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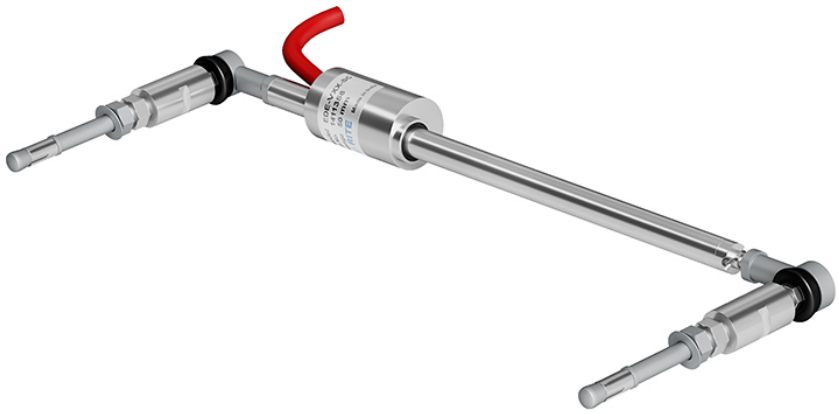
USERS' MANUAL

VIBRATING WIRE CRACK METER

MODEL EDJ-40V



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1 INTRODUCTION

This crack-joint meter is designed for surface joint measurement and consists of an EDE-VXX vibrating wire displacement transducer, fixed between anchors, installed on opposite sides of the crack-joint. It converts mechanical displacement to an electrical frequency output. This frequency output can be read or logged by Encardio-rite model EDI-54V remote digital readout unit, Encardio-rite model EDAS-10 data acquisition system or by model ESDL-30 datalogger via SDI-12 interface unit.

1.1 Features

- Corrosion proof, rugged, and robust construction.
- Easy to install.
- Reliable, accurate and simple to read.
- Adaptable to data loggers or data acquisition system.
- Rapid and accurate measurement can be made with tape extended in any direction.

1.2 Applications

Crack meter used to monitor cracks in:

- Concrete and arch dams.
- Concrete, rock, soil and masonry structures.
- Buildings affected due to nearby construction or excavation activity.

1.3 Conventions used in this manual

WARNING! Warning messages calls attention to a procedure or practice, that if not properly followed could possibly cause personal injury.

CAUTION: Caution messages calls attention to a procedure or practice, that if not properly followed may result in loss of data or damage to equipment.

NOTE: Note contains important information and is set off from regular text to draw the users' attention.

1.4 How to use this manual

This users' manual is intended to provide sufficient information for making optimum use of tape extensometer in various applications.

NOTE: The installation personnel must have a background of good installation practices and knowledge of the fundamentals of geotechnics. Novices may find it very difficult to carry on installation work. Intricacies involved in installation are such that even if a single essential but apparently minor requirement is ignored or overlooked, the most reliable of instruments will be rendered useless.

A lot of effort has been made in preparing this instruction manual. However, the best of instruction manuals cannot provide for each and every condition in the field, which may affect the performance of the instrument. Also, blindly following the instruction manual will not guarantee success. Sometimes, depending upon field conditions, the installation personnel will have to consciously depart from the written text and use their knowledge and common sense to find solution to a particular problem.

To make this manual more useful we invite valuable comments and suggestions regarding any addition or enhancement. We also request to please let us know of any errors that are found while going through the manual.

This manual is divided into a number of sections. Each section containing a specific type of information. The list given below tells you where to look for in this manual if you need some specific information.

It is however recommended that you read the manual from the beginning to the end to get a thorough grasp of the subject. You will find lots of unexpected information in the sections you feel you may skip.

2 VIBRATING WIRE CRACK METER

2.1 Operating principle

Vibrating wire displacement sensor basically consists of a magnetic, high tensile strength stretched wire, one end of which is anchored and other end fixed to a shaft through a precision coil spring that deflects in some proportion to displacement. Any change in position of shaft, deflects the spring proportionally and this in turn affects tension in the stretched wire. Thus any change in displacement, directly affects tension in the wire and thus frequency of vibration.

The wire is plucked by a coil magnet. Proportionate to tension in wire, it resonates at a frequency 'f', which can be determined as follows:

$$f = [\sigma g/\rho]^{1/2}/ 2l \text{ Hz}$$

where σ = tension of wire in kg/cm^2
g = 980 cm/sec^2
ρ = density of wire in kg/cm^3
l = length of wire in cm

The length of the wire in the displacement sensor is 5.5 cm. Consequently the formula can be reduced to:

$$\mathbf{f = 32 [\sigma]^{1/2} Hz}$$

The resonant frequency, with which the wire vibrates, induces an alternating current in the coil magnet. The displacement is proportional to square of frequency and the readout unit is able to display this directly in engineering units.

2.2 General description

The Encardio-rite model EDJ-40V crack/joint meter consists of a displacement transducer, fixed between anchors on opposite side of the crack or joint. EDJ-40V crack meter measures the relative displacement between anchors (in one dimension) with passage of time. It basically consists of an independent orthogonally mounted vibrating wire linear displacement transducer with ball joints at both the ends, anchored to any structure or concrete slab at opposite sides of the joint or crack, to resolve the relative movement along the perpendicular direction (or axes).

The displacement transducer converts the mechanical displacement to an electrical output. Model EDI-54V portable readout unit is available to take readings. The sensors can also be connected to automatic dataloggers like model ESDL-30 through vibrating wire interface or to model EDAS-10 data acquisition system through busmux or multiplexers, for continuous/online monitoring.

3 TOOLS & ACCESSORIES REQUIRED FOR INSTALLATION

The following tools and accessories are required for proper installation of the crack/joint meter:

1. Spanner size 8, 13 & 14 no.
2. Pliers
3. Measuring steel tape
4. EDI-54V read-out logger
5. Multimeter
6. Cable ties, Cloth for cleaning (lintless)

4 PRE-INSTALLATION CHECK

The displacement transducers should be checked for proper operation (including the thermistor) before installation.

CAUTION: The displacement sensor is a delicate and sensitive instrument. It should be handled with care. Twisting or applying too much force on the shaft with respect to the sensor body may result in a zero shift or even permanent damage. Always displace shaft axially while checking or installing sensor.

The shaft end is provided with an alignment pin that sits inside an alignment slot on sensor body. When not in use or while tightening sensor against a shaft mounting object, keep the pin engaged inside the slot to prevent any damage to the sensor by rotation of sensor against shaft body.

Check the sensors before installation. Four core signal cable from the displacement sensor has red and black cores for frequency signal; green and white for temperature monitoring through a thermistor. Check working of sensor as follows:

Displacement sensor

- Connect sensor to model EDI-54V readout unit. With displacement shaft in retracted position enter sensor constants from Test Certificate and set reading in engineering units at zero mm.
- Using a scale, move the shaft by about 5 mm. The readout unit should read around 5 mm. This change in reading ensures proper functioning of displacement sensing system.
- Check the coil resistance by the digital multimeter, value should lie between 130-180 Ohm.
- Switch EDI-54V indicator to Temperature mode; the displayed temperature should be near to the ambient temperature.

5 INSTALLATION PROCEDURE

The crack meter is installed as per figure-1. Two holes are drilled on either side of crack, at a distance 'A' given in table-1, depending on the range of sensor used. The displacement sensors are provided with ball joints and threaded spacer at both ends that are mounted on the Hilti anchors ("Hilti" type HSA-M8 x 75). EDJ-40V is fixed to the location across crack/joint with these Hilti anchors. The initial reading of the sensor is taken as the base. Subsequent readings are then compared with the initial reading to determine the magnitude of change in displacement across the opening.

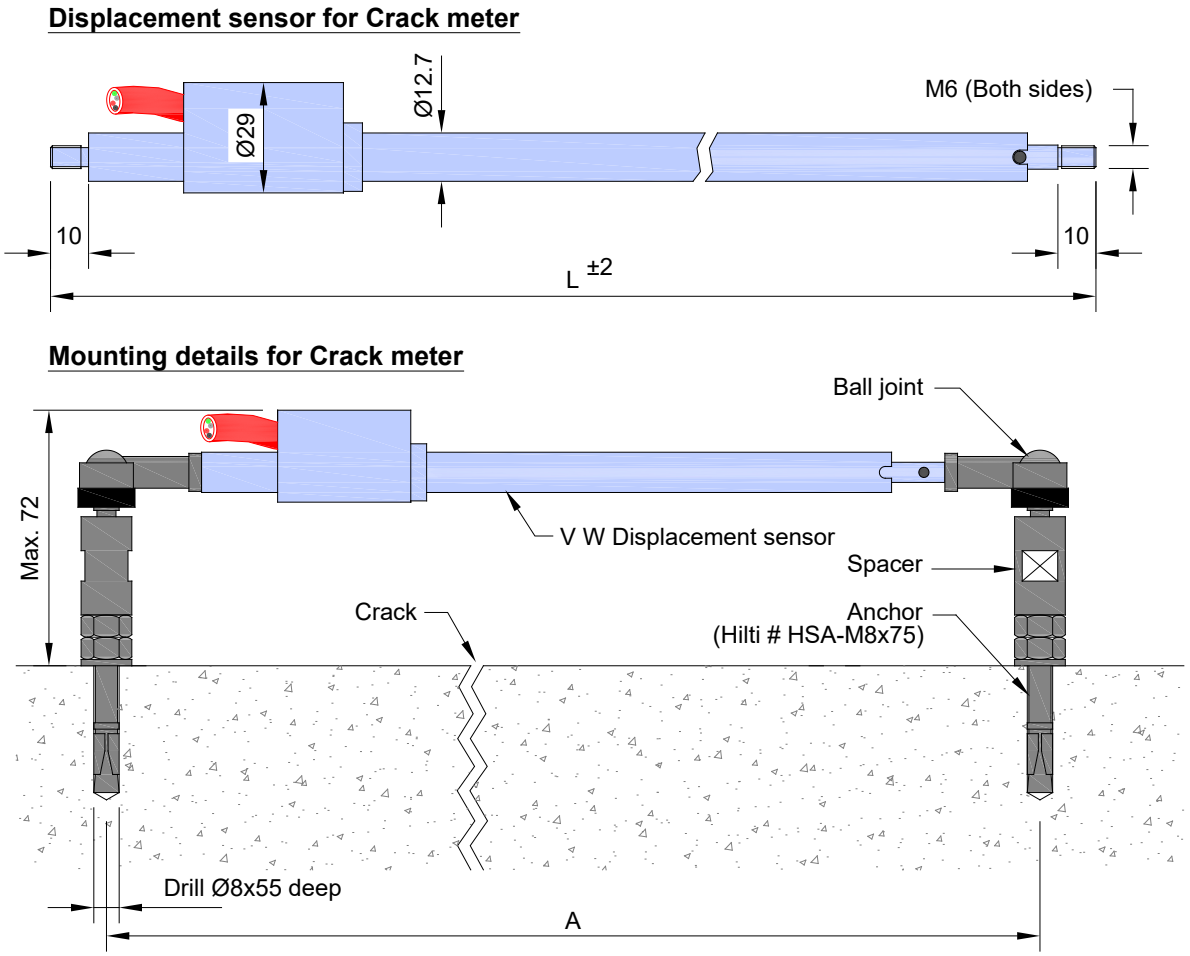
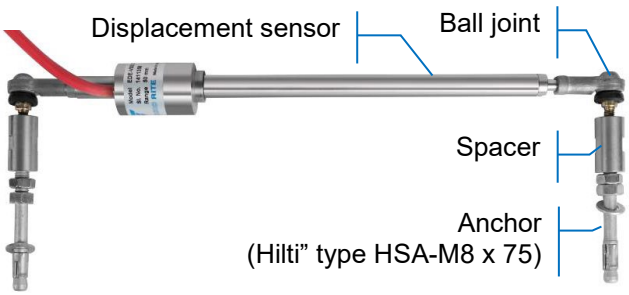


Figure 1: Installation of crack/joint meter

1. Drill a hole 8 mm diameter, 55 mm deep on one side of the crack along a line perpendicular to the direction of crack. Take care that the hole is drilled perpendicular to the surface. Clean the hole with an air-pump.
2. Drill another 8 mm diameter, 55 mm deep hole on the other side of the crack as shown in the figure.
3. Remove the expandable anchors from EDJ-40V assembly and insert it inside respective holes upto the end.
4. Loosely screw the locking nut on both the anchors.



EDJ-40V crack/joint meter

5. Tighten the spacers with the ball joints using spanners size 8 and 14 mm.
6. Fix the displacement sensor assembly (with ball joints and spacers) to Hilti anchors; manually screwing the spacer by rotating it around the anchor (spacer is free to rotate around ball joint).
7. Tighten the spacer and anchors joint using spanners size 14 and 13 mm.

Range mm	L mm	A mm (half open position)
15	207	~ 255
25	222	~ 275
50	292	~ 357

Table 1: Installation details

8. Check displacement reading of sensors with the model EDI-51V read-out logger. Reset zero in read-out logger as described in the instruction manual. Subsequent readings in the EDI-51V will determine relative displacement between anchors.
9. Connect leads to connector pins in junction box. The data from the sensor can be transmitted from the junction box to a central data acquisition system.

CAUTION: Never rotate shaft of displacement sensor with respect to the outside body. This will permanently damage the sensor. During installation push or pull shaft only axially. A pin has been provided at the end of displacement sensor that sits flush in a groove in sensor body. During assembly operation and while using spanners for tightening, keep sensor in closed position with pin seated inside groove such that no torque is exerted on its shaft and there is no rotational movement.

CAUTION: Do not use thread sealant on any thread while mounting the sensor as it may have to be replaced at a later date.

5.1 Taking readings with the model EDI-54V vibrating wire indicator

The model EDI-54V vibrating wire indicator (figure 2) is a microprocessor-based read-out unit for use with Encardio-rite's range of vibrating wire sensors. It can display the measured frequency in terms of time period, frequency, frequency squared or the value of measured parameter directly in proper engineering units. It uses a smartphone with Android OS as readout having a large display with a capacitive touch screen which makes it easy to read the VW sensor.

Figure 2 – Vibrating wire indicator

The EDI-54V vibrating wire indicator can store calibration coefficients from 10,000 vibrating wire sensors so that the value of the measured parameter from these sensors can be shown directly in proper engineering units. For transducers with built-in interchangeable thermistor, it can also display the temperature of the transducer directly in degree Centigrade.

The vibrating wire indicator has an internal non-volatile memory with sufficient capacity to store about 525,000 readings from any of the programmed sensors. Each reading is stamped with the date and time the measurement was taken.

Refer instruction manual WI-6002.112 of model EDI-54V for entering the transducer calibration coefficients. The gage factor of the model EDS-70V borehole extensometer is given in the test certificate provided with every supply. The initial reading IR will be the actual reading in digits from the sensors fixed to the borehole extensometer after the complete assembly, anchors are properly set in grout mixture.

An internal 6 V 4 Ah rechargeable sealed maintenance-free battery is used to provide power to the vibrating wire indicator. A battery charger is provided to charge the internal battery which operates from 90 V to 270 V AC 50 or 60 Hz V AC mains. A fully discharged battery takes around 6 hours to get fully charged. The indicator uses a smartphone as a readout that has its own internal sealed rechargeable Li-ion maintenance battery as a power source. A separate battery charger/adapter unit for the smartphone, operating from universal AC mains supply is supplied with each EDI-54V indicator unit.

The EDI-54V vibrating wire indicator is housed in an impact resistant plastic moulded housing with weatherproof connectors for making connections to the vibrating wire transducer and the battery charger.

5.2 Sample test certificate

TEST CERTIFICATE

Instrument : Vibrating wire displacement sensor
Serial number : xxxxxxx Date : 07.04.2018
Capacity : 50 mm Temperature : 28°C

Input Displacement (mm)	Observed value Up1 (Digit)	Up2 (Digit)	Average (Digit)	End Point Fit (mm)	Poly Fit (mm)
0.00	2261.3	2250.4	2250.4	2255.9	0.00	0.00
10.00	3515.5	3489.3	3503.2	3509.4	10.10	10.01
20.00	4761.3	4736.0	4750.6	4755.9	20.15	20.01
30.00	5997.7	5977.4	5989.9	5993.8	30.13	29.99
40.00	7233.3	7215.3	7226.5	7229.9	40.09	40.00
50.00	8459.3	8459.3	8458.9	8459.1	50.00	50.00
				Error (%FS)	0.30	0.02

Digit : f ²/1000
Linear gage factor (G) : 8.0603E-03 mm/digit
Thermal factor (K) : 0.011 mm/°C
Polynomial constants :
A= 1.5269E-08 B= 7.8979E-03 C= -1.7899E+01

Displacement "D" is calculated with the following equation:
Linear : D(mm) =G(R1-R0)-K(T1-T0)
Polynomial : D(mm) = A(R1)² + B(R1) + C -K(T1-T0)-D0
R1 = current reading & R0 is initial reading in digit.
D0 = Initial reading in mm

Zero reference (initial position) in the field must be established by recording the initial reading R0 (digit) along with temperature T0 (°C) just after installation.

Note : Zero displacement reading given in above calibration chart is taken at around 3 mm from mechanical zero, i.e. slider fully in

Pin configuration/wiring code: Red & black: Signal Green & white: Thermistor

CAUTION: Never rotate shaft of displacement sensor in respect to the outside body. This will permanently damage the sensor. During checking pull or push shaft only axially. A pin has been provided at end of displacement sensor that sits flush in a groove in sensor body.

6 THERMISTOR - TEMPERATURE RESISTANCE CORRELATION

6.1 Thermistor - temperature resistance correlation

Thermistor type Dale 1C3001-B3

Temperature resistance equation

$T = 1/[A + B(LnR) + C(LnR)^3] - 273.2\ ^oC$

where T = temperature in ^oC
LnR = Natural log of thermistor resistance
A = 1.4051×10^{-3}
B = 2.369×10^{-4}
C = 1.019×10^{-7}

Ohm	Temp. °C	Ohm	Temp. °C	Ohm	Temp. °C
201.1k	-50	16.60K	-10	2417	+30
187.3K	-49	15.72K	-9	2317	31
174.5K	-48	14.90K	-8	2221	32
162.7K	-47	14.12K	-7	2130	33
151.7K	-46	13.39k	-6	2042	34
141.6K	-45	12.70K	-5	1959	35
132.2K	-44	12.05K	-4	1880	36
123.5K	-43	11.44K	-3	1805	37
115.4K	-12	10.86K	-2	1733	38
107.9K	-41	10.31K	-1	1664	39
101.0K	-40	9796	0	1598	40
94.48K	-39	9310	+1	1535	41
88.46K	-38	8851	2	1475	42
82.87K	-37	8417	3	1418	43
77.66K	-36	8006	4	1363	44
72.81K	-35	7618	5	1310	45
68.30K	-34	7252	6	1260	46
64.09K	-33	6905	7	1212	47
60.17K	-32	6576	8	1167	48
56.51K	-31	6265	9	1123	49
53.10K	-30	5971	10	1081	50
49.91K	-29	5692	11	1040	51
46.94K	-28	5427	12	1002	52
44.16K	-27	5177	13	965.0	53
41.56k	-26	4939	14	929.6	54
39.13K	-25	4714	15	895.8	55
36.86K	-24	4500	16	863.3	56
34.73K	-23	4297	17	832.2	57
32.74K	-22	4105	18	802.3	58
30.87K	-21	3922	19	773.7	59
29.13K	-20	3748	20	746.3	60
27.49K	-19	3583	21	719.9	61
25.95K	-18	3426	22	694.7	62
24.51K	-17	3277	23	670.4	63
23.16K	-16	3135	24	647.1	64
21.89K	-15	3000	25	624.7	65
20.70K	-14	2872	26	603.3	66
19.58K	-13	2750	27	582.6	67
18.52K	-12	2633	28	562.8	68
17.53K	-11	2523	29	525.4	70

6.2 Measurement of temperature

Thermistor for temperature measurement is incorporated in each crack/joint meter. The thermistor gives a varying resistance output related to the temperature (see § 5). The thermistor is connected between the green and white leads. The resistance can be measured with an Ohm meter. The cable resistance may be subtracted from the Ohm meter reading to get the correct thermistor resistance. However the effect is small and is usually ignored.

The Encardio-rite model EDI-54V read-out unit gives the temperature from the thermistor reading directly in engineering units.

6.3 Temperature correction

Each vibrating wire displacement sensor is relatively insensitive to temperature variations within certain limits and often the effect of temperature can be ignored. However in case a 'displacement - temperature variation' correlation is required, correction for the temperature effect on the sensor can be made by making use of the temperature zero shift factor (K) provided in the test certificate (see § 2.5) and substituting it in the following equation:

$d_{correction}$ = (current temperature - initial temperature) x K

The temperature correction value is subtracted from the displacement reading from the EDI-54V read-out.

7 TROUBLE SHOOTING

The crack/joint meter is installed during construction of the structure. Once installed, the cell is usually inaccessible and remedial action is limited. Maintenance and trouble shooting is consequently confined to periodic checks of cable connection and functioning of the read-out unit. Refer to the following list of problems and possible solutions should problems arise. For any additional help, consult the factory.

7.1 Symptom: displacement sensor reading unstable

- Check the insulation resistance. The resistance between any lead and the protective armour should be > 500 M Ohm. If not, cut a meter or so from the end of cable and check again.
- Does the read-out work with another crack/joint meter? If not, the read-out may have a low battery or be malfunctioning. Consult the manual of the readout unit for charging or trouble shooting instructions.
- Use another read-out unit to take the reading.
- Check if there is a source of electrical noise nearby. General sources of electrical noise are motors, generators, transformers, arc welders and antennas. If so the problem could be reduced by shielding from the electrical noise.

7.2 Symptom: displacement sensor fails to read

- The cable may be cut or crushed. Check the nominal resistance between the two gage leads using an Ohm meter. It should be within 130 - 180 Ohm. The correct value is given in the test certificate. Please add the cable resistance when checking. If the resistance reads infinite or a very high value, a cut in the cable is suspected. If the resistance reads very low (<100 Ohm), a short in the cable is likely.
- Does the read-out work with another displacement sensor? If not, the read-out may have a low battery or be malfunctioning. Consult the manual of the readout unit for charging or trouble shooting instructions.
- Use another read-out unit to take the reading.

8 WARRANTY

The Company warrants its products against defective workmanship or material for a period of 12 months from date of receipt or 13 months from date of dispatch from the factory, whichever is earlier. The warranty is however void in case the product shows evidence of being tampered with or shows evidence of damage due to excessive heat, moisture, corrosion, vibration or improper use, application, specifications or other operating conditions not in control of Encardio-Rite. The warranty is limited to free repair/replacement of the product/parts with manufacturing defects only and does not cover products/parts worn out due to normal wear and tear or damaged due to mishandling or improper installation. This includes fuses and batteries

If any of the products does not function or functions improperly, it should be returned freight prepaid to the factory for our evaluation. In case it is found defective, it will be replaced/repaired free of cost.

A range of technical/scientific instruments are manufactured by Encardio-rite, the improper use of which is potentially dangerous. Only qualified personnel should install or use the instruments. Installation personnel must have a background of good installation practices as intricacies involved in installation are such that even if a single essential but apparently minor requirement is ignored or overlooked, the most reliable of instruments will be rendered useless.

The warranty is limited to as stated herein. Encardio-rite is not responsible for any consequential damages experienced by the user. There are no other warranties, expressed or implied, including but not limited to the implied warranties of merchantability and of fitness for a particular purpose. Encardio-rite is not responsible for any direct, indirect, incidental, special or consequential damage or loss caused to other equipment or people that the purchaser may experience as a result of installation or use of the product. The buyer's sole remedy for any breach of this agreement or any warranty by Encardio-rite shall not exceed the purchase price paid by the purchaser to Encardio-rite. Under no circumstances will Encardio-rite reimburse the claimant for loss incurred in removing and/or reinstalling equipment.

A lot of effort has been made and precaution for accuracy taken in preparing instruction manuals and software. However best of instruction manuals and software cannot provide for each and every condition in field that may affect performance of the product. Encardio-rite neither assumes responsibility for any omissions or errors that may appear nor assumes liability for any damage or loss that results from use of Encardio-rite products in accordance with the information contained in the manuals or software.

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