

Vibrating Wire Crackmeter User Manual





What's this manual about?

This manual tells you about the Vibrating Wire Crackmeter and how to use it to monitor crack displacement.

Who does this apply to?

Installers, field engineers and technicians who need to measure crack displacement using a Vibrating Wire Crackmeter.

Welcome!

Thank you for choosing the Vibrating Wire Crackmeter.

This manual has been written to provide you with relevant information and to guide you in best practice when using a Vibrating Wire Crackmeter in order for you to gain the most from our product.

Please read this manual thoroughly before use to help avoid any problems and keep it handy when using a Vibrating Wire Crackmeter.

Vibrating Wire Crackmeter

The Vibrating Wire Crackmeter provides accurate measurement of crack propagation for structural or geotechnical monitoring.

The sensor is made from high quality Stainless Steel, incorporates 'O' ring seals to allow for underwater use and is designed for long-term, reliable monitoring.

Fitted across a crack or joint, the sensor monitors displacement by detecting a change in tension in the Vibrating Wire inside the sensor.

The Vibrating Wire Crackmeter provides accurate, repeatable readings over long cable lengths combined with a long working life and long-term stability and reliability.

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PRECISELY MEASURED

instrumentation and monitoring

Part I – General User Guide

Contents

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Introduction: Important Information

The following symbols are used throughout the manual



IMPORTANT
INFORMATION



QUESTION



WARNING



TIP



! Important: Failure to adhere to the warnings in this manual may result in network disruption and possible data loss.

Failure to observe the warning may result in injury, product malfunction, unexpected readings or damage to the product that may invalidate its warranty.



Tips give additional information that may be helpful when using a Vibrating Wire Crackmeter.

PRODUCT CHANGES

Soil Instruments has an on-going policy of design review and reserves the right to amend the design of their product and this instruction manual without notice.

WARRANTY

Refer to our terms and conditions of sale for warranty information. The batteries are a consumable item and are excluded from the warranty.

DISPOSAL

Products marked with the  symbol are subject to the following disposal rules in European countries:

- This product is designated for separate collection at an appropriate collection point
- Do not dispose of as household waste
- For more information, contact Soil Instruments or the local authority in charge of waste management.

System Description

Things You Need to Know About the Vibrating Wire Crackmeter

FEATURES

- Uses proven Vibrating Wire technology
- Ideal for long-term monitoring
- Suitable for manual or remote monitoring
- Fully waterproof
- Fitted with thermistor for temperature monitoring

BENEFITS

- Accurate, repeatable readings over long cable lengths
- Long working life
- Long-term stability and reliability
- Connecting cable is strong, screened and flexible

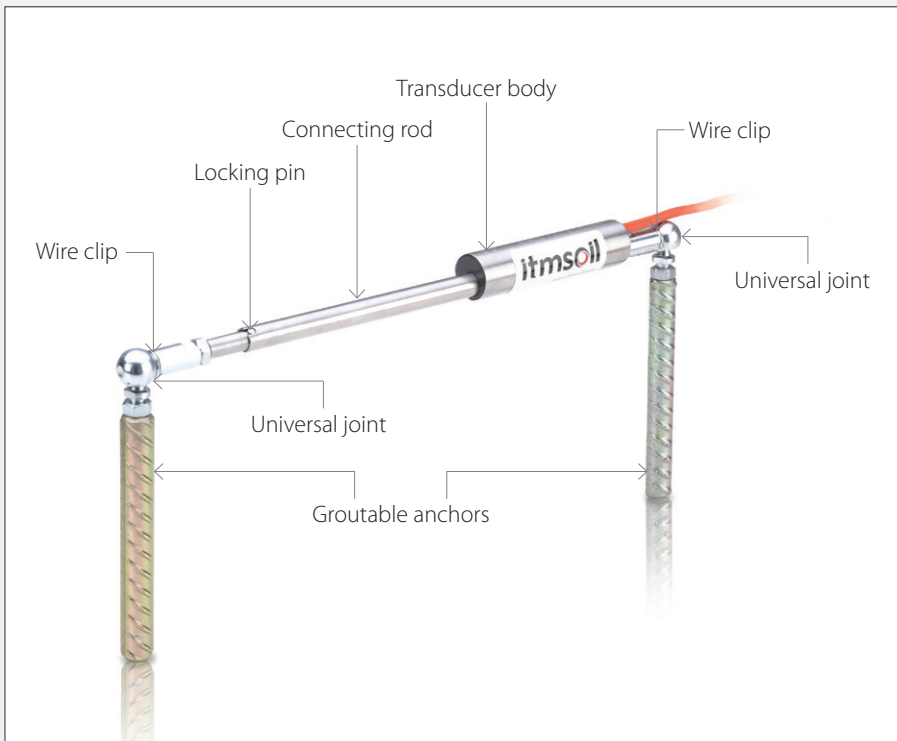
System Components

OVERVIEW

The Vibrating Wire Crackmeter consists of a telescoping sensor body incorporating a sprung, tensioned Vibrating Wire element. Each end of the telescoping body is anchored either side of the crack to be monitored.

A change in distance between the anchors by the crack opening or closing will cause the connecting rod to move within the transducer body, changing the tension on the spring and thus altering the resonant frequency of the wire.

Vibrating Wire Crackmeter Components



Follow the precautions outlined in this manual at all times to ensure the correct working order of your instrument

Quick Guide to Using the Vibrating Wire Crackmeter

Soil Instruments recommend an **intermediate** skill level for installing a Vibrating Wire Crackmeter.



It is essential that the equipment covered by this manual is handled, operated and maintained by competent and suitably qualified personnel.



The connecting rod must be withdrawn and re-inserted into the body in a controlled manner, as withdrawing and releasing the rod will result in it returning into the body at speed and damaging the Vibrating Wire element.



The rod is connected directly to the wire via the spring; therefore the rod should not be rotated or extended beyond the range of the instrument at any point during the installation process as this will cause damage to the Vibrating Wire element.

PRELIMINARY TEST

- Unpack the Vibrating Wire Crackmeter and familiarise yourself with the product
- Connect the wires from the crackmeter cable to a readout unit
- Pull the connecting rod out to approximately 3mm
- Check that the reading is stable for the crackmeter (and thermistor if included)
- Record the reading for the crackmeter (and thermistor if included)

For further information on Vibrating Wire readouts, please refer to datasheets *RO-1-VW-NOTE Vibrating Wire Note* and *RO-1-VW-READ Vibrating Wire Readout* which can be downloaded from either our **website www.itmsoil.com** or our support site **www.itmsoilsupport.com**.



You must perform the preliminary test on each sensor before you install it.

INSTALLING THE SENSOR

Soil Instruments recommend an **intermediate** skill level for installing a Vibrating Wire Crackmeter.



The crackmeter may be installed with groutable or expanding shell anchors.



To allow for compression of the crack to be monitored, it is recommended that the sensor is installed with 25% of the available range of the instrument reserved for compression and 75% available for extension.



When you have established the installed distance between the anchors, which is the length of the crackmeter, measured between the centres of the universal joints, plus 25% of the range of the instrument, a drill template can be made to make multiple installations quicker and easier.

STEP

ACTION

1

Measure the length of the crackmeter from the centres of the universal joint sockets

2

Add 25% of the range of the instrument to the length of the crackmeter measurement

3

Mark out the locations for drilling at either side of the crack, with the crack central, using the determined measurement

4

Measure the depth of the chosen anchors to establish the depth of the hole to be drilled



Once you have measured the correct depth for the anchors, mark the drill bit with insulation tape to avoid drilling the holes to deep/shallow and to save time on multiple installations.



If you are installing the crackmeter over a segment joint or an uneven surface, you may need to offset the anchors to ensure the crackmeter has suitable clearance.

STEP	ACTION
5	Drill the holes to the required depth and extract the dust from the holes
6	Remove the wire clips from the universal joints at each end of the crackmeter and remove the balls from the sockets of the joints, making sure the wire clips are retained in a safe place for re-assembly



Remove the wire clip by rotating the loop over the joint and withdrawing.

STEP	ACTION
7	Attach the ball parts of the universal joints to the anchors
8	Place the anchors into the holes using the appropriate method for the chosen anchors



For groutable anchors, fill the holes with grout or resin and push the anchors in place and allow to set. For expanding shell anchors push the anchors into the holes and expand by tightening the anchor bolt.



The connecting rod must be withdrawn and re-inserted into the body in a controlled manner, as withdrawing and releasing the rod will result in it returning into the body at speed and damaging the Vibrating Wire element.

STEP**ACTION**

9

Refit the crackmeter to the ball joints on the anchors by attaching the cable end of the instrument first and re-inserting the clip, followed by the opposite end



Push the socket at the cable end of the crackmeter over the ball on the anchor and re-insert the clip through the holes on the side of the joint socket, then rotate the loop over the joint into its original position. Withdraw the rod end and position over the ball on the second anchor and hold in place until the clip has been re-fitted.

STEP**ACTION**

10

Record the reading of the crackmeter (and thermistor if included) and the sensor serial number and retain in a safe place as the base (zero) reading of the instrument for data interpretation.

Please refer to Datasheets *RO-1-VW-NOTE Vibrating Wire Note* and *RO-1-VW-READ Vibrating Wire Readout* for details on Soil Instruments Vibrating Wire handheld readouts.



Make sure you record the readings from each crackmeter (and thermistor if included) during the preliminary test and after the installation as well as the sensor serial number and its location. Please refer to *Part III – Appendices – Appendix A - Installation Record Sheet Example* in this manual for details.

Wiring Identification

The four wires from the crackmeter are identified in the table below:

WIRE COLOUR	IDENTIFICATION
Red	Crackmeter sensor +
Black	Crackmeter sensor -
Green	Thermistor +
White	Thermistor -
Shield	Shield

SPLICING THE CABLE

Because Vibrating Wire transducers output frequency or period, a direct derivative of frequency rather than current or voltage, slight variations in cable resistance have no detrimental effect on the readings.

Consequently, splicing has no effect on instrument performance allowing cables to be spliced and routed to junction boxes and then connected to multi-conductor cables for transmission to a central location.

Part II – Data Reduction & Temperature Correction

Contents

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Calculation of Engineering Units From Frequency Based Units

OVERVIEW

The mathematical relationship between the frequency of vibration of a tensioned wire and the force applying the tension is an approximate straight line relationship between the square of the measured frequency and the applied force. '**Engineering units**' of measurement maybe derived from the '**frequency based units**' measured by vibrating wire readouts, in three traditional ways;

From '**period**' units ($t \times 107$) and from '**linear**' ($f^2/1000$) units using two methods; a simple '**linear**' equation or a '**polynomial**' equation.

CALCULATION USING PERIOD UNITS

The following formula is used for readings in '**period**' units.

$$E = K (10^7/P0^2 - 10^7/P1^2)$$

Where;

'**E**' is the '**pressure**' in resultant '**engineering units**,'

'**K**' is the '**period gauge factor**' for units of calibration (from the calibration sheet)

'**P0**' is the installation '**period base**' or '**zero**' reading

'**P1**' is the current '**period**' reading.

This method of calculation is used by Soil Instruments Vibrating Wire loggers' (models '**RO-1-VW**' and with serial numbers starting '**VL**' or '**TVL**') internal processors, for calculating and displaying directly on the loggers' LCD screen, the required '**engineering based units**'.

The loggers' require '**period base**' or '**zero**' reading units for entering into their channel tables, to calculate and display correctly the required '**engineering units**'.

If an '**engineering based unit**' is required other than the units of calibration, then the correct '**K**' factor will have to be calculated using the standard relationship between '**engineering units**'. For example, if the units of '**engineering**' required were in inches (") and the calibration units were millimetres (mm), we we can conclude that 1mm, is equal to 0.03937", so we would derive the '**K**' factor for inches by multiplying the '**K**' factor for millimetres by 0.03937.



A negative sign represents a decrease in length across the crackmeter anchor points.

CALCULATION USING LINEAR UNITS

The following formula is used for readings in '**linear**' units.

$$E = G (R_0 - R_1)$$

Where;

'**E**' is the resultant '**engineering unit**,'

'**G**' the '**linear gauge factor**' for the units of calibration (from the calibration sheet)

'**R₀**' is the installation '**linear base**' or '**zero**' reading

'**R₁**' is the current '**linear**' reading.

The '**linear gauge factor**' for units other than the units of calibration would need to be calculated using the same principles as stated in the '**Calculation Using Period Units**' section.

LINEAR UNIT CALCULATION USING A POLYNOMIAL EQUATION

'**Linear**' units may be applied to the following polynomial equation, for calculation of '**engineering units**' to a higher order of accuracy.

$$E = AR_1^2 + BR_1 + C$$

Where;

'**E**' is the resultant '**engineering unit**'

'**A**,' '**B**' and '**C**' the '**polynomial gauge factors**' (from the calibration sheet)

'**R₁**' is the current '**linear**' reading.

The value '**C**' is an offset value and relates to the '**zero**' value experienced by the transducer at the time of calibration.

This value should be re-calculated at the installation time as follows;

$$C = - (AR_0^2 + BR_0)$$

Where;

'**A**' and '**B**' are as above,

'**R₀**' is the installation '**linear base**' or '**zero**' reading.

Please note that the sign of the re-calculated value of '**C**,' should be the same as the original value of '**C**,' so if the original is negative then the re-calculated value should also be negative.

Conversion to '**engineering units**' other than the units of calibration, would best be done after conversion, using a factor calculated using the same principles as stated in the '**Calculation Using Period Units**' section.

Temperature Correction

The Vibrating Wire Crackmeter working elements are made primarily of steel and Stainless Steel and are affected by changing temperature to a certain predictable degree. In case of large temperature changes, application of temperature correction will improve the accuracy of the measurements.

The approximate temperature effect on the gauge is;
-0.02mm per °C
therefore a temperature increase of 10°C, will indicate;

(-0.02mm x 10) -0.2mm
to the result indicated by the crackmeter reading.

A fall in temperature will result in a positive change in linear measurement which can be corrected accordingly.

Barometric pressure changes do not affect the crackmeter reading.

ENVIRONMENTAL FACTORS

Since the purpose of the crackmeter installation is to monitor site conditions, factors which may affect these conditions should always be observed and recorded.

Seemingly minor effects may have a real influence on the behaviour of the structure being monitored and may give an early indication of potential problems.

Such factors include but are not limited to;

- Blasting
- Rainfall
- Tidal levels
- Excavation, fill levels and sequences
- Site traffic
- Temperature and barometric changes
- Changes in personnel reading the instruments
- Nearby construction activities
- Seasonal changes

Part III – Appendices

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Appendix A – Installation Record Sheet Example

Installer name	John Smith	Site name	Example Site
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Sensor serial number	Cal cert (match serial number)	Date	Preliminary test reading (F2/1000)	Location	Date	Installed 25% range reading (F2/1000)	Date	Reading from datalogger (F2/1000)
040901	Yes	01/01/14	4541.1	NB bay 1	01/01/14	5671.2	02/01/14	5671.4
040902	Yes	01/01/14	4562.2	NB bay 2	01/01/14	5669.3	02/01/14	5669.1
040903	Yes	01/01/14	4489.1	NB bay 3	01/01/14	5648.3	02/01/14	5648.5
040904	Yes	01/01/14	4550.3	NB bay 4	01/01/14	5667.2	02/01/14	5667.3
040905	Yes	01/01/14	4543.4	NB bay 5	01/01/14	5675.9	02/01/14	5675.7
040906	Yes	01/01/14	4540.8	NB bay 6	01/01/14	5637.2	02/01/14	5637.1
040907	Yes	01/01/14	4520.2	NB bay 7	01/01/14	5621.2	02/01/14	5621.1
040908	Yes	01/01/14	4529.6	NB bay 8	01/01/14	5632.3	02/01/14	5633.1
040909	Yes	01/01/14	4539.1	NB bay 9	01/01/14	5642.1	02/01/14	5641.9
040910	Yes	01/01/14	4540.4	NB bay10	01/01/14	5672.5	02/01/14	5672.1
040911	Yes	01/01/14	4552.3	NB bay11	01/01/14	5665.3	02/01/14	5664.9
040912	Yes	01/01/14	4549.8	NB bay12	01/01/14	5657.2	02/01/14	5656.9

Appendix B – Troubleshooting Guide

Before any of the steps below are followed, a Vibrating Wire readout unit should be used to verify the stability of the reading.

The method used to verify the signal will be dependent on which type of VW readout is being used; all Soil Instruments readouts use 'FFT' analysis, where as some other manufacturers use 'audio' signal.



Please refer to the manufacturers' user manual for details on the method required for verifying signal strength.

Please refer to Datasheets *RO-1-VW-NOTE Vibrating Wire Note* and *RO-1-VW-READ Vibrating Wire Readout* for details on Soil Instruments Vibrating Wire handheld readouts.

Wildly fluctuating readings from the sensor (or an unsteady audio signal) are both indications of possible problems with the instrument or related electrical cables.



If the readout is giving faulty readings or audio signals from all of the crackmeters, a faulty readout unit and/or lead must be suspected. Another lead/readout unit should be used to check the readings. If there is a fault with the readout unit, please contact www.itmsoilsupport.com for assistance.

STEP

ACTION

1

The resistance across the two conductors of the electrical cable should be tested using a multimeter. Check the resistance across the two conductors, either at the end of the cable if available, or at the corresponding terminals if wired into a Datalogger.

The resistance across the two conductors should be approximately 120Ω to 180Ω. The majority of this resistance will come from the crackmeter, approximately 130Ω, with the remainder from the electrical cable connected to the transducer (for 22 gauge copper, resistance is approximately 1Ω /15m).

Before proceeding, the continuity should be checked between conductors and the earthing screen of the electrical cable.

If continuity exists, a damaged cable is confirmed.

Appendix B – Troubleshooting Guide Continued

STEP	ACTION
2	<p>If the resistance across the two conductors is much higher than the values quoted in 'STEP 1', or is infinite, a severed cable must be suspected.</p> <p>If the location of the cable damage is found, the cable can be spliced in accordance with recommended procedure.</p>
3	<p>If the resistance across the two conductors is much lower than the values quoted in 'STEP 1', (less than 80 Ω) it is likely that cable damage has occurred causing a 'short' in the circuit.</p> <p>It is possible to calculate approximately how far from the cable end (or readout location) the suspected fault is. If the resistance of a known length of conducting cable is measured, a resistance/length unit can be found. This figure can be used to calculate the length of the conductor cable in between the readout location and the break in the circuit. If the location of the cable damage is found, the cable can be spliced in accordance with recommended procedure.</p>



This method is only applicable if the 'short' occurs between the two conductors of the electrical cable. Since cables are generally buried or hidden it is may not be possible to confirm a 'short' is of this nature using this method.

STEP	ACTION
4	<p>If the resistance is within the values quoted in 'STEP 1' and no continuity exists between the conductor and the earth screen AND the reading from the crackmeter is unstable or wildly fluctuating, it must be assumed that the integrity of the circuit is good and the fault lies within the crackmeter. In this case please contact our support team at itmsoilsupport.com.</p>

Appendix C – Calibration Sheet Example



BS EN ISO 9001:2008
FM 553710



Bell Lane, Uckfield, East Sussex t: +44 (0) 1825 765044 e: sales@itmsoil.com
TN22 1QL, United Kingdom f: +44 (0) 1825 744398 w: www.itmsoil.com

itmsoil group Ltd. Registered in England. Number: 4239206. Registered Office: Bell Lane, Uckfield, East Sussex TN22 1QL.

VIBRATING WIRE INSTRUMENTS CALIBRATION CERTIFICATE

Instrument Type : J2 Vibrating Wire Crack Meter Serial No. : 049836
 Instrument Range : 0.00 to 100.0 mm Calibration Date : 23/12/2013
Gauge Factors in mm Ambient Temperature : 22°C
 Period Gauge Factor (K): -177.6106000 Barometric Pressure : 1003 mbar
 Linear Gauge Factor (G): (mm/digit)-0.0177600 Calibration Technician : Mark Lintott
 Polynomial Gauge Factor A: 0.000000012298030 Calibration Equipment:
 Polynomial Gauge Factor B: 0.0175800900 Digital Micrometer Scale
 Vibrating Wire Data Recorder DR216
 Polynomial Gauge Factor C**: -80.099120 Regression Zero : 4545.1

Applied (mm)	Reading (Period)	Reading F ² /1000	Calculated (Linear)	Error %FS (Linear)	Linear Increment	Calculated (Polynomial)	Error %FS (Polynomial)
0.00	4692.5	4541.5	-0.064	-0.06	0.0	-0.006	-0.01
10.00	4424.0	5109.3	10.021	0.02	567.8	10.044	0.04
20.00	4199.4	5670.6	19.990	-0.01	561.3	19.986	-0.01
30.00	4007.4	6226.9	29.870	-0.13	556.3	29.847	-0.15
40.00	3832.9	6806.9	40.172	0.17	580.0	40.137	0.14
50.00	3685.2	7363.5	50.058	0.06	556.6	50.019	0.02
60.00	3551.8	7926.9	60.064	0.06	563.4	60.029	0.03
70.00	3432.7	8486.3	70.000	0.00	559.4	69.976	-0.02
80.00	3324.6	9047.3	79.964	-0.04	561.0	79.960	-0.04
90.00	3225.9	9609.3	89.945	-0.05	562.0	89.969	-0.03
100.00	3135.1	10174.3	99.980	-0.02	565.0	100.039	0.04

Formulae: Linear* E = G(R0 - R1)
 Polynomial** E = AR1² + BR1 + C

* The zero reading should be established on site by the user on installation.
 ** The site value of C must be calculated using the formula C = -(AR0² + BR0)

The instrument detailed herein has, as applicable, been tested and calibrated in accordance with procedures, which are part of our ISO 9001:2008 Quality Management System, and unless otherwise indicated, performs within ± 0.20% (Polynomial) as specified. Thus, the instrument conforms in all respects to our relevant specifications and drawings.

Certified: Line MANAGER

SUPPORT

www.itmsoilsupport.com

+44 (0) 1825 765044

soil

INSTRUMENTS

Bell Lane, Uckfield, East Sussex
TN22 1QL United Kingdom

t: +44 (0) 1825 765044
f: +44 (0) 1825 744398

e: info@itmsoil.com
w: www.itmsoil.com