and various status files to be communicated to INFRA Net. No configuration data is saved on the memory card.

File formats on the memory card are only compatible with the INFRA Net server and are not described in this manual.

The memory card can be accessible as a removable drive via the USB connector, see section 5.8.5.

If the memory card is unintentionally missing (or corrupt), an error message will be displayed at start-up.

Please contact Sigicom Support for guidance regarding memory card formatting or other memory card issues.

Note! Only use a memory card approved by Sigicom.

2.7 SIM Cards

If activated when ordering, the embedded SIM card is used. This is pre-configured for the customer.

If the customer needs to use their own SIM card, a mini-SIM card can be inserted. The mini-SIM card must have an active “data plan”. The inserted mini-SIM card will then be used instead of the embedded SIM card.

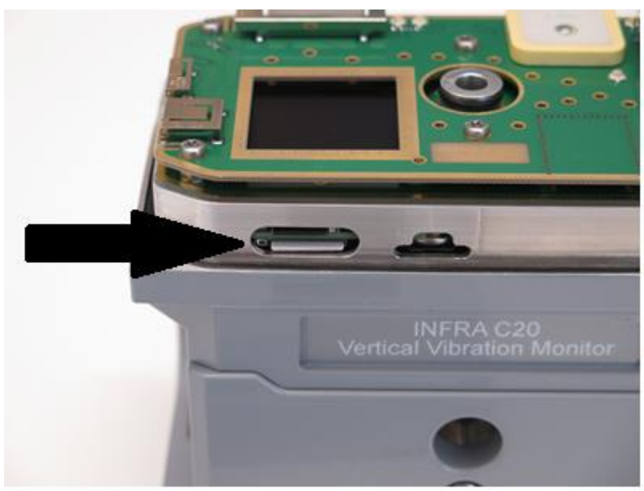


Figure 1. The location of the mini-SIM card.
Insert with the cut corner first and to the right

Note! If a mini-SIM with an active PIN-code lock is used, either deactivate the PIN-code lock (contact your network provider for more information) or follow the instructions in Appendix J on how to configure a PIN-code in the C22.

For activation or deactivation of the embedded SIM card, please contact Sigicom Support.

3 Measuring Parts

3.1 Measuring Hardware

3.1.1 Vibration Sensor

The C22 uses three geophones with low frequency responses down to 4.5 Hz. The low frequency resonance of the geophones is electrically dampened, and their characteristics are measured during calibration and saved in the instrument's calibration memory. This data is later used as input for the digital frequency compensation used in some measurement standards.

3.1.2 Analog Electronics

An adjustable amplifier enhances the geophone signal according to the selected measurement standard. The signal is then low pass filtered with an analog filter to avoid aliasing. Then the signal passes through an analog-digital converter and all subsequent signal processing is digital.

3.1.3 Analog-Digital Conversion

All sampling is performed at 4096 Hz. The analog-digital converter has a 16 bits resolution which, at measurements up to 250 mm/s (10 in/s) in the largest range, provides a minimum resolution of 0.01 mm/s (0.0004 in/s). In the display, the resolution of interval values is set to 0.05 mm/s (0.002 in/s) in this range.

3.1.4 Digital Signal Processing

The main processor of the C22 is a combined general processor and a digital signal processor (DSP). The DSP part of the processor filters, compensates and detects the signals according to the selected measurement standard.

3.2 Measuring Logic

3.2.1 Measurement Standards

The C22 contains several pre-configured measurement standards, used in different countries and for different types of measurements. More measurement standards may be added in future firmware versions.

Measurement standard is selected through INFRA Net or the graphical user interface.

Note! Remember to review all measurement settings after any change of standard.

A more thorough description of the available measurement standards is given in 0.

3.2.2 Interval Measurements

The C22 processes the vibration signal through the filters and detectors of the selected measurement standard. The interval value is the maximum value of the processed signal within a selected interval time. When the interval end time is reached, the maximum value is saved, and a new interval is started. The timestamp of the interval is set to the interval end time.

The interval time can be set to a value between 5 seconds and 20 minutes. It is set through INFRA Net or the graphical user interface.

Each direction, V, L and T, creates at least one interval channel. Even for standards with frequency weighting, the first channel is unweighted[2].

Depending on the selected standard, the following sub-channels may be added:

- **Frequency** (one channel per direction). Frequency is estimated using a zero-crossing method: the time T between two adjacent zero crossings is used in the formula: $f = \frac{1}{2*T}$. The frequency value is limited within 0.5Hz – 512Hz. If the signal[3] is continuously low[4], no frequency is estimated for that channel, because the value would not be accurate enough. The RMS-standards also estimates the frequency for intervals, and here the estimation is made on the signal *before the RMS-detector*, using the method described above. For standard 74A and 74B SBR-A:2017 this channel is the relative frequency, see Appendix G.
- **Relative values** (one channel per direction). If frequency weighting is active, a weighted interval value will be stored as an additional channel, with its value in percentage relative the frequency weighting curve for the selected standard. Appendix G shows some examples of this.
- **Relative frequencies** (one channel per direction). Is the frequency where the relative value was measured.
- **Resultant** (one channel). Calculated by, sample by sample, finding the maximum resultant of the three directions. This is also known as the **Peak Vector Sum** (PVS).

[2] This is different from the INFRA legacy system, e.g. V12 and C12. Also, for standards 74A and 74B SBR-A:2017, the main channel is weighted. See more in Appendix G.
[3] The signal here means the one filtered according to the selected standard.
[4] The limit here is equal to the lowest possible threshold for the chosen standard e.g. 0.4 mm/s (0.02 in/s) for standards with level range 250 mm/s, and 0.04 mm/s (0.002 in/s) for standards with level range 25 mm/s.

- **VDV** (one channel per direction). Vibration Dose Value accumulated over each interval [$m/s^{1.75}$]
- **Accumulated VDV** (three channels). Vibration Dose Value accumulated over one day/night [$m/s^{1.75}$]. Day is defined between 07:00 – 23:00, and night 23:00 – 07:00.

On questions regarding the different interval channels, please contact sales@sigicom.com

3.2.3 Transient Recording

When an instantaneous value exceeds the selected trigger level for any of the three directions, a transient recording of all three directions is initiated. A transient recording can also be initiated via the Menu of the graphical user interface ("Manual trigger" under the "Main Menu") when monitoring is on. This recording will work the same way as event triggered recordings, except it being triggered by the user.

Each channel has a trigger level which can be set through INFRA Net or the graphical user interface. Their maximum and minimum values depend on the selected measurement standard. The trigger levels are common for all standards.

Note! It is very important to set to an adequate trigger level. When set too high, there will be no recordings. If, on the other hand, the level is set too low, there will be lots of (continuous) triggering/recordings, which would lead to:

- Increase of battery consumption
- Lots of data storage on memory card
- High data transfer rate/cost

The length of the recording is 1 to 5 seconds before the trigger point (pre-trig time), plus an adjustable time between 1 and 120 seconds. The adjustable time is referred to as "Record time" in the graphical user interface and "Transient time" in INFRA Net.

The pre-trig time depends on Record time according to the table (was added with FW-version 2.5.0):

Record time [s]	Pre-trig time [s]
1 – 9	1
10 - 19	2
20 - 29	3
30 -39	4
40 - 120	5

For each maximum value ("EVT" in the graphical user interface) of the transients, a frequency is estimated using a zero-crossing algorithm, see description of this in section 3.2.2.

3.2.4 Overload Handling

If analog or digital overload occurs in one or more samples during an interval period, the interval value of that interval period is tagged with an overload flag. Similarly, if analog or digital overload occurs in one or more samples during recording of a transient, the corresponding transient will be tagged with an overload flag. In this way INFRA Net can indicate possible overload in its interval and transient data reports. Overload is indicated in the display with a “>” before the value.

3.3 Data Storage

C22 follows the data storage model for the new generation of Sigicom’s INFRA instruments. Although data files are accessible through the USB interface (see section 5.8.5), data is only readable after post-processing through INFRA Net.

3.3.1 Transient Data

In INFRA Net it is possible to override the default setting, and filter according to another measurement standard. INFRA Net includes all implemented standard filters.

3.4 Additional Hardware

3.4.1 Humidity Sensor

The C22 is equipped with a humidity sensor. A warning message is sent to INFRA Net if the relative humidity becomes higher than 95%. The last measured value of the humidity can be read in the GUI, by selecting Instrument status in the Menu, see section 5.8.

3.4.2 GPS Receiver

The C22 is equipped with a GPS receiver. It is first started directly after the start of monitoring to retrieve time information and get the position. It is also started every hour to update the time and every night to update the position. The position data is communicated to INFRA Net when Monitoring is started. For further information, see section 6.2.

4 Configuration and Installation

4.1 Configurations and Settings

The customer's INFRA Net account is pre-set from Sigicom prior to delivery and cannot be changed by the customer. Contact Sigicom Support if this needs to be changed.

4.1.1 INFRA Net Communication Schedule

Through INFRA Net you can set which hours the C22 shall connect (when monitoring is on). The connection will start within the first 15 minutes (randomly distributed) of each configured hour.

If there are communication difficulties, the unit will continue to connect to INFRA Net until successful, using a time delay pattern to minimize power consumption.

4.1.2 Disable communication (Flight Mode)

C22 can be set to disable communication (Flight mode) where INFRA Net (and other) communication is inhibited, see section 5.8.2 for this configuration.

4.1.3 Configuration Menu

For setup of monitoring parameters, go to the Monitoring configuration menu, see section 5.8.1.

4.1.4 INFRA Net Messages

All messages are handled through INFRA Net under the Messages tab.

4.1.5 Factory Default Settings

- Communication schedule: Each hour
- Measurement standard: 1A (*SS 460 48 66 Spräng*, 250mm/s)
- Threshold: 2.0 mm/s (ON)
- Interval time: 2 minutes
- Record time: 4 seconds
- GPS timesync: Disabled

4.2 Mounting

1. Identify an even surface where the C22 can be mounted
2. Drill for the fastener (e.g. a concrete anchor)
3. Insert fastener
4. Screw a nut to the head of the bolt, keep it loose but close to head of the screw
5. Attach a washer to the bolt/nut
6. Insert the bolt through the center hole of the C22 and screw the into the anchor (C22 hanging loose)
7. Hold the head of the bolt still with one tool and use an appropriate tool to tighten the nut to secure the C22 to the wall

If the wall or ground is not completely flat, you can adjust one or two of the mounting screws to ensure all three have full contact with the wall.

Make sure that the C22 is firmly attached and aligned (plumb and level). For correct measuring results, the mounting angle of the instrument must not exceed 5º relative to the horizontal plane. Refer to Sigicom product catalog for more information on mounting solutions.

Note! The instrument must not be submerged in water.

4.3 Site Startup Check

After mounting, it is recommended to start the instrument and check:

- Battery level
- Clock set
- INFRA Net communication
- Monitoring

5 Operation

5.1 Startup

To turn the C22 on, press . The display is lit up and the unit is ready for use. See section 2.2 for a description of start-up sequence. If the access code is activated, see section 5.9 for more information.

The following options are available:

- Start monitoring as described in section 5.2
- Initiate a manual communication to INFRA Net,
  see section 5.4.2
- Open the GUI menu, see section 5.8

Instrument errors, if present, will be indicated at bottom right on the main screen and should be addressed prior to monitoring. See section 9.

If last known monitoring mode was ON, the C22 will automatically restart monitoring after instrument start-up.

5.2 Start Monitoring

To start Monitoring[5], press . The display will indicate the mode transition and its steps:

1. First a sensor test will be done (see 5.2.1). This takes a few seconds, and the monitoring symbol is yellow during this phase.
2. Monitoring is started, indicated with a flashing green or red circle. If the color of the circle flashes green everything is OK; if it flashes red either Sensor test failed, or the alignment of the sensor is not horizontal enough.

After transition into monitoring mode, the instrument will communicate to INFRA Net and transmit its status.

Note! Any key stroke while in monitoring mode may cause a disturbance in the measuring result.

If monitoring does not start when pressing the key, one of the following reasons may apply:

- Another screen that the main screen is present
- GUI locked by passcode
- Battery level too low

[5] In previous INFRA systems, Monitoring is called registration (REGON).

5.2.1 Sensor Test

While entering the monitoring mode, the vibration sensor will be tested by activating an electronic pulse and then evaluating the response of the sensor signal. The purpose of this sensor test is to check that:

- The vibration sensor works as it should
- Your instrument is correctly mounted

If the test pulse from the vibration sensor indicates error:

- An error symbol will be displayed
- The error will be communicated to INFRA Net
- Monitoring will continue

The test pulses and analyzed results are saved and communicated to INFRA Net.

For each transient, information about the current alignment of the unit and a health parameter of the electronics involved in the measurement chain is added to the data. This information will be used to present "sensor health" in transient reports made in INFRA Net

5.3 Stop Monitoring

To stop monitoring (assuming display is on), press and acknowledge with . The monitoring symbol will be grayed out.

If the instrument is recording when monitoring off is selected, the recording will be completed before monitoring is stopped. Once monitoring is stopped, the instrument will communicate to INFRA Net and update the instrument's new status and data.

5.4 INFRA Net Communication

When INFRA Net communication is mentioned in this document, it refers to internet communication and data transfer to the INFRA Net server. The communication status is displayed in the communication field of the main screen. A more detailed status is presented on the communication screen (see section 5.4.2).

During INFRA Net communication, all data files on the memory card are transmitted to the INFRA Net server and automatically removed from the memory card.

If there are communication problems, the C22 will continue to attempt to communicate with incrementally increasing time intervals between communication attempts.

5.4.1 Automatic INFRA Net Communication

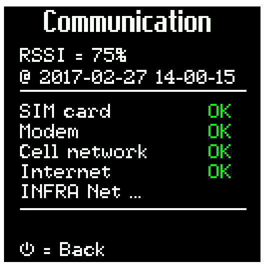
Automatic communication will be done in the following situations:

- After start or stop of monitoring
- After a transient recording

- When an error has been detected
- Scheduled upload

5.4.2 Manual INFRA Net Communication

Manual communication can be initiated from the communication screen. Press to enter this screen, and then press again to start the communication. The communication process is displayed on the screen:



It is possible to initiate manual communication when monitoring is either on or off.

5.4.3 More Communication Information

Pressing in the communication screen will open up another screen, “Comm details”, with further communication and legal information. Use the and keys to scroll through this information:

- SIM card info
- Modem info
- Cell network info
- Legal info

5.5 Power Off

The C22 instrument will automatically power off after a period of no activity, referred to as time-out. If an activity has taken place, e.g. a key is pressed, the time-out will be prolonged.

Power off may be inhibited by internal activities such as:

- Monitoring is on
- Monitoring is stopped but there is a recording on-going
- C22 is communicating with INFRA Net communication

Any such activity must be finished before powering off is performed. For manual power off, see section 5.8.8.

5.6 Power Lost

When the batteries are completely discharged, monitoring will stop and the C22 will turn off.

If power was accidentally lost while in monitoring mode (e.g. if the batteries were improperly removed), the C22 will restart monitoring when new or recharged batteries are reinserted.

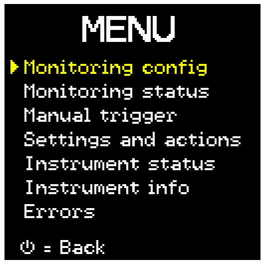
5.7 Removal and replacement of Li-Ion batteries:

- Remove the front lid using a Torx T20 driver, see Figure 5.
- Turn the battery lock lever to one side and remove/replace the first battery
- Turn the battery lock lever to the other side and remove/replace the second battery
- Reset the lock lever in its middle position for the lid to fit
- Replace the front lid using a Torx T20 driver

Figure 5. Instrument with front lid removed

5.8 GUI Menu

The GUI menu is reached by pressing :

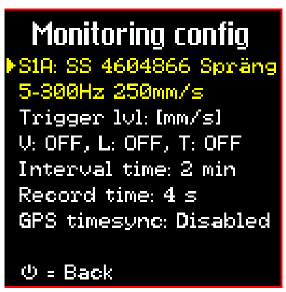


Some of the menu selections are described in the following sections.

5.8.1 Monitoring config

To view and possibly change the monitoring parameters, select “Monitoring config”:

→ Monitoring config



Frequency weight parameter may also be available, as an additional option, depending on selected standard.

Use and to select parameter, and to enter the parameter settings screen.

Note! The recommended way to configure the Monitoring parameters is to use INFRA Net (see section 5.10).

5.8.2 Communication config

Communication config has two parameters with different settings possible:

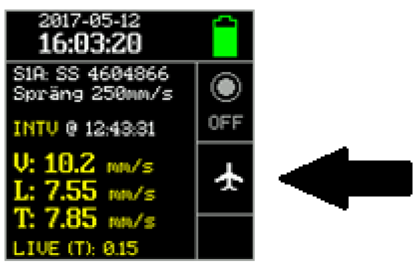
- Comm: Enabled / Disabled (Flight-mode)
- Radio mode: 4G+3G+2G / 4G+2G / 4G Only

Use and to select parameter, and to swap between possible settings.

If having new settings selected a “Save changes” option will appear, use and to select “Save changes” and to confirm.

→ Settings and actions → Communication config.

Disabled communication (Flight mode) will be indicated on the main screen with an airplane symbol.



There is also a section with information about if the unit is using embedded or external SIM. The Radio modes can be useful to improve connectivity in areas with known poor 3G or 2G coverage (or areas where these are discontinued technologies).

5.8.3 Clock Set

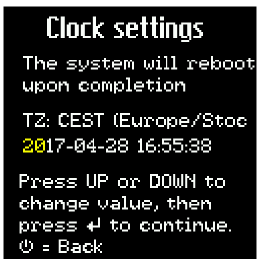
Time synchronization is normally handled automatically using GPS time or Internet time (see section 6.3).

Because the synchronization is fairly slow and increases the power consumption, it may still be useful to set the clock manually before monitoring is started.

When set manually, it is recommended to ensure the clock is set to the correct second.

A more precise way to set the clock is to initiate and wait for a complete cellular connection before monitoring is started and then make a controlled system reboot. Internet time will be received and set correctly on the unit.

For manual setting, select “Clock set” by pressing
→ Settings and actions → Clock set.



Note! To change the Clock settings, Monitoring must be OFF and Communication mode set to disabled (Flight mode).

Use to step forward and arrow keys (or) to change a value. Finish with the key.

Note! C22 will reboot after the clock is changed.

5.8.4 Clock Format

Time can be displayed in either 12- or 24-hour format, which is configured by this selection. This configuration is only for the instrument, INFRA Net is not affected by this.

5.8.5 USB Memory Interface Mode

In this mode the files and directories of the SD Memory card can be accessed, just as a normal USB memory. Select “USB mode” by pressing:

→ Settings and actions → Set USB mode.

Note! To set USB mode, Monitoring must be OFF and Communication mode set to disabled (Flight mode).

1. Connect a USB cable between a PC and the C22 USB connector, see section 2.5
2. Press
3. The microSD memory should now appear as a removable drive in the file system of the PC
4. When finished command the PC to eject the removable disc
5. Disconnect the USB connector from the instrument and it will reboot automatically

5.8.6 Firmware Upgrade

This section describes how to upgrade to latest FW version when the C22 is in the office. To upgrade a C22 which is monitoring out in the field (so called *Remote firmware upgrade*), see section 5.10.1.

The latest FW release is available for download from the Sigicom Support page: http://support.sigicom.com/infra/index.html

Note! Monitoring must be OFF, and communication mode set to disabled (Flight mode), see section 5.8.2, to perform a firmware upgrade.

This is the procedure to do this:

1. Set the C22 in USB mode (see section 5.8.5, step 1 to 3)
2. Copy the new firmware (a .bin-file plus a .meta-file) to the file system root on the memory card
3. Return from USB mode (see section 5.8.5, from step 4 until reboot)
4. The copied firmware files will be indicated by "FW" in the upper left corner of the main screen
5. Go to the firmware upgrade menu screen:
   → Settings and actions → Firmware upgrade

6. Press and wait for reboot. The C22 instrument will then restart with the new firmware

The upgrade sequence is indicated by the LED[6] flashing in RED (erasing) → BLUE (programming) → GREEN/RED (ok/fail).

[6] The LED is positioned just above the REC-key on the keypad.

An alternative way to upgrade FW to the latest version, without connecting any USB-cable, is to:

1. Set communication mode to Normal mode, see section 5.8.2
2. Stop monitoring
3. On the main screen, wait for the communication to finish, indicated by “idle” displayed below the communication symbol. This may take several minutes.
4. In INFRA Net Hardware tab, select Special commands → Remote Firmware Upgrade. Then select Manage changes → Commit.
5. On the C22 again: Perform a manual communication, see section 5.4.2
6. On the main screen, wait for the communication to finish, which is indicated by “Idle” displayed below the communication symbol in the display. It takes at least two minutes to upload the FW files. When the FW files are downloaded this is indicated by the following symbol[7] in the upper left corner.

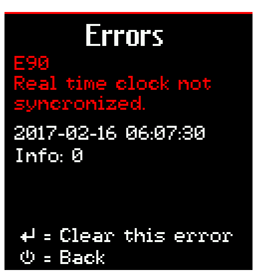
   This symbol was introduced in FW version 1.1.0.

7. Set communication mode to disabled (Flight mode), see section 5.8.2
8. Go to the firmware upgrade menu screen:
   → Settings and actions → Firmware upgrade

Press and wait for reboot. The C22 instrument will then restart with the new firmware.

5.8.7 Errors and Warnings

A yellow or red triangle at the bottom right of the main screen indicates that an error code is set. Yellow is the warning level, and red indicates a more serious problem. For viewing and resetting any of the error codes, select Errors in the GUI menu, and press .



Errors are in red text, and warnings in orange. If there are several errors, use the arrow keys to scroll between them. Each individual error code can be acknowledged / cleared with the key.

A list of errors and warnings is presented in Appendix E.

[7] Note! FW in green; if it is in yellow and without a frame the files are in downloading state.

5.8.8 Power off and Reboot

Power off and Reboot is reached via the Menu by:

→ Settings and actions → Power off / Reboot.

Note! Monitoring must be OFF when doing Power off or Reboot.

Select either Power off or Reboot in the list and click .

If none of the two selections is wanted, back out with .

5.9 GUI Passcode

To prevent unauthorized access, a passcode (not changeable) can be activated for the C22 graphical user interface (GUI).

If the passcode is not active, activate it through the menu:

→ Settings and actions → GUI Passcode.

The passcode is then entered on the keypad at start-up.

Use the and keys, followed by .

The default passcode is: “1-2-3”. It can be entered in the following ways:

or

.

If the passcode is active at display start-up, and the passcode is entered incorrectly (or not entered at all), the C22 GUI will be opened in a ‘view-only’ mode. All settings and actions (including monitoring start) are prohibited.

An active passcode may be deactivated in the following way:

→ Settings and actions → GUI Passcode.

5.10 INFRA Net Remote Control

Note! For full functionality of the INFRA Net Remote control system, the C22 shall be monitoring. The C22 does not communicate automatically when monitoring is off.

When communicating to INFRA Net, the C22 sends its status and parameter settings. On the Hardware page in INFRA Net, the operator can view all status and settings, and request changes of configurable parameters.

When the operator has committed any instrument changes (i.e., communication schedule, service messages, settings) they will be applied to the C22 at its next communication schedule.

While the instrument is monitoring, change of some parameters (e.g. the trigger level) will:

1. Cause temporary stop of monitoring
2. Change the parameter(s)
3. Restart monitoring.

Other parameters (e.g. the INFRA Net communication schedule), can be changed without a monitoring stop/restart procedure.

Also, when the instrument is in monitoring off mode, the INFRA Net Remote system can be used, however physical access is required. Use the following procedure:

1. Perform a manual communication (upload) on the C22 to send the current status and settings to INFRA Net (see section 5.4.2)
2. Wait for the status to be updated on INFRA Net (Hardware tab)
3. Use INFRA Net to change parameter settings
4. Perform a manual communication again on the C22 to read the new change request. The changes will then be performed.

For further information about INFRA Net remote control, see INFRA Net Hardware manual.

5.10.1 Remote Firmware Upgrade

It is possible to upgrade FW also on a C22 which is “at work”, monitoring vibrations. This is done by selecting (in INFRA Net – Hardware tab)

Special commands → Remote Firmware Upgrade

And then

Manage changes → Commit.

The C22 will download the new firmware at the next communication[8], and the upgrade will be performed sometime between 3 a.m. and 5 a.m. (local instrument time).

[8] It may take several minutes until the firmware files have been downloaded.

5.10.2 Remote Reboot

It is possible to force a reboot (=restart) on an C22 which is “at work”, monitoring vibrations. This is done by selecting (in INFRA Net – Hardware tab)

Special commands → Remote Reboot

followed by

Manage changes → Commit.

The data logger will perform the reboot at the next communication.

5.10.3 Remote Shut Down

It is possible to force a shutdown[9] on an C22 which is “at work”, monitoring vibrations. This is done by selecting (in INFRA Net – Hardware tab)

Special commands → Remote Shut Down

followed by

Manage changes → Commit.

The data logger will perform the shutdown at the next communication.

5.10.4 Remote Update GPS Position

GPS position is updated every time Monitoring is started, but it is possible to remotely call for an update of the GPS position.

Please select (in INFRA Net – Hardware tab)

Special commands → Remote Update GPS Position

followed by

Manage changes → Commit.

The C22 will perform the update at the next communication.

[9] First a controlled “Stop Monitoring” will be performed.

6 Other Functions

6.1 Disable Communication

Disable communication (Flight mode) means that all communication is disabled and can be selected in the “Settings and actions” menu (see section 5.8.2).

6.2 GPS position

Every time monitoring is started and every morning at five o’clock local time, the internal GPS unit is activated to receive a position to be visualized in INFRA Net. After a short while, a preliminary position is received, but the GPS unit runs up to five minutes or until the accuracy of the position becomes 7 meters. This is a compromise between accuracy and power consumption.

GPS status can be seen in the “Monitoring status” screen:

The GPS-symbol is positioned to the right in the display, and its color depends on the status of the GPS functionality:

- Grey: GPS position unknown
- Red: no GPS position is (yet) received after 90 seconds
- Yellow: a GPS position is received with lower accuracy
  (estimated position error normally > 20 m)
- Green, a GPS position is received with high accuracy
  (estimated position error < 20 m, but it needs to be outdoor)

6.3 Time Synchronization through GPS or Internet

The internal clock controls the sampling frequency, and all time handling within the system, and cannot be adjusted in steps while the unit is running.

When an external time reference is available, the internal clock is trimmed against the reference by changing the speed of the internal clock until it is settled.

When a GPS signal is available, GPS time will be used as time reference. The GPS unit will start every hour to retrieve time with millisecond precision.

If GPS time cannot be retrieved by some reason, NTP (Internet time) is used as a backup reference using the cellular connection.

When GPS time has been valid for some time and the calculated difference between the internal clock and the GPS time is accurate within 3 milliseconds, the difference will be added to recorded transients. INFRA Net users may use this information to calculate a more exact time for a transient, e.g. in two units to calculate ground speed where the demand for precision is moderate.

The status screen shows information about the time synchronization system.

- Sync'd - last time a time reference was received
- TimeDiff - time reference currently used and time difference between the reference and the internal clock when last reference was received
- LiveDiff - remaining difference while trimming of the internal clock is ongoing. "/*" indicates that GPS is used and the accuracy is within 3 ms.

For both "Diff" values, a positive number means the internal clock is lagging.

No time reference is available:

NTP is used as reference:

GPS is used as reference but accuracy of LiveDiff isn't secured

GPS is used as reference with accuracy of LiveDiff within 3 ms ("/*")

Notes:

- GPS (Global Positioning System) is the first satellite-based positioning system built by the US government. Our GNSS receiver (Global navigation satellite system) supports GPS, as well as other systems. For simplicity, we keep using GPS to reference to all GNSS systems.
- For NTP (Network Time Protocol), SNTP according to RFC 4330 is used. No user configuration of the NTP server can be made.

6.4 GPS time synchronization mode

In “Monitoring config” it is possible to enable the function “GPS timesync”.

This marks each transient with the time difference between the internal clock and the nearest exact (whole) second taken from the GPS module to make it possible to use two or more INFRA C22 to measure ground wave speed with high precision.

Expected accuracy for time synchronization between a pair of C22:s is 3ms (1.5ms per unit).

Example: A distance of 10m between the pair of C22:s with a ground wave speed of 150 m/s would result in an accuracy better than 10%. Increasing the distance between the pair it will equally increase the accuracy.

A green “TS” on the upper row indicates that the GPS time synchronization is enabled and working.

A red “TS” on the upper row indicates that the GPS time synchronization is enabled but has some kind of issues.

Notes:

- With “GPS Timesync” activated, the power consumption increases with almost 700%, and the time the battery is empty is thus shortened with the same factor.
- Because this mode only calculates the difference to the nearest second, ensure the clock is set to the right second before starting monitoring. See notes in 6.3 about this.
- The trigger level must be set low enough so that all units trigger on the event.
- Contact Sigicom for further details if you want to use this function.

6.5 Daylight Saving Time

Automatic transition between daylight saving time (DST) and standard time (STD) is configured with the time zone mentioned above. The C22 does not need to turn monitoring off during the transition.

All data from C22 is time stamped with UTC time. Daylight Saving Time only affects the presentation of time.

7 Technical Specifications

Enclosure:	Aluminum painted gray 146 x 127x 89 mm (5.7 x 5.0 x 3.5 in). Weather proofed by O-rings in all seams.
Weight:	Excl. batteries: 1420 g (3.1 lbs.) Incl. batteries: 1820g (4.0 lbs.)
Memory:	1GB microSD.
Battery:	Two Li-Ion 14.4V/3.4Ah/48Wh. Important! When not in use, store batteries at charge state < 40% (<14.3V), and at room temperature or lower. Expected service lifetime: 3-6 years (70% remaining charging capacity).
Power consumption:	Less than 20 mW (in monitoring mode; display and communication off).
Run-time:	Up to 4 months, depending on ambient temperature, quantity of transient recordings and scheduled INFRA Net communications etc.
Backup battery:	Expected life > 5 years. **Note!** The Backup battery may only be replaced by Sigicom technician or agent.
Modem:	Cellular 2G/3G/4G modem (some variations exist).
Antennas:	Adjusted for 900/1800/2100 MHz, for users within EU and 850/1900/2100 MHz, for users in the US.
Reference conditions:	Standard: Special cal. standard Vibration level: 10 mm/s (0.394 in/s) Frequency: 80 Hz Ambient temperature: 23 ºC (73.4 ºF) Static pressure: 101.3 kPa (14.7 psi)
Accuracy:	Noise and interference according to EMC demands in IEC61326-1:2006. Transient low-pass filter characteristics: - 0.5 dB at 467Hz, -3dB at 627Hz.

Operations temp: -20°C to +50°C (-4°F to 122°F)

8 Accessories

- Memory card (microSD), part number 080-01436-0
- Spare desiccant bag, part number 947-00001-0
- Spare Li-Ion battery B50, part number 080-01620-0
- Battery charger Li-Ion B50/B100, part number 080-01628-0
- Power supply C2x (EU), part number 080-01682-0 (Valid for outdoor use)
  Note! Make sure that any connector or cord used with this power supply is also approved for outdoor use.
- Mounting plate C2x, 080-01818-0
- External antenna kit, future product on request
- Wire lock, part number 080-01830-0
- Socket wrench 10 mm with handle, part number 080-01893-0
- Hex screwdriver 3 mm (for plastic antenna cover) (part number 080-01894-0)
- Transport case INFRA C2x, part number 080-01888-0

See latest INFRA product catalogue for a complete list of accessories and more details.

9 Maintenance and Calibration

- The recommended calibration interval of the C22 is 12 months. If a unit is mounted long term, it is acceptable to increase the interval to 24 months. Local measurement standards, rules and regulations may state another calibration interval.
- The C22 is a precision instrument, thus sensitive to shock. If dropped on a hard surface it must be recalibrated.
- Firmware update is done remotely via INFRA Net
- To keep the C22 dry and protect the electronics from corrosion, check/replace the desiccant bag in its compartment regularly. It is recommended to check once per year and change every two years. If suspicion of any moisture inside the enclosure, find the cause, dry it out and replace the desiccant bag. If sent to repair after damage from moisture, please remove both main batteries and the backup battery to minimize damage.
- If the backup battery drops below 2.6 V, a warning message will be communicated. For replacement of the backup battery, send the instrument to Sigicom.
- If repair is required, please contact Sigicom prior to sending the instrument in for repair

10 Contact and Support

Web: http://www.sigicom.com

Support page with detailed
information about all instruments: http://support.sigicom.com/infra

World-wide Support:
Phone: +46 8 44 99 770
Email: support@sigicom.com

Sweden:
Sigicom AB
Glasfibergatan 8
SE-125 45 ÄLVSJÖ
Phone: +46 8 4499750
Email: info@sigicom.com

France:
Sigicom SARL
3 bis, impasse Bagatelle
14000 CAEN
Phone: +33 2 31 94 66 04
Email: info@sigicom.fr

UK:
Sigicom Ltd.
19 Oakhurst Business Park Wilberforce Way
Horsham RH13 9RT, UK
Phone: +44 0 1403 595020
Email: info@sigicom.co.uk

USA:
Sigicom Inc
2636 Midpoint Drive Ste B
Fort Collins, CO 80525
Phone: +1 970 493-1552
Email: info@sigicom.us

Canada:
Sigicom Canada Inc.
350 Palladium Dr Suite 104
Ottawa, ON K2V 1A8
Phone: +1 613 238 3232
Email: info@sigicom.ca

Appendix A. Battery Level Limits

Monitoring is stopped, and the system turns off automatically if the battery state of charge falls to the BAT EMPTY level. For automatic restart of monitoring, a higher level or external power is needed.

The reason for this shut-down mechanism is to prevent data loss and to protect the batteries from permanent damages.

Falling voltage:	**SOC**[10]	**Display symbol**
BAT FULL => BAT NORMAL	95%	green scale
BAT NORMAL => BAT LOW	15%	yellow scale
BAT LOW => BAT CRITICAL	5%	red scale, ticked
BAT CRITICAL => BAT EMPTY	0%	red outline
Rising voltage:		
BAT EMPTY => BAT CRITICAL	2%	red ticked scale, ticked outline
BAT CRITICAL => BAT LOW	7%	yellow scale, ticked outline
BAT LOW => BAT NORMAL	17%	green scale
BAT NORMAL => BAT FULL	97%	green full scale

If one of the two batteries is removed, the indicated SOC level will be halved and the warning message “BATTERY LOST” will be communicated.

If the SOC level of the two batteries differs more than 15%, the warning message “UNBALANCED” will be communicated.

Service messages are sent when the SOC level falls below the BAT LOW or BAT CRITICAL levels.

For replacement of the backup battery, send the instrument to Sigicom.

[10] SOC = State-Of-Charge (a combined state of charge of the two batteries).

Appendix B. Li-Ion Battery Transport

Air transport of Li-Ion batteries or equipment with installed Li-Ion batteries is regulated as dangerous goods by IATA and UN.

The shipping operator may also have their own regulations.

The shipper is always responsible for the transport and its documentation.

Regulations are updated annually or more frequently.

For more information about shipping and travelling with Li-Ion batteries, please see Sigicom Support page.

Transport of C22 with batteries installed:

- Before air transport, set the C22 in “disabled communication” (Flight mode), then select “Power off” via “Settings and actions” in the graphical user interface
- Make sure that the equipment is packed in such a way that the instrument does not start up during transport
- Use original packaging material, an INFRA C2x transport case (see chapter 8 Accessories) or similar

A battery identified as being defective by safety means:

- Transport by Air is **prohibited** according to the IATA Special Provision A154
- Follow safety instruction for Li-Ion batteries in the beginning of this manual
- Call Sigicom for consultation before any transportation

Note! Worn out batteries are forbidden in air transport.

Appendix C. Safe Handling of Li-Ion Batteries

Preparing your office for safe handling of Li-Ion batteries:

- Separate battery warehouse from the site where charging is taking place.
- Keep batteries in its original inner packaging or equivalent at the warehouse. Also, separate batteries from each other to prevent a burning battery from igniting adjacent batteries.
- Only charge during office hours (use mains timer).
- Make sure that charger is standing firmly at the table and are not in danger of falling to the floor during charging.
- Have foam extinguisher, CO_2 or ABC dry chemical available on sites where batteries are handled regularly.
- Have fire alarms on sites where batteries are handled regularly.
- Have a metallic bucket half filled with sand available to put batteries into in case of a burning battery.
- Interpret the "In case of Li-Ion battery fire" instruction example into all local languages used in the office.
- Place the safety instruction easily seen in all sites where batteries are handled.
- Inform personnel about the instruction.
- Report all safety related events to management.

Reference: http://batteryuniversity.com/learn/article/safety_concerns_with_li_ion

Appendix D. In Case of Li-Ion Battery Fire

IN CASE OF FIRE IN CHARGABLE LITHIUM-ION BATTERY

IF THE FIRE CANNOT BE EXTINGUISHED OR KEPT SAFE
- ACTIVATE THE OFFICE FIRE ROUTINES

SEEK ATTENTION TO A COLLEAGUE FOR STANDING BY WHILE HANDLING THE FIRE

REMOVE POWER FROM CHARGER

REMOVE THE BATTERY FROM CHARGER, DEVICE OR COMBUSTABLE MATERIAL

PLACE THE BATTERY IN SAND FILLED BUCKET, PLACE OUTSIDE IF POSSIBLE

USE FIRE EXTINGUISHER

WATER IS OK IF NO OTHER KIND OF FIRE EXTINGUISHER IS AVAILABLE

PUT SEEMINGLY BURNED-OUT BATTERY OUTSIDE FOR A TIME

Appendix E. Errors and Warnings

The table below lists some of the errors and warnings:

Code	Error/warning text	Comment/tip
E10	Battery level low	Charge the battery
E11	Battery level critical	Charge the battery
E12	Battery level empty	Charge the battery
E14	Battery imbalance	No problem, will balance out.
E16	Battery temperature high	Contact Sigicom Support
E18	Battery is missing	Check that both batteries are installed
E19	Backup battery low	Contact Sigicom Support
E43	Sensor test error	Check that the instrument is correctly aligned. If it is, contact Sigicom Support.
E81	Monitoring started automatically	After instrument reboot
E86	Instrument alignment incorrect	The instrument shall be mounted horizontally
E90	Real-time clock not synchronized	Check instrument clock[11]
E91	Real-time clock poorly synchronized	Check instrument clock and set if it differs two seconds or more.
E100/1	Temperature alarms	Cool down the instrument
E102	Instrument humidity warning	Check that all screws of the instrument lid are tightened
E110	File system failure	Format the SD-card

Table continuous on the next page.

[11] Is set if instrument time differs two seconds or more from correct time, see section 0

E111	Many spool files on memory card	Connect to the server so the files can be upload
E113	Slow file handling	Format the SD-card
E114	SD-card is full	Connect to the server so the files can be upload
E115	Slow file opening	Format the SD-card
E116	SD-card is almost full	Connect to the server so the files can be upload

Appendix F. Measurement Standards

Frequency: is saved as an additional interval channel per direction.
Resultant: is only calculated when frequency weighting is OFF, and is saved as an additional interval channel. This also applies for triggering on resultant.

Standard	Name	Frequency	Frequency weighting	Resultant (* - no trig on res.)	Level range	Frequency range
S1A	SS 4604866 Spräng	No	No	No	250 mm/s	5 – 300 Hz
S1B	SS 4604866 Spräng	No	No	No	25 mm/s	5 – 300 Hz
S3	SS 025211 Schakt	No	No	No	25 mm/s	5 – 150 Hz
S5	SS 025211 Schakt	No	No	No	25 mm/s	2 – 150 Hz
S7	SS 4604861 Komfort RMS 1s	Yes	No	No	20 mm/s	1 – 80 Hz
S8	SS 4604861 Komfort RMS 1s	Yes	No	No	700 mm/s^2	1 – 80 Hz
S9	DIN 4150-2 KB RMS 125 ms	Yes	No	No	20 mm/s	1 – 80 Hz
S15	ÖNORM S 9012, RMS 1s	Yes	No	No	700 mm/s^2	1 – 80 Hz
S16A	ISO 8569 Acceleration	No	No	No	125 m/s^2	5 – 300 Hz
S16B	ISO 8569 Acceleration	No	No	No	12.5 m/s^2	5 – 300 Hz
S17	ISO 10816-2 RMS 1s	Yes	No	No	200 mm/s	5 – 500 Hz
S18A	DIN 4150-3 Anlage	Yes	Yes	No	250 mm/s	1 – 315 Hz
S18B	DIN 4150-3 Anlage	Yes	Yes	No	25 mm/s	1 – 315 Hz
S20A	NS 8141:2001 Byggverk	No	No	No	250 mm/s	5 – 300 Hz
S20B	NS 8141:2001 Byggverk	No	No	No	25 mm/s	5 – 300 Hz
S22	NS 8176 Komfort RMS 1s	Yes	No	No	20 mm/s	1 – 80 Hz
S23A	NS 8141-1:2022 Byggverk	No	No	No	250 mm/s	2 – 400 Hz

Table continues on the next page.

Standard	Name	Frequency	Frequency weighting	Resultant (* - no trig on res.)	Level range	Frequency range
S23B	NS 8141-1:2022 Byggverk	No	No	No	25 mm/s	2 – 400 Hz
S25A	NS 8141:2013 Byggverk	No	No	No	250 mm/s	3 – 400 Hz
S25B	NS 8141:2013 Byggverk	No	No	No	25 mm/s	3 – 400 Hz
S27	ISO 2631-2 RMS 1s	Yes	No	No	20 mm/s	1 – 80 Hz
S28A	SN 640312a	Yes	Yes	Yes	250 mm/s	5 – 150 Hz
S28B	SN 640312a	Yes	Yes	Yes	25 mm/s	5 – 150 Hz
S30A	BS 7385	Yes	No	Yes	250 mm/s	1 – 300 Hz
S30B	BS 7385	Yes	No	Yes	25 mm/s	1 – 300 Hz
S33	ANSI S2.71 RMS 1s	Yes	No	No	20 mm/s	1 – 80 Hz
S35	AS 2187.2-2006	Yes	No	Yes	250 mm/s	2 – 250 Hz
S38A	ÖNORM S 9020	Yes	Np	Yes	250 mm/s	1 – 315 Hz
S38B	ÖNORM S 9020	Yes	No	Yes	25 mm/s	1 – 315 Hz
S40	Arrêté du 1994	Yes	Yes	Yes *	250 mm/s	1 – 150 Hz
S41	ICPE-Circ86	Yes	Yes	Yes	25 mm/s	1 – 150 Hz
S42A	IN 1226	Yes	Yes	Yes	250 mm/s	1 – 150 Hz
S42B	IN 1226	Yes	Yes	Yes	25 mm/s	1 – 150 Hz
S44	OfM 9/1997 RMS 1s	Yes	No	No	50-117 dB (rel. 1 μm/s²)	1 – 80 Hz
S45	Turkey Mining and Quarry	No	No	Yes	250 mm/s	2 – 250 Hz
S46A	SBR-A:2010	Yes	Yes	No	250 mm/s	1 – 100 Hz
S46B	SBR-A:2010	Yes	Yes	No	25 mm/s	1 – 100 Hz
S47	SBR-B Comfort RMS 125ms	Yes	Yes	No	20 mm/s	1 – 80 Hz
S48	Toronto bylaw 514	Yes	Yes	No	250 mm/s	2 – 250 Hz
S49	Toronto bylaw 514	Yes	Yes	No	250 mm/s	1 – 100 Hz

Table continues on the next page.

Standard	Name	Frequency	Frequency weighting	Resultant (* - no trig on res.)	Level range	Frequency range
S51A	ISEE Seismograph	Yes	Yes	Yes	10 in/s	2 – 250 Hz
S51B	ISEE Seismograph	Yes	Yes	Yes	1 in/s	2 – 250 Hz
S53A	Geophone	No	No	No	250 mm/s	5 – 500 Hz
S53B	Geophone	No	No	No	25 mm/s	5 – 500 Hz
S55A	ISEE/USBM	Yes	Yes	Yes	250 mm/s	2 – 250 Hz
S55B	ISEE/USBM	Yes	Yes	Yes	25 mm/s	2 – 250 Hz
S57A	DIN 4150-3 Anlage	Yes	No	No	10 in/s	1 – 315 Hz
S57B	DIN 4150-3 Anlage	Yes	No	No	1 in/s	1 – 315 Hz
S58A	PN-B-02170	Yes	Yes	No	250 mm/s	1 – 100 Hz
S58B	PN-B-02170	Yes	Yes	No	25 mm/s	1 – 100 Hz
S59	FTA VdB RMS 1s	Yes	No	No	50-118 dB (rel.1 µin/s)	1 – 80 Hz
S60A	NCh 3577	Yes	Yes	No	250 mm/s	1 – 315 Hz
S60B	NCh 3577	Yes	Yes	No	25 mm/s	1 – 315 Hz
S70A	BS 6841	No	No	No	125 m/s^2	(VDV)[12]
S70B	BS 6841	No	No	No	12.5 m/s^2	(VDV)
S71A	BS 7385 & 6841 (VDV)	Yes	No	Yes *	250 mm/s	1 – 300 Hz
S71B	BS 7385 & 6841 (VDV)	Yes	No	Yes *	25 mm/s	1 – 300 Hz
S72	Metro Vancouver	Yes	Yes	No	250 mm/s	3-100 Hz
S73	NP-2074:2015	Yes	Yes	Yes	250 mm/s	2-80 Hz
S74A	SBR-A:2017 struc. C1	Yes	Yes[13]	No	250 mm/s	1 – 100 Hz
S74B	SBR-A:2017 struc. C2	Yes	Yes[13]	No	25 mm/s	1 – 100 Hz
S75A	SBR-A:2017 struc. C1 (adapted)	Yes	Yes[13]	No	250 mm/s	1 – 100 Hz
S75B	SBR-A:2017 struc. C2 (adapted)	Yes	Yes[13]	No	25 mm/s	1 – 100 Hz

[12] Different depending on vertical or horizontal. See Appendix H for a detailed description.
[13] The frequency weightings for the standards are different from other standards. Please see Appendix G for detailed information.

1A. SS 4604866 Spräng

Vibration och stöt – Riktvärden för sprängningsinducerade vibrationer i byggnader.

Level and frequency ranges:	250 mm/s, 5-300 Hz.
Max resolution in presentation:	0.05 mm/s and 3 significant digits.
Threshold range:	0.4 – 220 mm/s.

1B. SS 4604866 Spräng

Vibration och stöt – Riktvärden för sprängningsinducerade vibrationer i byggnader.

Level and frequency ranges:	25 mm/s, 5-300 Hz.
Max resolution in presentation:	0.005 mm/s and 3 significant digits.
Threshold range:	0.04 – 22 mm/s.

3. SS 025211 Schakt

Vibration och stöt – Riktvärden för vibrationer i byggnader härrörande från pålning, spontning, schaktning och packning för bedömning av skaderisk.

Level and frequency ranges:	25 mm/s, 5-150 Hz.
Max resolution in presentation:	0.005 mm/s and 3 significant digits.
Threshold range:	0.04 – 22 mm/s.

5. SS 025211 Schakt

Vibration och stöt – Riktvärden för vibrationer i byggnader härrörande från pålning, spontning, schaktning och packning för bedömning av skaderisk.

Level and frequency ranges:	25 mm/s, 2-150 Hz.
Max resolution in presentation:	0.005 mm/s and 3 significant digits.
Threshold range:	0.04 – 22 mm/s.

7. SS 4604861 Komfort

Vibration och stöt – Mätning och riktvärden för bedömning av komfort i byggnader.

Level and frequency ranges:	20 mm/s, RMS, 1-80 Hz. Filtered according to ISO 2631-2, time constant 1 s.
Max resolution in presentation:	0.005 mm/s RMS and 3 significant digits.
Threshold range:	0.04 – 15 mm/s.

8. SS 4604861 Komfort

Vibration och stöt – Mätning och riktvärden för bedömning av komfort i byggnader.

Level and frequency ranges:	700 mm/s^2, RMS, 1-80 Hz. Filtered according to ISO 2631-2, time constant 1 s.
Max resolution in presentation:	0.1 mm/s^2 RMS and 3 significant digits.
Threshold range:	1 – 550 mm/s^2.

9. DIN 4150-2 KB
Erschütterungen im Bauwesen – Teil 2: Einwirkungen auf Menschen in Gebäuden.

Level and frequency ranges:	20 mm/s, RMS, 1-80 Hz.
	Filtered according to ISO 2631-2, time constant 125 ms.
Max resolution in presentation:	0.005 mm/s RMS and 3 significant digits.
Threshold range:	0.04 – 15 mm/s.

15. ÖNORM S 9012
Beurteilung der Einwirkung von Schwingungsimmissionen des landgebundenen Verkehrs auf den Menschen in Gebäuden — Schwingungen und sekundärer Luftschall.

Level and frequency ranges:	700 mm/s^2, RMS, 1-80 Hz.
	Filtered according to ISO 2631-2, time constant 1 s.
Max resolution in presentation:	0.1 mm/s^2 RMS and 3 significant digits.
Threshold range:	1 – 550 mm/s^2.

16A. ISO 8569 Acceleration
Mechanical vibration and shock – Measurement and evaluation of shock and vibration effects on sensitive equipment in buildings.

Level and frequency ranges:	125 m/s^2, 5-300 Hz.
Max resolution in presentation:	0.01 m/s^2 and 3 significant digits.
Threshold range:	0.1 – 110 m/s^2.

Note! The stated level range is only valid at 80Hz because the sensor elements measure velocity. At lower frequencies the level range is lower, it is for example 25 m/s^2 at 16 Hz. Above 80Hz the level range is higher.

16B. ISO 8569 Acceleration
Mechanical vibration and shock – Measurement and evaluation of shock and vibration effects on sensitive equipment in buildings.

Level and frequency ranges:	12.5 m/s^2, 5-300 Hz.
Max resolution in presentation:	0.001 m/s^2 and 3 significant digits.
Threshold range:	0.04 – 11 m/s^2.

Note! The stated level range is only valid at 80Hz because the sensor elements measure velocity. At lower frequencies the level range is lower, it is for example 2.5 m/s^2 at 16 Hz. Above 80Hz the level range is higher.

18A. DIN 4150-3 Anlage
Erschütterungen im Bauwesen – Teil 3: Einwirkungen auf bauliche Anlage.

Level and frequency ranges:	250 mm/s, 1-315 Hz.
Max resolution in presentation:	0.05 mm/s and 3 significant digits.
Threshold range:	0.4 – 220 mm/s.

18B. DIN 4150-3 Anlage

Erschütterungen im Bauwesen – Teil 3: Einwirkungen auf bauliche Anlage.

Level and frequency ranges:	25 mm/s, 1-315 Hz.
Max resolution in presentation:	0.005 mm/s and 3 significant digits.
Threshold range:	0.04 – 22 mm/s.

20A. NS 8141:2001 Byggverk

Vibrasjoner og støt - Måling av svingehastighet og beregning av veiledende grenseverdier for å unngå skade på byggverk.

Level and frequency ranges:	250 mm/s, 5-300 Hz.
Max resolution in presentation:	0.05 mm/s and 3 significant digits.
Threshold range:	0.4 – 220 mm/s.

20B. NS 8141:2001 Byggverk

Vibrasjoner og støt - Måling av svingehastighet og beregning av veiledende grenseverdier for å unngå skade på byggverk.

Level and frequency ranges:	25 mm/s, 5-300 Hz.
Max resolution in presentation:	0.005 mm/s and 3 significant digits.
Threshold range:	0.04 – 22 mm/s.

22. NS 8176 Komfort

Vibrasjoner og støt - Måling i bygninger av vibrasjoner fra landbasert samferdsel og veiledning for bedømmelse av virkning på mennesker.

Level and frequency ranges:	20 mm/s RMS, 1-80 Hz. Filtered according to ISO 2631-2, time constant 1 s.
Max resolution in presentation:	0.005 mm/s RMS and 3 significant digits.
Threshold range:	0.04 – 15 mm/s .

23A. NS 8141-1:2022 Byggverk

Vibrasjoner og støt - Måling av svingehastighet og beregning av veiledende grenseverdier for å unngå skade på byggverk.

Level and frequency ranges:	250 mm/s, 2-400 Hz.
Max resolution in presentation:	0.05 mm/s and 3 significant digits.
Threshold range:	0.4 – 220 mm/s.

23B. NS 8141-1:2022 Byggverk

Vibrasjoner og støt - Måling av svingehastighet og beregning av veiledende grenseverdier for å unngå skade på byggverk.

Level and frequency ranges:	25 mm/s, 2-400 Hz.
Max resolution in presentation:	0.005 mm/s and 3 significant digits.
Threshold range:	0.04 – 22 mm/s.

25A. NS 8141:2013 Byggverk
Vibrasjoner og støt - Veiledende grenseverdier for bygge- og anleggsvirksomhet, bergverk og trafikk - Del 1: Virkning av vibrasjoner og lufttrykkstøt fra sprengning på byggverk, inkludert tunneler og bergrom.

Level and frequency ranges:	250 mm/s, 3-400 Hz.
Max resolution in presentation:	0.05 mm/s and 3 significant digits.
Threshold range:	0.4 – 220 mm/s.

25B. NS 8141:2013 Byggverk
Vibrasjoner og støt - Veiledende grenseverdier for bygge- og anleggsvirksomhet, bergverk og trafikk - Del 1: Virkning av vibrasjoner og lufttrykkstøt fra sprengning på byggverk, inkludert tunneler og bergrom.

Level and frequency ranges:	25 mm/s, 3-400 Hz.
Max resolution in presentation:	0.005 mm/s and 3 significant digits.
Threshold range:	0.04 – 22 mm/s.

27. ISO 2631-2
Human exposure to mechanical vibration and shock.

Level and frequency ranges:	20 mm/s, RMS, 1-80 Hz. Filtered according to ISO 2631-2, time constant 1 s.
Max resolution in presentation:	0.005 mm/s RMS and 3 significant digits.
Threshold range:	0.04 – 15 mm/s.

28A. SN 640312a
Erschütterungseinwirkungen auf Bauwerke.

Level and frequency ranges:	250 mm/s, 5-150 Hz.
Max resolution in presentation:	0.05 mm/s and 3 significant digits.
Threshold range	0.4 – 220 mm/s.

28B. SN 640312a
Erschütterungseinwirkungen auf Bauwerke.

Level and frequency ranges:	25 mm/s, 5-150 Hz.
Max resolution in presentation:	0.005 mm/s and 3 significant digits.
Threshold range	0.04 – 22 mm/s.

30A. BS 7385
Evaluation and measurement for vibration in buildings - Part 2: Guide to damage levels from ground-borne vibration.

Level and frequency ranges:	250 mm/s, 1-300 Hz.
Max resolution in presentation:	0.05 mm/s and 3 significant digits.
Threshold range:	0.4 – 220 mm/s.

Sigicom

30B. BS 7385

Evaluation and measurement for vibration in buildings - Part 2: Guide to damage levels from ground-borne vibration.

Level and frequency ranges:	25 mm/s, 1-300 Hz.
Max resolution in presentation:	0.005 mm/s and 3 significant digits.
Threshold range:	0.04 – 22 mm/s.

33. ANSI S2.71

Guide to the Evaluation of Human Exposure to Vibration in Buildings.

Level and frequency ranges:	0.8 in/s, RMS, 1-80 Hz. Filtered according to ISO 2631-2, time constant 1 s.
Max resolution in presentation:	0.0001 in/s RMS and 3 significant digits.
Threshold range:	0.001 – 0.75 in/s.

35. AS 2187.2-2006

Explosives - Storage, transport and use - Use of explosives.

Level and frequency ranges:	250 mm/s, 2-250 Hz.
Max resolution in presentation:	0.05 mm/s and 3 significant digits.
Threshold range:	0.4 – 220 mm/s.

38A. ÖNORM S 9020

Beurteilung der Einwirkung von Schwingungsimmissionen des landgebundenen Verkehrs auf den Menschen in Gebäuden — Schwingungen und sekundärer Luftschall.

Level and frequency ranges:	250 mm/s, 1-315 Hz.
Max resolution in presentation:	0.05 mm/s and 3 significant digits.
Threshold range:	0.4 – 220 mm/s.

38B. ÖNORM S 9020

Beurteilung der Einwirkung von Schwingungsimmissionen des landgebundenen Verkehrs auf den Menschen in Gebäuden — Schwingungen und sekundärer Luftschall.

Level and frequency ranges:	25 mm/s, 1-315 Hz.
Max resolution in presentation:	0.005 mm/s and 3 significant digits.
Threshold range:	0.04 – 22 mm/s.

40. Arrêté du 1994

Arrêté du 22 septembre 1994 relatif aux exploitations de carrières et aux installations de premier traitement des matériaux de carriers.

Level and frequency ranges:	250 mm/s, 1-150 Hz.
Max resolution in presentation:	0.05 mm/s and 3 significant digits.
Threshold range:	0.4 – 220 mm/s.

41. ICPE-Circ86

French standard ICPE Circulaire du 23/07/86.

Level and frequency ranges:	25 mm/s, 1-150 Hz.
Max resolution in presentation:	0.005 mm/s and 3 significant digits.
Threshold range:	0.04 – 22 mm/s.

42A. IN 1226

French standard IN 1226.

Level and frequency ranges:	250 mm/s, 1-150 Hz.
Max resolution in presentation:	0.05 mm/s and 3 significant digits.
Threshold range:	0.4 – 220 mm/s.

42B. IN 1226

French standard IN 1226.

Level and frequency ranges:	25 mm/s, 1-150 Hz.
Max resolution in presentation:	0.005 mm/s and 3 significant digits.
Threshold range:	0.04 – 22 mm/s.

44. OfM 9/1997

Orientation fra Miljøstyrelsen Nr. 9 1997 - Lavfrekvent støj, infralyd og vibrationer i externt miljø.

Level and frequency ranges:	50 - 117 dB (rel. 10^{-3} mm/s^2), RMS, 1-80 Hz. Filtered according to ISO 2631-2, time constant 1 s.
Max resolution in presentation:	0.1 dB and 3 significant digits.
Threshold range:	60-115 dB.
Transient file resolution:	1 mm/s^2.

45. Turkey – Mining and Quarry

Same as standard 55A.

Level and frequency ranges:	250 mm/s, 2-250 Hz.
Max resolution in presentation:	0.05 mm/s and 3 significant digits.
Threshold range:	0.4 – 220 mm/s.

46A. SBR-A:2010

Level and frequency ranges:	250 mm/s, 1-100 Hz.
Max resolution in presentation:	0.05 mm/s and 3 significant digits.
Threshold range:	0.4 – 220 mm/s.

46B. SBR-A:2010

Level and frequency ranges:	25 mm/s, 1-100 Hz.
Max resolution in presentation:	0.005 mm/s and 3 significant digits.
Threshold range:	0.04 – 22 mm/s.

47. SBR-B

Level and frequency ranges: 20 mm/s, RMS, 1-80 Hz.
Filtered according to ISO 2631-2, time constant 125 ms.
Max resolution in presentation: 0.005 mm/s RMS and 3 significant digits.
Threshold range: 0.04 – 15 mm/s.

48. Toronto bylaw 514

Level and frequency ranges: 250 mm/s, 2-250 Hz.
Max resolution in presentation: 0.05 mm/s and 3 significant digits.
Threshold range: 0.4 – 220 mm/s.

49. Toronto bylaw 514

Level and frequency ranges: 250 mm/s, 1-100 Hz.
Max resolution in presentation: 0.05 mm/s and 3 significant digits.
Threshold range: 0.4 – 220 mm/s.

51A. ISEE Seismograph

ISEE - Performance specifications for blasting seismographs.
Level and frequency ranges: 10 in/s, 2-250 Hz.
Max resolution in presentation: 0.002 in/s and 3 significant digits.
Threshold range: 0.02 – 9 in/s.

51B. ISEE Seismograph

ISEE - Performance specifications for blasting seismographs.
Level and frequency ranges: 1 in/s, 2-250 Hz.
Max resolution in presentation: 0.0002 in/s and 3 significant digits.
Threshold range: 0.002 – 0.9 in/s.

53A. Geophone

Unfiltered geophone signal. Upper frequency limit 500 Hz.
Level and frequency ranges: 250 mm/s, 5-500 Hz.
Max resolution in presentation: 0.05 mm/s and 3 significant digits.
Threshold range: 0.4 – 220 mm/s.

53B. Geophone

Unfiltered geophone signal. Upper frequency limit 500 Hz.
Level and frequency ranges: 25 mm/s, 5-500 Hz.
Max resolution in presentation: 0.005 mm/s and 3 significant digits.
Threshold range: 0.04 – 22 mm/s.

55A. ISEE/USBM

Same as standard 51A, ISEE standard, but in SI units.
Level and frequency ranges: 250 mm/s, 2-250 Hz.
Max resolution in presentation: 0.05 mm/s and 3 significant digits.
Threshold range: 0.4 – 220 mm/s.

55B. ISEE/USBM
Same as standard 51B, ISEE standard, but in SI units.

Level and frequency ranges:	25 mm/s, 2-250 Hz.
Max resolution in presentation:	0.005 mm/s and 3 significant digits.
Threshold range:	0.04 – 22 mm/s.

57A. DIN 4150-3 Anlage (US-units)
Erschütterungen im Bauwesen – Teil 3: Einwirkungen auf bauliche Anlage.

Level and frequency ranges:	10 in/s, 1-315 Hz.
Max resolution in presentation:	0.002 in/s and 3 significant digits.
Threshold range:	0.02 – 9 in/s.

57B. DIN 4150-3 Anlage (US-units)
Erschütterungen im Bauwesen – Teil 3: Einwirkungen auf bauliche Anlage.

Level and frequency ranges:	1 in/s, 1-315 Hz.
Max resolution in presentation:	0.0002 in/s and 3 significant digits.
Threshold range:	0.002 – 0.9 in/s.

58A. PN-B-02170
Harmfulness assessments of vibrations transmitted by the foundation to buildings.

Level and frequency ranges:	250 mm/s, 1-100 Hz.
Max resolution in presentation:	0.05 mm/s and 3 significant digits.
Threshold range:	0.4 – 220 mm/s.

58B. PN-B-02170
Harmfulness assessments of vibrations transmitted by the foundation to buildings.

Level and frequency ranges:	25 mm/s, 1-100 Hz.
Max resolution in presentation:	0.005 mm/s and 3 significant digits.
Threshold range:	0.04 – 22 mm/s.

59. FTA VdB
Federal Transport Administration (USA)

Level and frequency ranges:	50 - 118 dB (rel. 10^{-6} in/s), RMS, 1-80 Hz. Filtered according to ISO 2631-2, time constant 1 s.
Max resolution in presentation:	0.1 dB and 3 significant digits.
Threshold range:	60-115 dB. Transient file resolution: 0.002 in/s.

60A. NCh 3577
Metodología para evaluar las vibraciones producidas por voladuras sobre infraestructuras.

Level and frequency ranges:	250 mm/s, 1-315 Hz.
Max resolution in presentation:	0.05 mm/s and 3 significant digits.
Threshold range:	0.4 – 220 mm/s.

60B. NCh 3577
Metodología para evaluar las vibraciones producidas por voladuras sobre infraestructuras.
Level and frequency ranges: 25 mm/s, 1-315 Hz.
Max resolution in presentation: 0.005 mm/s and 3 significant digits.
Threshold range: 0.04 – 22 mm/s.

70A. BS 6841
Acceleration standard including channels for VDV (Vibration Dose Value).
See Appendix H for further description.
Level and frequency ranges: 125 m/s^2.
Max resolution in presentation: 10^{-4} $m/s^{1.75}$ and 3 significant digits.
Threshold range: 0.1 – 110 $m/s^{1.75}$.

70B. BS 6841
Acceleration standard including channels for VDV (Vibration Dose Value).
See Appendix H for further description.
Level and frequency ranges: 12.5 m/s^2.
Max resolution in presentation: 10^{-4} $m/s^{1.75}$ and 3 significant digits.
Threshold range: 0.04 – 11 $m/s^{1.75}$.

71A. BS 7385 & 6841(VDV)
Evaluation and measurement for vibration in buildings - Part 2: Guide to damage levels from ground-borne vibration. In addition the interval channels VDV and VDV-accu are calculated (*see Appendix H*).
Level and frequency ranges: 250 mm/s, 1-300 Hz.
Max resolution in presentation: 0.05 mm/s and 3 significant digits.
Threshold range: 0.4 – 220 mm/s.

71B. BS 7385 & 6841(VDV)
Evaluation and measurement for vibration in buildings - Part 2: Guide to damage levels from ground-borne vibration. In addition the interval channels VDV and VDV-accu are calculated (*see Appendix H*).
Level and frequency ranges: 25 mm/s, 1-300 Hz.
Max resolution in presentation: 0.005 mm/s and 3 significant digits.
Threshold range: 0.04 – 22 mm/s.

72. Metro Vancouver
Proximal Work Requirements - Metro Vancouver Water and Liquid Waste system Facilities. Version 2.0:2019.
Level and frequency ranges: 250 mm/s, 3-100 Hz.
Max resolution in presentation: 0.05 mm/s and 3 significant digits.
Threshold range: 0.4 – 220 mm/s.

73. NP-2074:2015
Avaliação da influência de vibrações impulsivas em estruturas.
Level and frequency ranges: 250 mm/s, 2-80 Hz.
Max resolution in presentation: 0.05 mm/s and 3 significant digits.
Threshold range: 0.4 – 220 mm/s.

74A. SBR-A:2017 Contructie Cat1
SBR Trillingsrichtlijn A: Schade aan bouwwerken: 2017
Level and frequency ranges: 250 mm/s, 1-100 Hz.
Max resolution in presentation: 0.05 mm/s and 3 significant digits.
Threshold range: 0.4 – 220 mm/s.

74B. SBR-A:2017 Contructie Cat2
SBR Trillingsrichtlijn A: Schade aan bouwwerken: 2017
Level and frequency ranges: 25 mm/s, 1-100 Hz.
Max resolution in presentation: 0.005 mm/s and 3 significant digits.
Threshold range: 0.04 – 22 mm/s.

75A. SBR-A:2017 Contructie Cat1 (Adapted)
SBR Trillingsrichtlijn A: Schade aan bouwwerken: 2017
Level and frequency ranges: 250 mm/s, 1-100 Hz.
Max resolution in presentation: 0.05 mm/s and 3 significant digits.
Threshold range: 0.4 – 220 mm/s.

75B. SBR-A:2017 Contructie Cat2 (Adapted)
SBR Trillingsrichtlijn A: Schade aan bouwwerken: 2017
Level and frequency ranges: 25 mm/s, 1-100 Hz.
Max resolution in presentation: 0.005 mm/s and 3 significant digits.
Threshold range: 0.04 – 22 mm/s.

Appendix G. Standards with Frequency Weighting

Some standards can be used with frequency weighting. If frequency weighting is disabled (OFF), a transient will be triggered if a peak becomes larger than the configured trigger level, independent of the frequency.

However, when frequency weighting is active, the trigger level will be referred to as a percentage-value, relative to the selected frequency weighting curve.

Different national standards define their own set of weighting curves. In the C22 you can set those in a sub parameter to the standard setting named “Frequency weighting”, or “Freq.wt” in the display. Please read respective national standards to find its weighting curves.

Note, that what we here call “weighting curves”, is actually a frequency dependent limit line, sometimes also named “Benchmark”.

Also, note that weighting in the C22 works differently from the INFRA “legacy” system, where the interval data is presented as absolute “pre-weighted” values, which should be compared to the absolute value limit at a nominal frequency.

Appendix G1 and G2 describes the most common type of weightings.

Appendix G3 describes the Standards 74A and 74B, SBR-A:2017, which is more complex by its use of safety factors, scaling both the measured values and the basic weighting curves Cat 1 and Cat 2.

The adapted versions of SBR-A (75A and 75B) are designed to meet customer adaptation to this standard and how it is used in field. The safety factor are in this case instead applied to the benchmarks and not on the reported vibration level (mm/s).

G1. Example with Standard 51

For standards 51A and 51B, there are two versions of frequency weighting, Drywall and Plaster, see Figure G1:

- Drywall: 0.75 in/s (4 – 15 Hz)
- Plaster: 0.50 in/s (2.6 – 10 Hz)

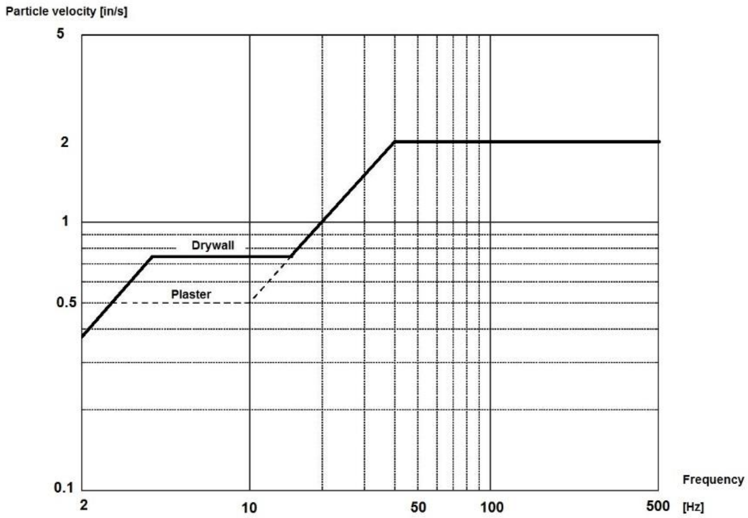


Figure G1. Frequency weighting curves for the standards S51A and S51B (ISEE Seismograph).

Example 1 (Drywall):
Suppose that selected trigger level is 100%. Then a transient will be triggered when for example:

- a signal (peak) is greater than 0.38 in/s and its frequency is 2 Hz
- a signal (peak) is greater than 0.75 in/s and its frequency is in the range 4 - 15 Hz
- a signal (peak) is greater than 2.0 in/s and its frequency is 40 Hz (or higher)

Example 2 (Drywall):
Suppose that selected trigger level is 50%. Then a transient will be triggered when for example:

- a signal (peak) is greater than 0.19 in/s and its frequency is 2 Hz
- a signal (peak) is greater than 0.38 in/s and its frequency is in the range 4 - 15 Hz
- a signal (peak) is greater than 1.0 in/s and its frequency is 40 Hz (or higher)

Example 3 (Plaster):
Suppose that selected trigger level is 100%. Then a transient will be triggered when for example:

- a signal (peak) is greater than 0.38 in/s and its frequency is 2 Hz
- a signal (peak) is greater than 0.5 in/s and its frequency is in the range 2.6 - 10 Hz
- a signal (peak) is greater than 2.0 in/s and its frequency is 40 Hz (or higher)

Example 4 (Plaster):
Suppose that selected trigger level is 200%. Then a transient will be triggered when for example:

- a signal (peak) is greater than 0.76 in/s and its frequency is 2 Hz
- a signal (peak) is greater than 1.0 in/s and its frequency is in the range 2.6 - 10 Hz
- a signal (peak) is greater than 4.0 in/s and its frequency is 40 Hz (or higher)

G2. Example with other standards

Taking the example in G1 for the Standards 18A and 18B, DIN 4150-3, the same principles will hold, but the two frequency weighting curves (Drywall and Plaster) shall be replaced by the Zeile curves displayed in Figure G2.

Figure G2. Frequency weighting curves for the standards S18A and S18B (DIN 4150-3).

This figure is copied from a Transient report in INFRA Net, where the different standard's frequency weighting curves can be displayed.

G3. SBR-A:2017

Note! The "Adapted" versions of SBR-A: 2017 (75A and 75B) are designed to meet customer adaptation to this standard. The "type of measurement" safety factors γ_v are in this case instead applied to the benchmarks and not on the reported measurement values. See G4.

SBR-A:2017 is different from other standards by focusing on absolute interval values compared to frequency dependent limit lines (weighting curves/ benchmarks). This forces the C22 implementation to send its data to INFRA Net little different than other standards.

- Main interval channel is the weighed absolute maximum value, compared to other standards giving the unweighted absolute max value
- The first frequency channel is a copy of the relative frequency channel where the weighed absolute maximum value was found, compared to other standards giving the frequency where the unweighted absolute max value was found

Relative value (in percent) and relative frequency channels are the same for all weighted standards.

Also, INFRA Net will not let the user select between weighing curves in the absolute value vs frequency graph. Instead, the weighting curve used in the INFRA C22 while measuring will be set automatically.

Note! Until "weighted" aggregation type is implemented in INFRA Net, you should avoid data reports using aggregation while using this standard.

Standard SBR-A:2017 uses three main categories, or basic weighting curves.

Unweighted, which is used for indoor measurements at the upper floor of the building

- Cat 1, which is mainly used for reinforced concrete or wood (S74A)
- Cat 2, which is mainly used for non-reinforced concrete, masonry or brittle stony materials (S74B)

In addition to the basic weighting curves, the standard specifies different safety factors, scaling both the measured values and the basic weighting curves.

In the C22, we have only implemented the most commonly used combinations, as weightings curves. Foundation (Fundering) type and short term vibration type (Kort) are not implemented.

There are three safety factor types:

- Type of measurement (type meering) γ_v
- Structure condition and monumental status (type Bouw) γ_s
- Type of vibration for structure (type Trill Contructie) γ_t

For each of these there is several scaling safety factor selections.

Safety factor γ_v is regarding type of measurement. This safety factor is used to scale up the measurement values.

Type of measurement	**Safety factor γ_v**
U, Uitgebreid (Comprehensive/extensive)	$\gamma_v = 1.0$
B, Beperkt (Limited)	$\gamma_v = 1.4$
I, Indicatief (Indicative)	$\gamma_v = 1.6$

Safety factors γ_t is related to the type of vibration sources and the architectural state. This safety factor is used to scale down the frequency dependent limit line.

Type of vibration	**Structure - Safety factor γ_t**

~~Kort (Short)~~ **NOT IMPLEMENTED**	~~$\gamma_t = 1.0$~~
HK, Herhaald Kortdurend (Repetitive short)	$\gamma_t = 1.5$
C, Continu (Continuously)	$\gamma_t = 2.5$

Safety factor γ_s is regarding structure condition and monumental status. This safety factor is used to scale down the frequency dependent limit line.

Structure condition and monumental status	**Safety factor** γ_s
GM, Gevoelig monumentaal (Sensitive structure condition and/or monument)	$\gamma_s = 1.7$
N, Normaal (Normal structure condition and no monument)	$\gamma_s = 1.0$

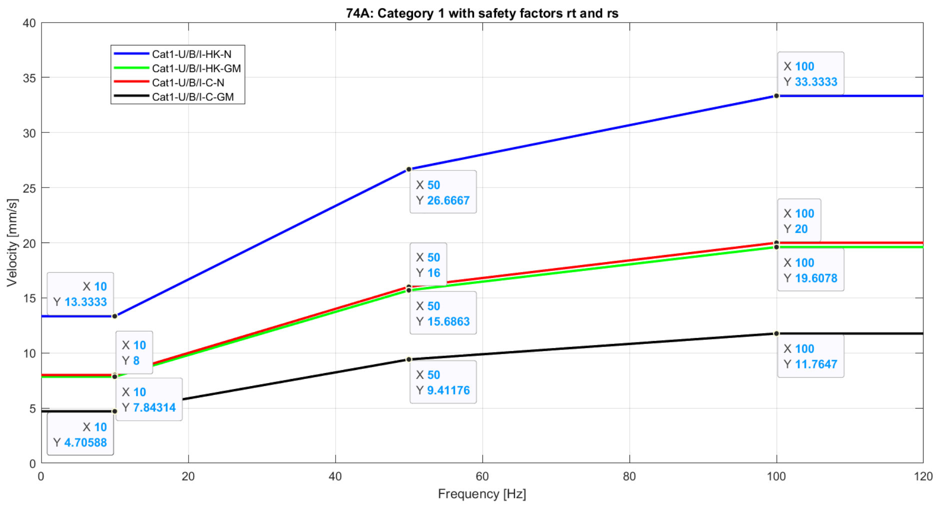
As follows are the detailed information about implemented weighting curves.

S74A: SBR-A:2017 struc. C1: (250 mm/s measurement range)			
Weighting short name	**Description**		**Note**
	Full name in Dutch	**Full name in English**	
Cat1_U_HK_N	Categorie 1_Uitgebreid_ Herhaald Kortdurend_ Normaal	Category 1_ comprehensive/ extensive_ repetitive short_ normal	No scaling with measurement data (safety factor of measurement type γ_v= 1.0)
Cat1_U_HK_ GM	Categorie 1_Uitgebreid_ Herhaald Kortdurend_ Gevoelig en/of monumentaal pand	Category 1_ comprehensive/ extensive_ repetitive short_ sensitive and/or monumental building	
Cat1_U_C_N	Categorie 1_Uitgebreid_ Continu_ Normaal	Category 1_ comprehensive/ extensive_ continuous _normal	
Cat1_U_C_GM	Categorie 1_Uitgebreid_ Continu_ Gevoelig en/of monumentaal pand	Category 1_ comprehensive /extensive_ continuous_ sensitive and/ or monumental building	
Cat1_B_HK_N	Categorie 1_Beperkt_ Herhaald Kortdurend_ Normaal	Category 1_ limited_ repetitive short_normal	The same benchmarks with the first four benchmarks, but with different measurement data (scaled with safety factor of measurement type γ_v= 1.4).
Cat1_B_HK_GM	Categorie 1_Beperkt_ Herhaald Kortdurend_ Gevoelig en/of	Category 1_limited_ repetitive short _sensitive and/	

	monumentaal pand	or monumental building	
Cat1_B_C_N	Categorie 1_Beperkt_ Continu_ Normaal	Category 1_ limited_ continuous_ normal	
Cat1_B_C_GM	Categorie 1_Beperkt_ Continu Gevoelig en/of monumental pand	Category 1_ limited_ continuous_ sensitive and/or monumental building	
Cat1_I_HK_N	Categorie 1_Indicatief_ Herhaald Kortdurend_ Normaal	Category 1_ Indicative_ repetitive short_normal	The same benchmarks with the first four benchmarks, but with different measurement data (scaled with safety factor of measurement type γ_v= 1.6).
Cat1_I_HK_GM	Categorie 1_Indicatief_ Herhaald Kortdurend_ Gevoelig en/of monumental pand	Category 1_ Indicative_ repetitive short_ sensitive and/ or monumental building	
Cat1_I_C_N	Categorie 1_Indicatief_ Continu_ Normaal	Category 1_Indicative_ continuous_ normal	
Cat1_I_C_GM	Categorie 1_Indicatief_ Continu_ Gevoelig en/of monumentaal pand	Category 1_ Indicative_ continuous_ sensitive and/ or monumental building	

Sigicom

Except of the data scaling by γ_v, there is actually only four different scalings:

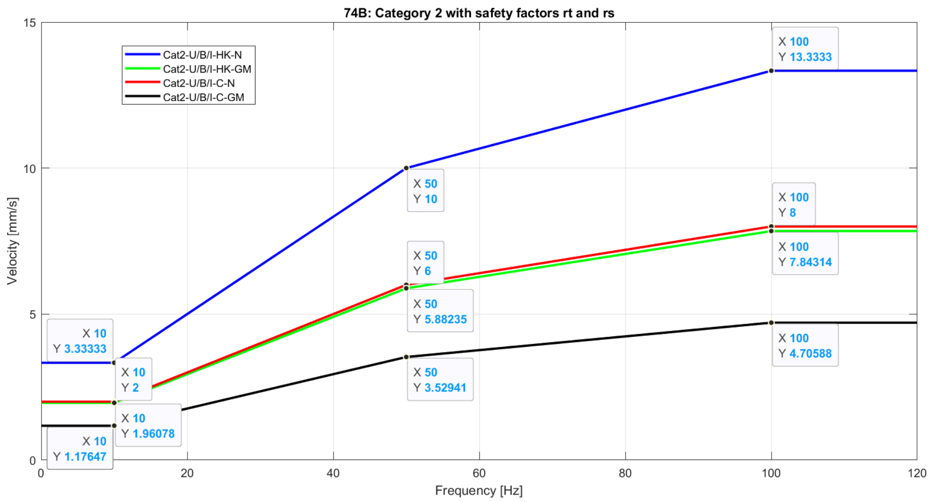


S74B: SBR-A:2017 struc. C2: (25 mm/s measurement range)			
Weighting short name	**Description**		**Note**
	Full name in Dutch	**Full name in English**	
Cat2_U_HK_N	Categorie 2_Uitgebreid_ Herhaald Kortdurend_ Normaal	Category 2_ comprehensive/ extensive_ repetitive short_ normal	No scaling with measurement data (safety factor of measurement type γ_v= 1.0)
Cat2_U_HK_ GM	Categorie 2_Uitgebreid_ Herhaald Kortdurend_ Gevoelig en/of monumentaal pand	Category 2_ comprehensive/ extensive_ repetitive short_ sensitive and/or monumental building	
Cat2_U_C_N	Categorie 2_Uitgebreid_ Continu_ Normaal	Category 2_ comprehensive/ extensive_ continuous _normal	

Cat2_U_C_GM	Categorie 2_Uitgebreid_ Continu_ Gevoelig en/of monumentaal pand	Category 2_ comprehensive /extensive_ continuous_ sensitive and/ or monumental building	
Cat2_B_HK_N	Categorie 2_Beperkt_ Herhaald Kortdurend_ Normaal	Category 2_ limited_ repetitive short_normal	The same benchmarks with the first four benchmarks, but with different measurement data (scaled with safety factor of measurement type γ_v= 1.4).
Cat2_B_HK_GM	Categorie 2_Beperkt_ Herhaald Kortdurend_ Gevoelig en/of monumentaal pand	Category 2_limited_ repetitive short _sensitive and/ or monumental building	
Cat2_B_C_N	Categorie 2_Beperkt_ Continu_ Normaal	Category 2_ limited_ continuous_ normal	
Cat1_B_C_GM	Categorie 1_Beperkt_ Continu Gevoelig en/of monumental pand	Category 1_ limited_ continuous_ sensitive and/or monumental building	
Cat2_I_HK_N	Categorie 2_Indicatief_ Herhaald Kortdurend_ Normaal	Category 2_ Indicative_ repetitive short_normal	The same benchmarks with the first four benchmarks, but with different measurement data (scaled with safety factor of measurement type γ_v= 1.6).
Cat2_I_HK_GM	Categorie 2_Indicatief_ Herhaald Kortdurend_ Gevoelig en/of monumental pand	Category 2_ Indicative_ repetitive short_ sensitive and/ or monumental building	

Cat2_I_C_N	Categorie 2_Indicatief_ Continu_ Normaal	Category 2_Indicative_ continuous_ normal	
Cat2_I_C_GM	Categorie 2_Indicatief_ Continu_ Gevoelig en/of monumentaal pand	Category 2_ Indicative_ continuous_ sensitive and/ or monumental building	

Except of the data scaling by γ_v, there is actually only four different scalings:



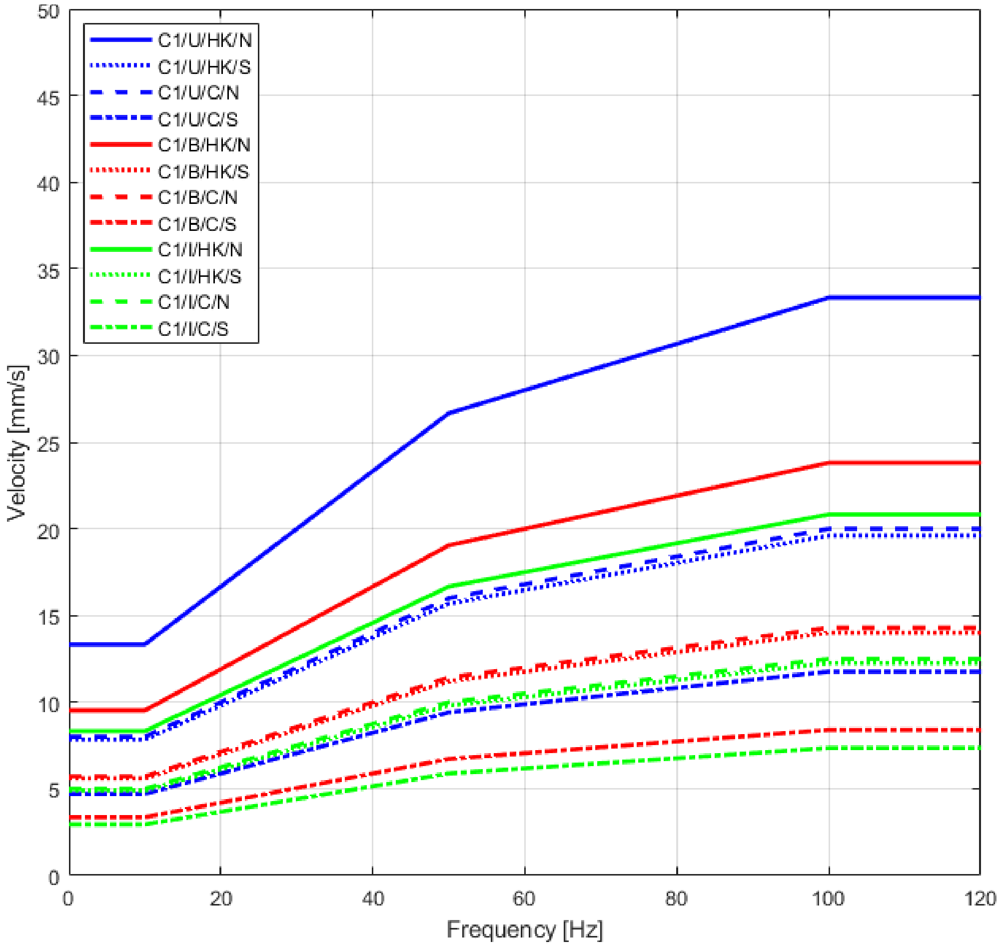
G4. SBR-A:2017 (Adapted)

Note! The “Adapted” versions of SBR-A: 2017 (75A and 75B) are designed to meet customer adaptation to this standard. The “type of measurement” safety factors γ_v are in this case instead applied to the benchmarks and not on the reported measurement values.

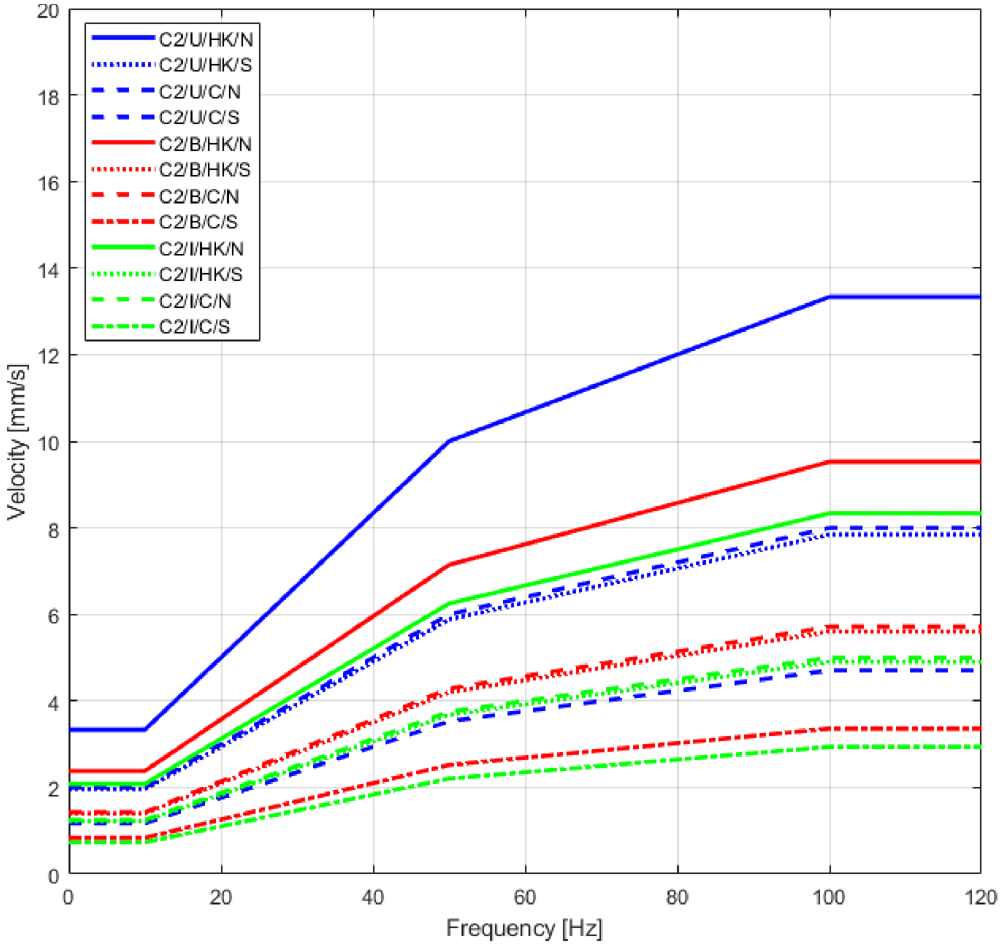
Note! Until “weighted” aggregation type is implemented in INFRA Net, you should avoid data reports using aggregation while using this standard.

With this adaptation the benchmarks will be at new levels also varying with the “type of measurement” γ_v (1.0,1.4 or 1.6). Resulting in more variations of benchmarks. No other differences are present in the implementations and both give same results in terms of relative % of a benchmark, it is just where the “type of measurement safety factor” is applied that differs.

Category 1 (Cat1):



Category 2 (Cat2):



Appendix H. British Standard BS 6841 (VDV)

Standard 70A and 70B are described in this appendix. Input signal is here acceleration which is band pass filtered into the frequency range 0.5- 80 Hz. After that another band pass filter is applied, with filter characteristics according to the graph in figure H1. As can be seen, this filter has different characteristics for the vertical and horizontal directions.

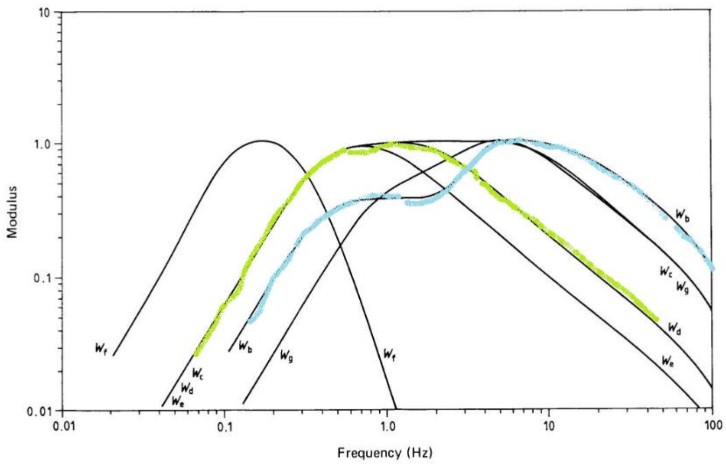


Figure H1. Second band pass filter for the standard BS 6841.
Filter W_b (blue) is applied for the vertical signal, and filter W_d (green) is applied for the horizontal signals

The output from the band pass filters is the base for the interval channels (V, L, T). However, these are not the only interval channels in this standard. There are also intervals based on Vibration Dose Values (VDV) calculated as

$$\mathrm{VDV} = \left(\int_0^T a^4(t)\, dt \right)^{1/4}$$

where *a* is the band pass filtered acceleration[14].

The interval channels (VDV-V, VDV-L, VDV-T) are the VDV values accumulated over each interval. The interval channels (VDV-V accu, VDV-L accu, VDV-T accu) are the VDV values accumulated over each day and night. Day is defined as the period 07:00 – 23:00, and night is defined as the period 23:00 – 07:00. The VDV accu values are seen as the main interval values and are therefore displayed in the GUI of the C22.

[14] The unit of VDV is m/s$^{1.75}$

In summary we have nine interval values:

- V, L, T: Band pass filtered acceleration.
- VDV-V, VDV-L, VDV-T: VDV over each interval
- VDV-V accu, VDV-L accu, VDV-T accu: VDV over each day (07:00 – 23:00) and each night (23:00 – 07:00)

Trigger an SMS and/or e-mail

VDV accu is also the base for the possibility to trigger an event, which can be used to generate an SMS or e-mail. This is configured in INFRA Net.

Note! Recordings are disabled in the VDV-standards 70A and 70B (but enabled for all other standards, including 71A and 71B).

Appendix I. Configure APN

This only applies when using a mini-SIM instead if the embedded SIM.

The APN (Access Point Name) is used internally by the mobile network provider to setup various communication parameters. The default APN is an empty string.

However, many mobile network providers require the APN to be set or may suddenly change its settings to require it. Therefore, it is recommended to set it by:

Ask your SIM provider which APN should be used with the SIM.

On a PC, make a text file with the name **extapn.txt** with the desired APN in its first (and only) line.

1. Set the C22 in USB mode and copy the file above to the root of the SD-card
2. Reboot. This will configure the internal APN in the configuration
3. When succeeded, the file name above is changed to _extapn.txt

If, by some reason the APN needs to be set back to empty, create the file **extapn.txt,** keep it empty and follow steps 1 to 3 form the list above.

Appendix J. Enter SIM PIN code

This only applies when using a mini-SIM instead if the embedded SIM.

If a SIM-card that requires a PIN code is used, the PIN code can be entered by doing the following:

1. On a PC, make a text file with the name simpin.txt with the PIN code in its first (and only) line.
2. Set the unit in USB mode and copy the file above to the root of the SD-card.
3. Reboot. This will configure the PIN code.
4. When succeeded, the file is automatically removed from the SD-card.
5. To verify the PIN code, start a manual connection and check the communication menu (from the main screen, press [COMM] twice. The unit must not be in “disabled communication”, flight mode). If the PIN code is incorrect, the remaining number of attempts will be shown when the connection fails. If a wrong PIN code has been used three times, the SIM-card will require the PUK code (together with a new PIN code) to unlock. This will also be clearly shown in the communication menu when a connection fails.

If needed, a PUK code can also be entered. When entering the PUK code, a new PIN code must also be provided and the SIM-card will be reconfigured to this. Create a text file named simpin.txt (same as above). Put the new PIN code on the first line, and the PUK code on the second line. If the PUK code is “12345678”, and the new PIN code is “1111”, write the following:

1111
12345678

After this is done, follow steps 2-5 from the list above. If successful, the SIM-card will now be unlocked, and the PIN code set to “1111”.

Note! The PIN code is stored in the unit, but the PUK code is not.

Note! The unit will only try a PIN code (or PUK code) once. This is to avoid accidentally locking the SIM-card if multiple connections are attempted. Therefore, it is safe (but useless) to retry a connection with an incorrect PIN code that has already been tested.

Appendix K. Configure PPP authentication

This only applies when using a mini-SIM instead if the embedded SIM.

If a SIM-card that requires PPP authentication is used, the PPP user and password can be entered by doing the following:

1. On a PC, make a text file with the name pppauth.txt with the username on the first line and the password on the second line. If for example the username is “User1”, and the password is “password123”, write the following:

   User1
   password123

2. Set the unit in USB mode and copy the file above to the root of the SD-card.

3. Reboot. This will configure the PPP username and password.

4. When succeeded, the file is automatically removed from the SD-card.

5. When configured, the PPP username can be viewed in the SIM information menu (from the main screen, press COMM->ENTER->DOWN). The password length can also be seen, but the actual password is hidden. Note that this information is available first after an attempted connection.

Note! To clear configured PPP authentication, follow the same steps but do not write anything in the pppauth.txt file. If PPP authentication is not configured, the fields “User” and “Pwd” will not be visible in the SIM information menu (see step 5 above).