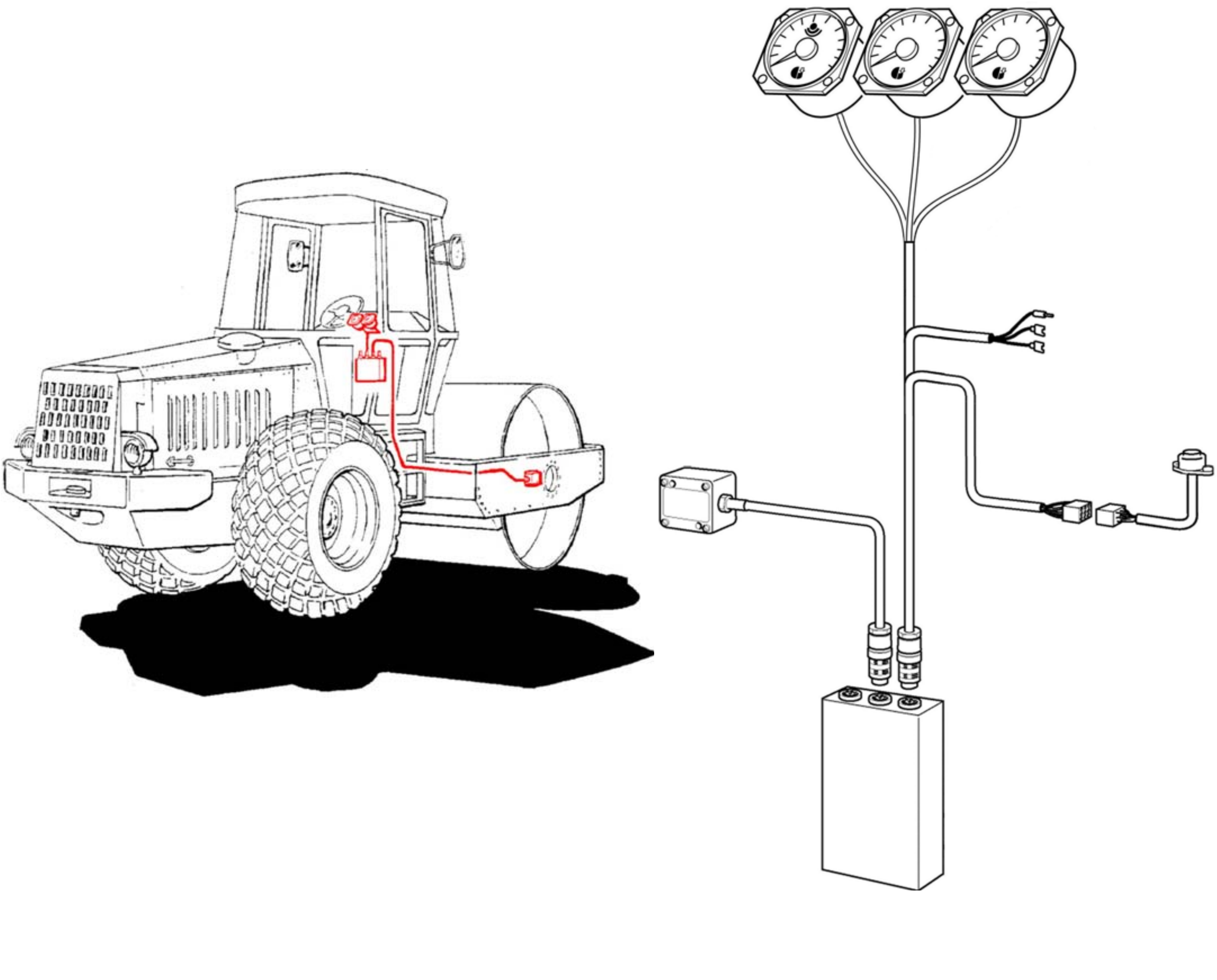
Compactometer, compaction meter for vibratory rollers

ALFA-030



ALFA-030-051E/0203

GEODYNAMIK

Contents

Introduction

The compaction meter known as the Compactometer has been developed and patented by Geodynamik. The Compactometer is mounted on a number of rollers of different makes all-over the world.

The Compactometer ALFA-030 has been developed to meet todays and future compaction specifications.

ALFA-030 is an improved version of ALFA-022R where the processor is much smaller and the weight is less. There is also a change in the CDS cable, which has been detached and can now be mounted separately. This makes a “hidden” mounting of the processor, for example behind the dashboard, possible.

1. Principle of operation

Vibrating rollers have one or two vibrating drums. Compaction is achieved by the drum hitting the ground. In general the drum hits the ground once every complete revolution of the eccentric's axis. The number of times the drum hits the ground per second (vibration frequency) depends on the size and type of the roller and lies between 25 and 40 (25-40 Hz) when compacting soil.

The Compactometer ALFA-030 is a compaction meter for vibrating rollers, i.e., an instrument that is mounted on a roller and continuously monitors and measures the compaction condition of the ground being compacted.

Every impact of the drum into the ground is registered and evaluated by the Compactometer. The measurement principle of the Compactometer can be compared to a continuous dynamic plate load testing of the ground. The vibration is detected by the Compactometer's A-sensor. This vibration is transformed into an electrical signal and then transferred to the Compactometer's processor where the signal is processed.

The processor contains electronics that extracts from the signal a halftone (A_H), a fundamental tone (A_F) and an overtone (A_O).

The ratio A_O/A_F multiplied by a certain constant gives the Compactometer´s CMV-value, which is a dimensionless relative unit. The CMV value depends on a number of parameters of the roller, i.e. size and type, vibration frequency, vibration amplitude, roll speed and roll direction in relation to the direction in which the eccentric's axis rotates. The CMV value is directly related to the compaction condition of the ground provided the roller parameters above are kept constant. Low CMV values mean that the ground is soft, which in turn means insufficient compaction. On the other hand high CMV values indicate high rigidity meaning that the ground is sufficiently compacted.

The ratio A_H /A_F is used to calculate the RMV-value which is a measure of the degree of double jump. High RMV values mean that the roller is in a resonance state with strong double jump. Theoretically, most rollers tend to have a certain small degree of double jump that is not noticeable and does not affect much the compaction process. From a certain compaction state, the degree of double jump can suddenly rise steeply and this can be noticed from the tremendous increase and violent vibration of the driver's cabin as well as a sharp rise in the noise level.

Compaction in a state of double jump ought to be avoided not only because it is unhealthy for the roller driver and destructive to the roller but also because it causes re-loosening of an already compacted ground. There is also a big risk that the powerful impacts can crush the grain shaped material and thereby degrade the soil.

The RMV-value helps the driver to know when the roller's double jump level is about to exceed the permissible level and then take appropriate measures in time, i.e., change to a low vibration amplitude or adjust the vibration frequency.

ALFA-030 even calculates the vibration frequency - number of impacts per second- and the results can be read from the frequency dial. This value can also be shown and registered in a documentation system connected to ALFA-030.

2. Compactometer components

A roller integrated compaction meter ALFA-030 (see figure 1) comprises of the following:

Alternative with dial instruments

1. Processor
2. A-sensor
3. CMV-instrument
4. Frequency dial (optional)
5. RMV-dial (optional)
6. Cabling
7. CDS-connector

Alternative with Compaction Indicator

8. Processor
9. A-sensor
10. I-sensor
11. Display unit
12. CI-cabling
13. CI- CDS-cable with CDS- connector

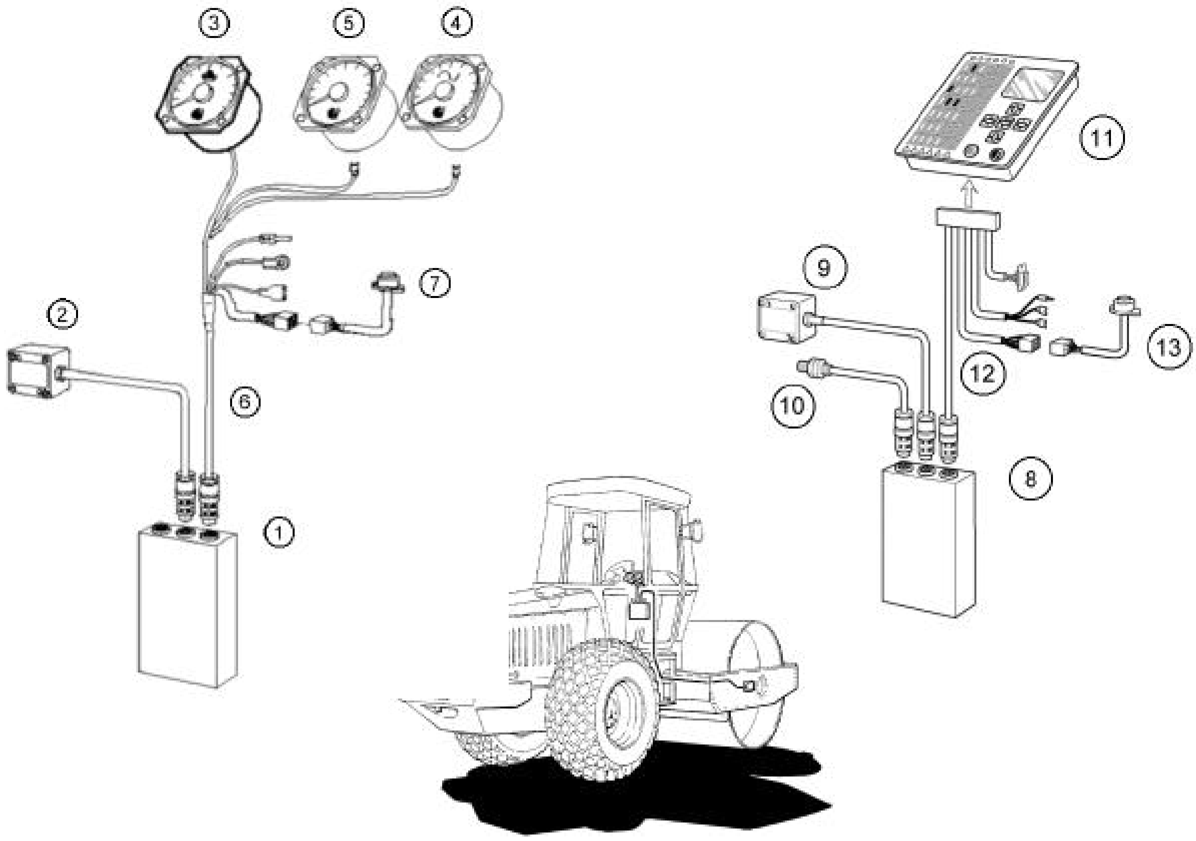


Figure 1. *Components of ALFA-030.*

The A-sensor is made up of an accelerometer and an amplifier enclosed in a shock- and water-proof box. The A-sensor detects the drum's vertical vibrations and transforms them into electric signals. Therefore, the A-sensor should be positioned in contact with drum as close as possible so that it exactly follows the drum's vertical vibration without rotating in contact with the drum.
Via a cable, the A-sensor signal is sent to the processor where it is processed. The processor, usually placed in the driver's cabin, contains electronics for the signal analysis. The signal is divided into its tone components. The ratio A_O / A_F , (where A_F is the fundamental tone and A_O is the overtone) multiplied by a certain scale factor gives the Compactometer value - CMV, which is a dimensionless relative value. The three Compactometer dials are usually mounted in the roller's dashboard from where the driver can read the CMV, RMV and the vibration frequency. A documentation system can be connected to the Compactometer ALFA-030 and the driver can then follow the compaction from a screen, record the compaction results and record the important data, i.e. roller parameters, project data and the reference co-ordinates of the compacted area.

3. Operating instructions

3.1 General instructions

The Compactometer ALFA-030 is permanently connected to the roller's electrical system and therefore it is always in operation as soon as the roller's engine is switched on. Before beginning compaction, make sure that the three dials are reading zero, if not, adjust the zero level with the help of the screw in the middle of each dial.

After switching on the vibration, adjust the frequency in accordance with the roller's specifications. The set frequency can be read from the frequency dial that is graduated in Hz, i.e. number of revolutions per second.

As long as the drum continues to vibrate, the CMV value can continuously be read from the CMV-dial. The value read from the dial is an average value of the CMV-values over an area whose width is equal to the drum's width and with a length equal to the length that the roller moves in half a second (with a drum of 2 m wide moving at a speed of 1m/s (3.6 km/h) the area will be nearly 1 m^2.). Average values are displayed in order to prevent the dial indicator from oscillating making the reading of the dial difficult.

Be aware that the CMV-value shown at a given time is an average value in an area just compacted whose width is equal to the width of the drum and whose length stretches a certain distance backward from the present contact line between the drum and the ground. Make sure also that the frequency and speed are kept constant all the time. Keep the roller in the same strip the whole length, in order to be able to compare the compaction results from different passes later.

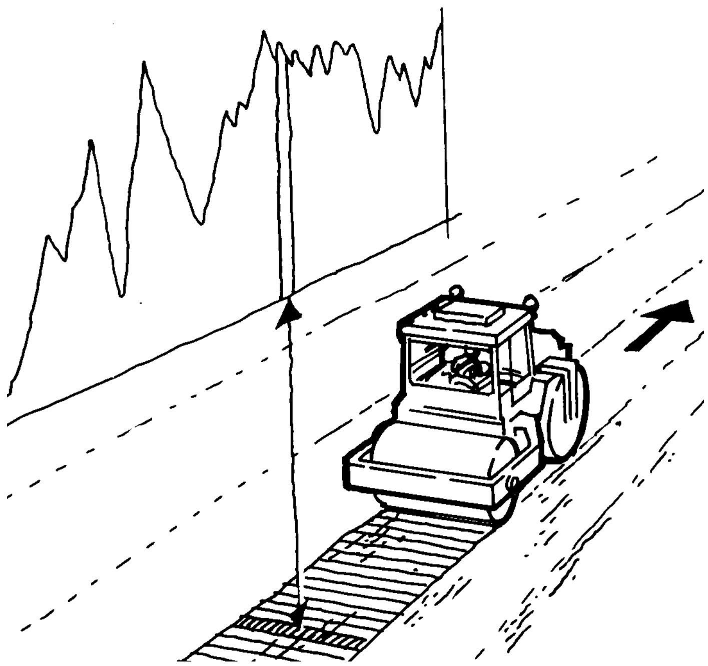


Figure 2. *Relationship between CMV and the area on the ground.*

3.2 Interpretation of the CMV-values

Generally the CMV values increase with increasing number of passes. The absolute increase from pass to pass depends on the roller's size and the properties of the material being compacted. If the CMV does not increase after repeated passes then either the ground is sufficiently compacted, which means that compaction should be stopped or it cannot be compacted anymore by the present roller and in that case extra measures ought to be taken, e.g. use another roller, change the water content or change the material altogether.

CMV-dial helps the driver to carry out the compaction work quickly and effectively because he can see

- Where compaction is complete
- Where it is useless to continue compaction because the CMV does not increase and where the risk is big that continued compaction will cause the material to re-loosen or be crushed.

CMV-values within different intervals can be interpreted more clearly in the following way:

Low CMV-values (5-15):

In principle, low values mean that the ground is soft and this can be due to the following:

- **Uncompacted material:**

The next pass will result in higher CMV-values therefore more passes ought to be made.

- **Uncompactable material:**

At times, when compacting fine grained material with high water content, the CMV values remain low irrespective of repeated compaction. Due to the material's low permeability, the water cannot be pressed out quickly enough for the grain deformation to take place. The pore water pressure that arises causes the roller to float on water, resulting in low or very low CMV-values (<5). As soon as the pore water pressure goes down, - e.g. after drying up - the compaction of the material gives higher CMV values.

It should be pointed out that low CMV-values do not mean that there is a fault in the Compactometer other than that the material in question cannot be effectively compacted with a vibrating roller.

- **Deep lying soft layers:**

When compacting with heavy rollers and at high vibration amplitude the roller's depth effect penetrates through the layer. If there is a section or layer with a deep bearing capacity beneath the layer being compacted, the CMV-values will be affected by this weak deep lying layer. The registered values will be lower than they should really be, i.e. do not correspond to the results from the spot methods with a smaller depth effect.

Normal CMV-values (> 20):

Depending on the roller's parameters and the general condition of the ground, the CMV-value increase with increasing number of passes. The rate at which the CMV rises will depend on the nature of the material.

High CMV-values (50-120):

In general high CMV-values mean that the ground has a high rigidity (bearing capacity).

Isolated high CMV values can mean the presence of isolated blocks near the surface. In such cases, the Compactometer can with high precision be used to localize such blocks. Some blocks under the pavement surface are often not revealed and they can later cause damage to the compacted surface.

3.3 Interpretation of the resonance values (RMV)

When the ground has reached a certain level of rigidity, there is a risk (with some rollers) that the drum might begin to vibrate in double jump. Compaction with double jump is unwanted and not permissible.

Compaction with double jump is **not wanted** because under double jump

- the roller driver will be subjected to very strong vibrations and very high noise
- the roller will be subjected to high strain (decreased lifetime)
- the ground will re-loosen and there is a risk that the material will be crushed
- the surround environment will be subjected to high vibrations.

Compaction with double jump is **not permissible** during the last pass of the continuous compaction control final documentation. With double jump, the CMV-values fall by nearly a half. This means that unpermissibly low CMV-values can be recorded in a strip with high normal values because of double jump.

The RMV-dial indicates the current double jump level that helps the driver to know when the double jump level is approaching or above the unpermissible limit. To avoid compaction in double jump mode, the driver must decrease the vibration amplitude from high to low in time, i.e. before the drum begins vibrating in double jump mode. In case the amplitude is already low and there is still a tendency towards higher double jump then compaction with the current roller ought to be terminated.

Be aware that the CMV-values recorded at a low amplitude cannot be compared to the CMV-values recorded at a high amplitude (changed roller parameters). It is therefore recommended - and specified in some countries - that the accept level should be determined during calibration at a low vibration amplitude and a low amplitude should be used during the last pass of the compaction results' documentation. It is also allowed to use high amplitude throughout if one is completely certain that double jump will not occur.

3.4 Calibration

To calibrate the CMV-value for the conditions of the area to be compacted, select a test area of about 20 m long and about 6 m wide (figure 3). The soil properties of this area, i.e., bearing capacity, material composition and layer thickness, should resemble those of the area to be compacted. If the properties of the area to be compacted varies a great deal, it is advisable to do separate calibrations on different test areas representative of the conditions and properties of the area to be compacted.

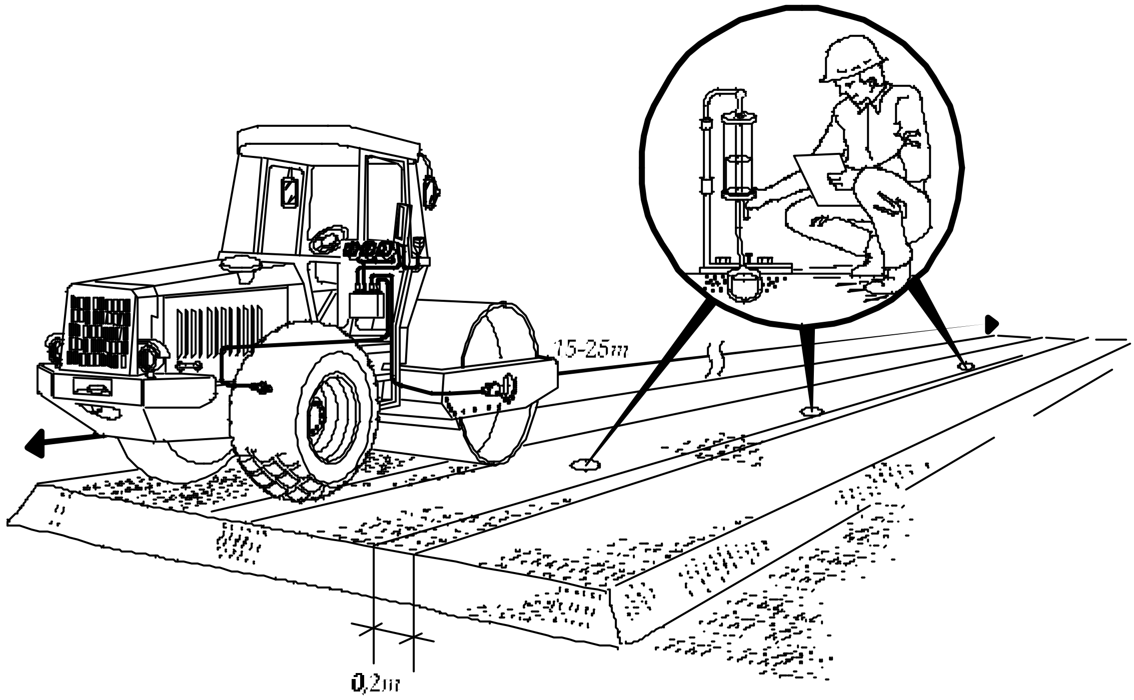


Figure 3. *Calibration area.*

In order to achieve comparable conditions, the base, i.e. the ground on which all the layers are to be spread, must be well compacted and continuously documented. If the bearing capacity of the base fluctuates a great deal, it is advisable first to spread a thick layer of a homogeneous material on the base and compact it.

A layer (of a prescribed thickness) of the material to be calibrated is spread out on the test area. The actual calibration should be carried out in accordance with the current project's specifications. Given below is a general calibration process.

Compact the material in 3 strips with about 20 cm overlap (about 10% of the drum's width) at a low amplitude. Every strip should be compacted in such a way that the vibration is on in the forward direction and off backwards. It is important that the roll speed and the vibration frequency are kept constant. Register the CMV-values of the middle strip using either a printer or a documentation system connected to the Compactometer.

Make spot control measurement in at least three places in the middle strip every other pass. The most common spot method used is the density measurement (water balloon, radiometric sond) or the plate load testing method. Altogether, about 8-10 passes ought to be made. If double jump occurs before the 10th pass, in spite of the low amplitude, compaction should be terminated.

If there are reasons to believe that double jump might occur, it is recommendable to continue compaction until double jump occurs. In that way, the conditions under which double jump occurs will be documented.

The obtained results - CMV-values and density, compaction grade or E-modulus - are plotted in a diagram (figure 4). Corresponding values are plotted for every pass made. The calibration diagram in figure 4 was made with the help of a PC- software CdsView.

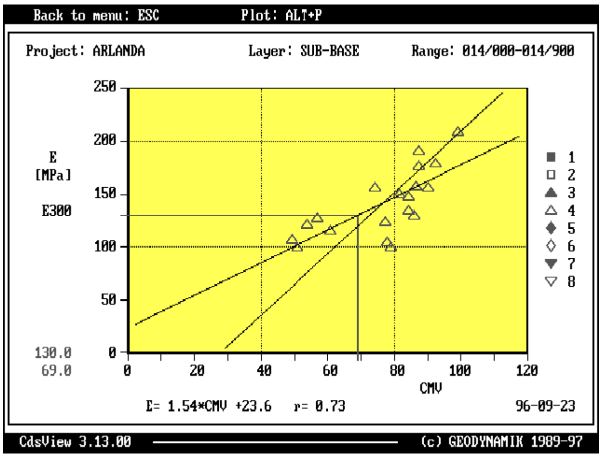


Figure 4. *Calibration diagram.*

Comparison of calibration results from different countries have shown that E_{V1}-values obtained from the static plate load tests give the best correlation with the CMV-values.

An "accept level", i.e. the CMV-value that corresponds to the compaction criteria set for the project, can be read from the calibration diagram. This criteria can be, for example, 98% Proctor (standard or modified) or a E_{V1}-value of 50 MPa.

This accept level is then used by the roller driver to make decisions as to when to stop compaction and as to where more compaction is required. This accept level is valid only under the conditions that the roll speed , frequency and amplitude of the roller throughout is the same as that used during calibration. Even the soil parameters ought to be equivalent to those that existed during calibration.

4. Installation

4.1 A-sensor

The A-Sensor (figure 5) comprises a box (that contains an accelerometer and the necessary electronics), a cable and a connector. The A-Sensor must be installed vertically over (or under) the drum axis on an undamped part of the bearings that follow the drum's vibrations but does not rotate.

As figure 5 shows, the arrow on the sensor must be directed to point vertically and the extension of which must pass through the central axis of the drum. On most rollers the A-Sensor is fastened with screws on a flat steel plate that is welded on the edges of the bearing plates. The flat steel plate has provision for clamping the A-sensor cable.

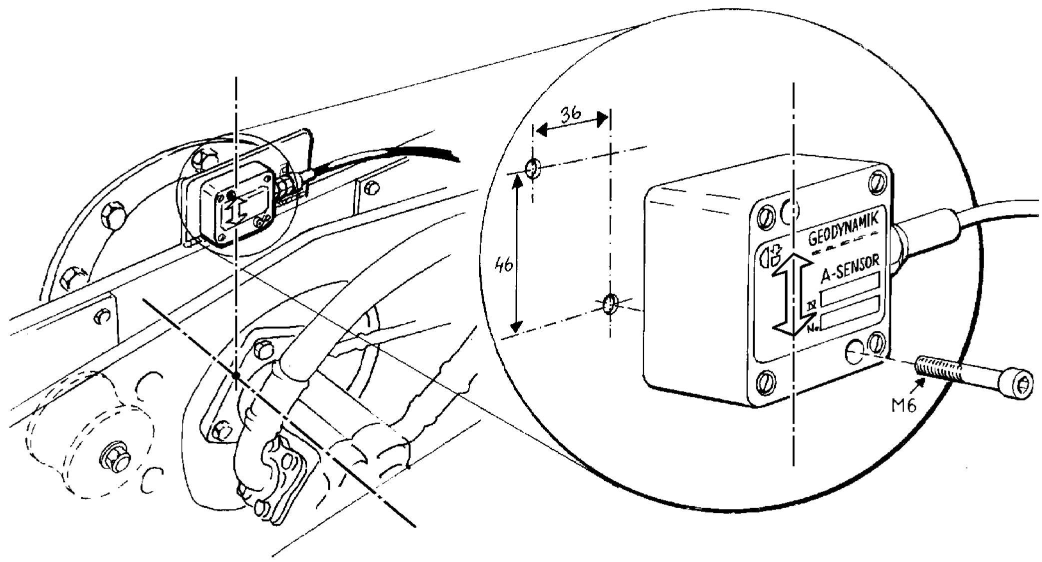


Figure 5. *A-sensor installation.*

The A-sensor should be mounted, if possible, on the side where there is a free bearing plate available, usually the side where the vibration engine is placed. In case, due to some reason, the A-sensor must be mounted on the same side as the roller driving engine, contact the roller manufacturer for help because the installation of the A-sensor in that case can be more complicated.

The A-sensor cable should be relieved of stress by clamping the end near the sensor to the mounting plate and then draw the cable to the processor clamping it to the roller frame and to the existing wiring and hydraulic hoses.

WARNING: The A-sensor must not be dropped on a hard surface and any welding close to the sensor must be avoided. In both cases the sensor can be destroyed and cannot be repaired.

4.2 Processor

The processor should be placed at a suitable location inside the cabin (figure 6), e.g. under the dashboard, behind or under the driver's seat. The processor should be placed in such a way that it is easy to reach and that there is enough space for easy connection of the necessary cables. Figure 6 shows the location of the mounting holes.

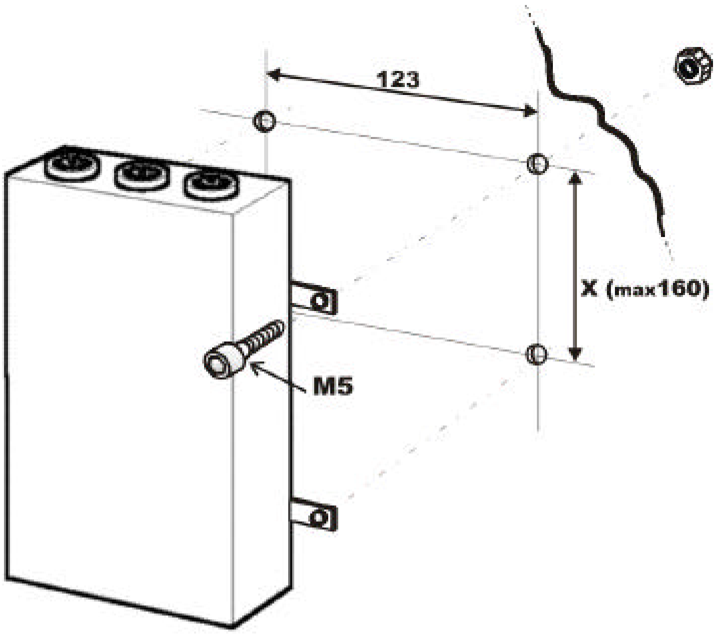


Figure 6. Installation of the processor.

4.3 Dial Instruments

The CMV-dial, Frequency-dial and the RMV-dial (optional) should be installed in the dashboard in accordance with figure 7.

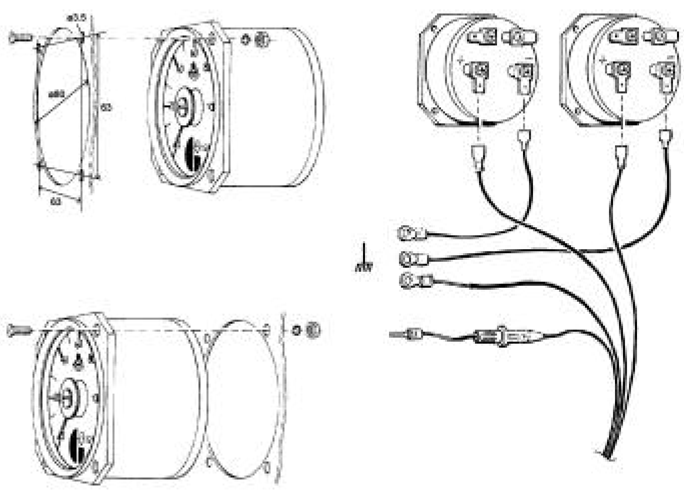


Figure 7. Connection of the dial instruments.

4.4 Compaction Indicator

For further information on mounting of CI- system parts, please read the CI manual.

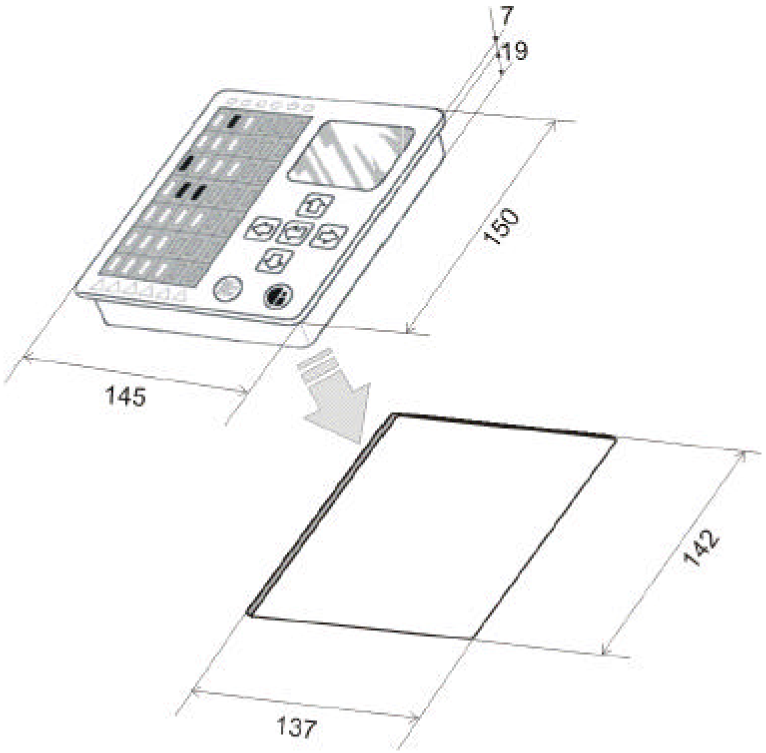


Figure 8. *Mounting of the CI display unit.*

4.5 I-sensor

The I-sensor is a proximity transducer that produces an electric pulse whenever a metallic object passes by. The metallic object can be a gear tooth, a wheel bolt or a hollowed metallic disc. The I-sensors are available in three diameters: M8, M12 and M18. Our standard sensor has a M18 diameter and a 5 m long cable.

The I-sensor can be mounted radially or axially, see figure 9.

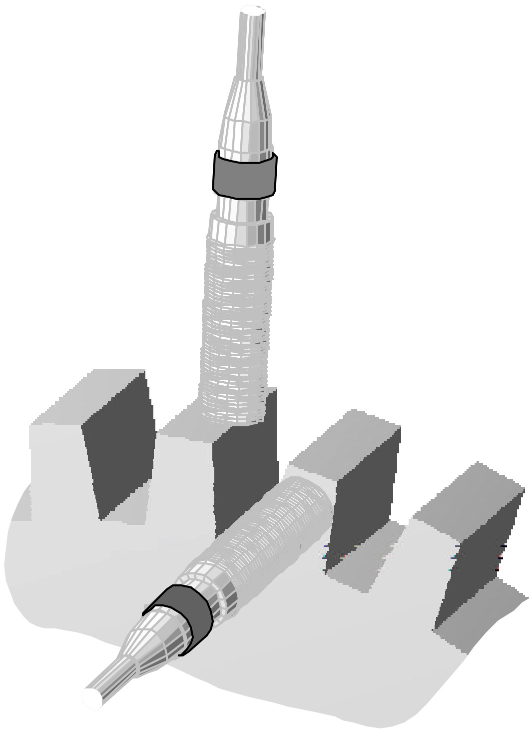
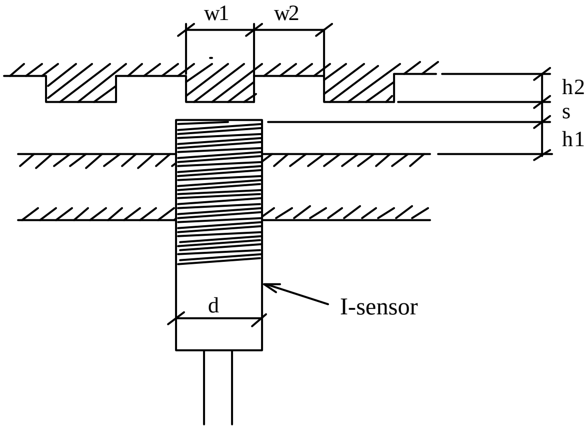


Figure 9. *Alternative ways to install an I-sensor, radially or axially*

Important sizes for a proper installation of an I-sensor are listed in table 1.



I-sensor type	d (mm)	s (mm)	h1,w1,w2 (mm)	h2 (mm)
M8	8	0,1 - 1,2	> 5	> 3
M12	12	0,1 - 1,6	> 8	> 5
M18	18	0,1 - 4,0	> 16	> 8

Table 1 *Critical measurements in I-sensor installation.*

The installation of an I-sensor to a roller is dependent on the type of the roller in question. For the instructions of how to install the I-sensor, contact the roller manufacturer or their agents in you country.

Pulses/m

One of the parameters required in the system is the number of pulses per roll length (pulses/meter). The value of this parameter can be calculated from the number of gear teeth, gears and the tire diameter. The minimum number of pulses should be 2/m and the maximum number should be 500/m and this number should preferably be a multiple of 2. This is particularly important if the number of pulses is less than 10 per meter.

In case you do not know this parameter and you are unable to calculate it then follow the instruction below step by step to determine the number of pulses per roll meter:

1. Mark out and measure the length of an even and plain strip. The strip length should be a multiple of the section interval (usually 20m) and occupies nearly the whole CDS strip length.
2. Enter a guessed number of pulses per meter in the CDS.
3. Drive the roller over the measured strip while registering with the CDS.
4. Read from the CDS the registered length that has been covered.
5. Change the number of pulses in the CDS to: (length read from CDS/ measured length) ∗ old number of pulses.
6. Repeat 3 and 4 to control the results.

Repeat 3-6 if necessary until the CDS registered length is equal to the measured length.

Note: Select "New area" in press to start menu every time you change this parameter.

4.6 Electrical Connection of Compactometer-Roller

The Compactometer cable contains the following connectors: (see figure 1) :

1. POW/OUT (connect this connector to the processor)
2. + 12 V (battery connector with a 2,5 A fuse)
3. Ground
4. CMV-dial (+ connector)
5. RMV-dial (+ connector)
6. Frequency-dial (+ connector)
7. Amplitude A (connector to be connected to the roller's amplitude switch gear to automatically detect high or low amplitude in a connected documentation system)
8. The CDS- connector is mounted for easy connection of the CDS- cable . It should Therefore be mounted in the dashboard or at some other easy accessible location.

Connect the dial connectors of the POW/OUT cable to their respective dial instruments first and make sure that the polarity is correct. The dial instruments must be separately grounded, see figure 7. Next, if needed, connect the cable connector marked “A” to the amplitude switch gear, otherwise isolate this connector. Finally connect the connector marked “+12 V” to the roller's +12 volts power supply.

The Compactometer is ready to use after connecting the A-sensor cable to the processor connector marked “A-SENSOR”.

The Compactometer connectors marked "I-SENSOR" and "CDS" are meant for a Documentation system and without it, those connectors are not used.

5. Performance Test

If the Compactometer does not work during normal compaction with vibration switched on, i.e. there is no reading on the dial instruments, then check the following:

1. Check the fuse and replace it if necessary.
2. Remove the A-SENSOR- and POW/OUT -cables from the processor and reconnect them again to the processor.
3. Check the connections of the dial instruments.
4. Make sure that the A-sensor is firmly screwed to the roller plate.
5. Inspect the A-sensor cable and make sure it is whole and not in anyway damaged.
6. Test the Compactometers A-SENSOR connector with an A-tester.

A-tester

The A-tester (figure 8) simulates the A-sensor. With the help of this tester it can be determined whether the problem originates from the A-sensor or not.

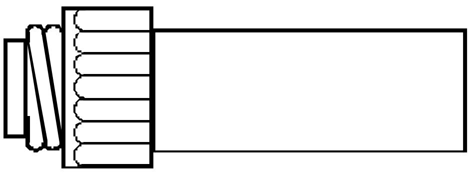


Figure 10. *A-tester.*

Disconnect the A-sensor from the Processor and replace it with the A-tester (see figure 10).

The A-tester generates a signal corresponding to an A-sensor signal with CMV = 100±5 and f = 30±3 Hz. If after replacing the A-sensor with the A-tester, the CMV-dial reads 100 and the Frequency-dial reads 30 Hz then the problem is in the A-sensor or the cable and it must be replaced.

If one of the dial instruments does not read anything then the problem might be either in the Processor, cables or the dial instrument.

6. Fault Detection

The dial instruments should read zero when the roller is not moving and the vibration is off even if the engine is on. As soon as the vibration is switched on, the CMV-dial should read a value and the Frequency-dial should read a frequency equal to the vibration frequency. Whether the RMV-dial will read something or not will depend on the rigidity of the ground under the roller. The CMV and RMV readings will depend on the variation of the compaction state of the ground. The dial pointers should not move up and down and when the vibration is switched off, the dials should show zero readings.

If any of the instruments reaction differs from that described above then there is something wrong with the system. The fault can probably be that the A-sensor was installed wrongly or that the A-sensor cable and connector are damaged.

6.1 No reading from the dials at all

To find the problem, examine the following:

6.1.1 Cables and connectors

Make sure that all the connections to the processor, dials and to the battery are perfectly and correctly connected.

All the cables from the processor to the dials, to the A-sensor and to the roller's power supply should be checked and if any is damaged it should be replaced.

6.1.2 Power supply

Make sure that the power reaches the processor and that the voltage on pin no. one (1) of the POW/OUT connector is 11-14 V. In order to measure this voltage you need a special test cable that is usually included in the service package.

6.1.3 A-sensor

Disconnect the A-sensor from the processor and replace it with an A-tester. The CMV-dial should read 100 and the Frequency-dial should read 30 Hz.

If the CMV- and the Frequency-dial's readings are correct the fault is in the A-sensor or its connector and/or cable. Inspect these parts for visible damage. If no damage can be found, measure the voltage on pin no. one (1) of the processor's CDS-connector while the A-tester is still connected to the processor. This voltage should be between 3.2-3.5 V.

If the measured voltage is between 3.2-3.5 V, and the dials still show nothing then the problem is perhaps with the dial instruments or the cables between the processor and the dials.

If the voltage there is wrong or none at all then remove the A-tester and measure the voltage again on pin 1 of the processors CDS connector. If the voltage is still wrong, REPLACE THE PROCESSOR.

Examine the cables again! Repair or replace damaged parts! Check the dials by first disconnecting the cables and connecting a 1.5V battery across each dial , make sure the polarity is right. A dial in good condition should now read about one third of a full scale.

WARNING! The A-sensor contains an accelerometer that can be damaged if roughly handled. Do not throw the sensor on a hard surface and avoid welding close to the sensor!

6.2 Faulty dial reading

If any of the dials gives a reading that is completely unbelievable, then the problem, most probably, is that the A-sensor was wrongly installed. Please check the following:

6.2.1 A-sensor mounting

Make sure that the A-sensor is firmly bolted either directly on the bearing bracket or on a plate that is welded to the bearing bracket. See to it that the sensor vibrates in unison with the drum and that there is no gap or any shock absorbing material, e.g. rubber elements between the A-sensor and the drum (never attach the A-sensor onto the roller's frame!).

6.2.2 A-sensor Positioning

The arrow on the A-sensor casing (see figure 5) must point vertical directly through the drum's longitudinal axis.

7. Continuous Compaction Control

Today, there is an increasing demand on high quality and low cost of a project as a whole. This applies to all projects and not only to big construction projects like highways, railways and runways. These demands have eventually resulted into many countries issuing new standards and specifications with the aim to:

- obtain uniform compaction so as to avoid settlement difference that can damage the construction.
- optimize both the compaction work and the compaction control in order to reduce the total cost for construction and future maintenance.

In order to fulfill this, the roller must be equipped with both a compaction meter and a documentation system (see figure 11).The Compactometer ALFA-022R is equipped with facilities for connecting a documentation system (CDS-012J).

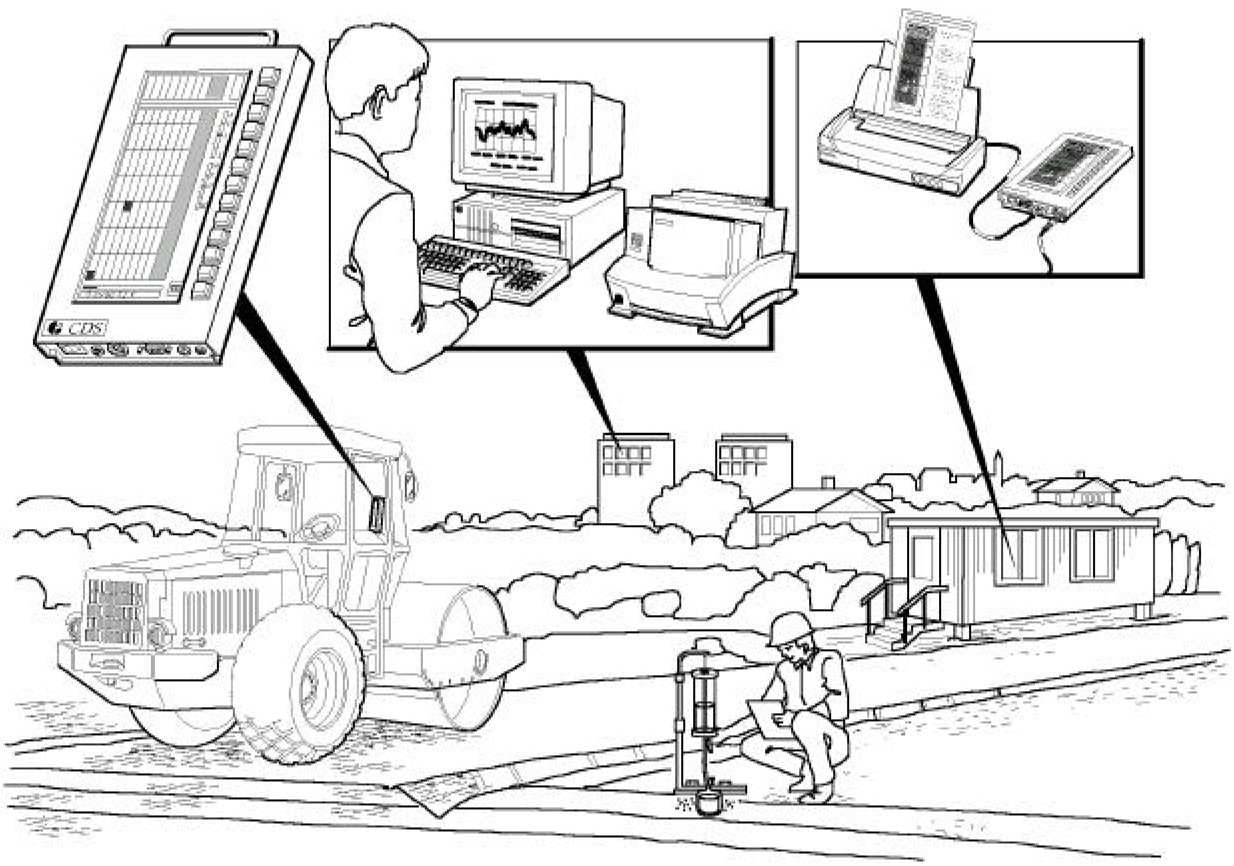


Figure 11. *Documentation system for "Continuous Compaction Control".*

The documentation system CDS-012 offers

- **the roller driver** a **quality controlling tool**, through the CDS screen that continuously displays the position of the roller, area where compaction is complete and areas where more compaction is required.
- **the contractor** a tool for an immediate **quality report.** Registered and recorded data can be printed out as an overview of the compaction results. This report speeds up the identification and location of weak points.
- **the customer** a **continuous compaction documentation** that helps to minimize the need for spot control methods and helps to ease the estimation of the need for reinforcement measures and also can serve later as a source of information and explanation for any eventual settlement.

8. Technical Data

8.1 Sizes and weight

8.1.1 A-sensor

The A-sensor together with the connector and a 5 m long cable weighs 950 g.

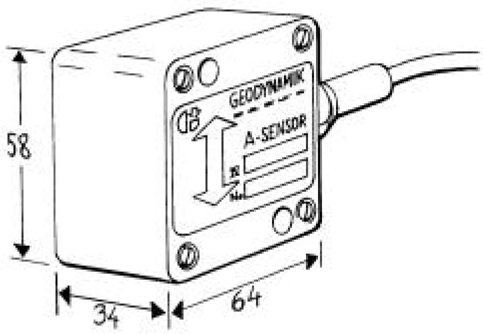


Figure 12. *A-sensor's dimensions in mm.*

8.1.2 Processor

The Processor weighs 650 g. and its dimensions are given in figure 13.

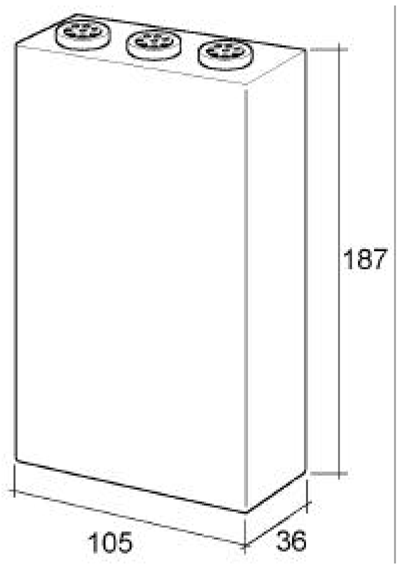


Figure 13. *The Processor's dimensions in mm**.***

8.1.3 Dial instrument

A dial instrument weighs 350 g and its dimensions are given in figure 14.

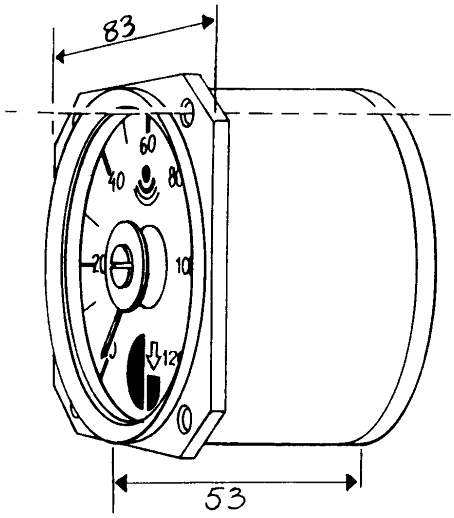


Figure 14. *Dimensions of a dial instrument in mm.*

8.2 Electrical Specification

1 CI-connector

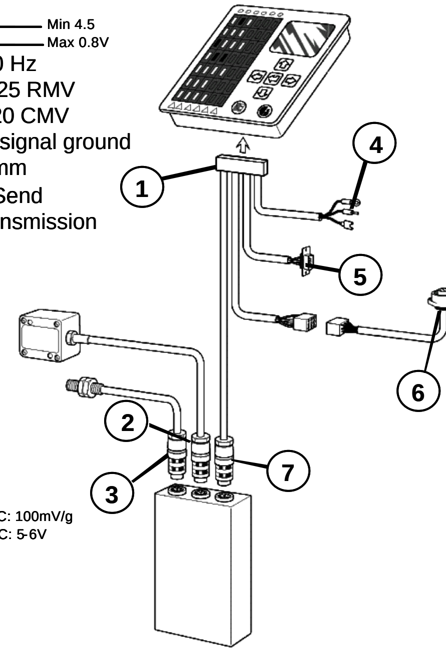
Pin	Designation	Comments
1	Ground	0V
2	RxD	RS232 reception
3, 15	High/Low	High <0.8V Low >4.5V
4, 5, 16	+12-24V	DC 11 - 29V
6,17,18	Ground	0V
7,19	I-Sensor	Min 4.5 Max 0.8V
8,20	Frequency	DC 4V=60 Hz
9,21	RMV	DC 2.5V=25 RMV
10,22	CMV	DC 4V=120 CMV
11,23	Sign.Gnd	Analogue signal ground
12,24	Amplitude	DC 4V=4mm
13	CTS	Clear To Send
14	TxD	RS232 transmission

4 AMP Terminal

Type	Designation	Comments
Wire pin	+12-24V	11-29V
Ring tongues	ground	0V
Socket	High/Low	High <0.8V Low >4.5 V

5 Serial 9-pin DSUB-connector

Pin	Designation	Comments
2	TXD	Transmit (output)
3	RXD	Receive(input)
5	ground	0V



6 CDS-connector

Pin	Designation	Comments
1	CMV	DC 4V=120 CMV
2	+12V	DC 11 - 15 V
3	I-Sensor	12 V. Max 0.8V
4	High/Low	High <0.8V Low >4.5 V
5	Frequency	DC 4V=60 Hz
6	RMV	DC 2.5V=25 RMV
⏚	ground	0V

2 A-Sensor-connector

Pin	Designation	Comments
1	+12V	DC 10-15 V
2	Shield	0V
3	A-Signal	AC: 100mV/g DC: 5-6V
4	Ground	0V

7 Power/Out-connector

Pin	Designation	Comments
1	CMV	DC 4V=120 CMV
2	+12/24V	11 - 29 V
3	I-Sensor	12 V.. Max 0.8V
4	Amplitude	DC 4V=4mm
5	Frequency	DC 4V=60 Hz
6	RMV	DC 2.5V=25 RMV
7	Sign. ground	Analogue signal ground
8	ground	0V

3 I-Sensor-connector

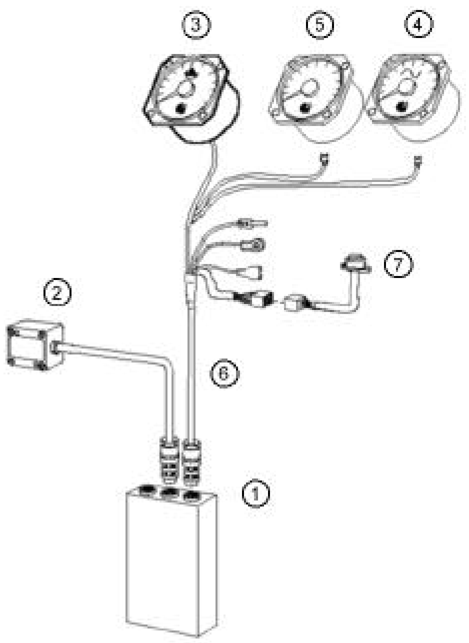
Pin	Designation	Comments
1	+12V	DC 10-15 V
2	ground	0V
3	I-Signal	12 V. Max 0.8V

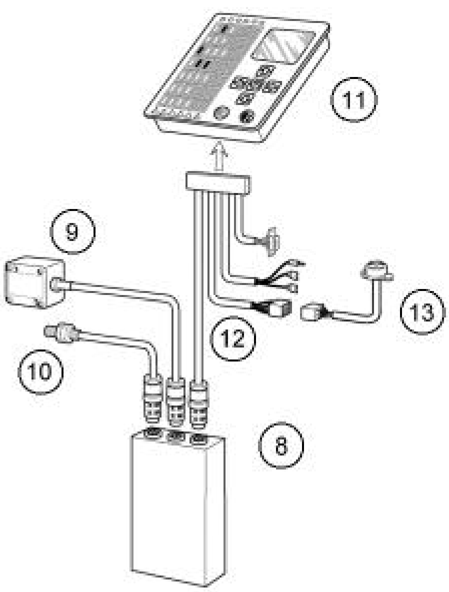
Figure 15. *Connection diagram.*

9.Spare parts

	ALFA-030	ALFA-030-000A/B/C
1,8	Processor	ALFA-030-001
6	Cable	ALFA-030-002
3	CMV-instrument	ALFA-020-003
4	Frequency-instrument	ALFA-020-004
5	RMV-instrument	ALFA-020-005
2,9	A-sensor	A-SENSOR-103
	A-tester	ALFA-030-020
	Testable 4-polig	ALFA-030-022
	Testable 7-polig	ALFA-030-023
	Manual	ALFA-030-051/E

	CI-011	CI-011-000
11	CI display unit	CI-010-001
12	CI cable	CI-010-002
7,13	CI-CDS cable	CI-010-003
10	I-sensor M12 with cable	I-SENSOR-112





10. Index