

DATA SHEET



VERTICAL IN-PLACE INCLINOMETER

MODEL EAN-52M

INTRODUCTION

Encardio-rite model EAN-52M vertical in-place inclinometer is used to measure lateral movement of earthworks or structures. It provides significant quantitative data on magnitude of inclination or tilt of a foundation, embankment or slope and its variations with time. It also provides the pattern of deformation, zones of potential danger and effectiveness of construction control measures undertaken.

With suitable datalogger, the data is transmitted over cellular network or RF network, to provide real-time data to stake holders, with instant alarms. This allows the authorities to have early warning in case of failures, helping them to take timely decisions and actions.

FEATURES

- Reliable, accurate and simple to read.
- Proven technology.
- Rugged and robust construction.
- Excellent temperature stability.
- Can be easily connected to a remote data acquisition system for continuous monitoring.

APPLICATION

- To accurately measure lateral movement of structures, retaining & diaphragm walls, piles etc
- Monitor lateral movement in embankment fills, earthworks and landslide areas
- Monitor deflection, rotation, movement at shear zone and stability in dams and tailings
- Construction control, stability investigation and monitoring of ground movement caused by tunneling and deep excavations



EAN-52M IPI SYSTEM

The in-place inclinometer (IPI) sensor array (chain) is used for determination of sub-soil ground displacement profile over depth. A series of inclinometer access tubes, attached to each other, are installed in a borehole or embedded in earth/rock fill or concrete structure during construction or fixed to the vertical face of a completed structure. The IPI system consisting of string of tilt sensors is positioned inside the inclinometer casing to span the movement zone.

Each digital tilt sensor with SDI-12 serial interface output is fitted with a pair of pivoted sprung wheels and connected to rigid bars (gage tube) of desired length. The total length of tilt sensor plus the length of gage tube forms the gage length for that particular tilt sensor. The IPI chain consists of tilt sensor and gage tube assemblies connected together end to end to form an array of sensors.

A single 3 conductor bus cable is threaded in a daisy chain fashion connecting each sensor to its next immediate neighbor in the IPI chain and finally to the top of the borehole and directly to the datalogger.

The sensor gage lengths can either be all of equal length in a chain or may have different lengths at different depths. Gage lengths varies from 1 m to 3 m.

A suspension stainless steel wire rope is available to position a single or group of sensors where profile of entire borehole is not of interest but only a specific portion needs monitoring.

OPERATION

When sub-soil ground displacement occurs, the inclinometer casing changes shape with sub soil ground movement and the IPI chain of tilt sensors measure the deviation of the casing as a series of connected straight lines, the straight lines being the gage length of the individual tilt sensors.

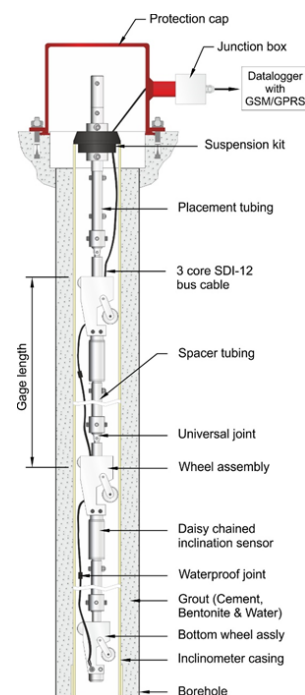
This results in change in output of the sensors, proportional to the tilt i.e the angle of inclination from the vertical. This tilt reading can be converted to lateral deviation - " $L \sin \theta$ " where L is gage length and θ is angle of tilt from vertical.

Displacement i.e. the lateral movement of casing can be calculated by subtracting initial deviation from current deviation. Provided that one end of the access tubing is known to be fixed, it is possible to obtain a complete profile of the access tubing by summing readings of successive sensors. By comparing these profiles, the horizontal displacement of the gage well at different depths over a period of time may be determined

SYSTEM COMPONENTS

Following sub-assemblies are available in the Encardio-rite in-place inclinometer system:

EAN-52M/1.1	Uniaxial sensor with SDI-12, with pair of wheels.
EAN-52M/1.2	Biaxial sensor with SDI-12, with pair of wheels.
EAN-52M/2-X	Gage tube for 1 m, 1.5 m, 2 m and 3 m gage length. 'X' suffix represents gage length required.
EAN-52M/3	Wheel assembly.
EAN-52M/4	Suspension kit with protective cap.
EAN-52M/5	Placement tubing (specify length) for placing string of sensors
EAN-52M/6	Protective rope to prevent loss of sensor down hole.
EAN-52M/7	Suspension stainless steel wire rope for positioning single or group of sensors in specific portion of bore-hole
CS-1002	3 core SDI-12 bus cable for sensors with SDI-12 card
Casings	For casing refer to datasheet 1918 on inclinometer casing





DATALOGGING

In-place inclinometer system is connected to Encardio-rite model ESDL-30 datalogger for continuous monitoring of the movements. The datalogger has the facility to collect and store recorded data and transfer it to a central remote server at desired intervals over a wired or cellular telemetry link.

If specifically requested, the datalogger at additional cost can be programmed to process inputs from different IPI bore-holes. However, this includes some limitations on the total number of sensors or IPI strings being connected, based on site conditions. Theoretically, three chains of up to 61 sensors can be connected to the datalogger. However, consult factory in case you have to install more than 60 sensors to the datalogger.



The datalogger is housed in a weatherproof enclosure making it suitable for harsh environment.

A data management software (Drishti) can be installed at a central server to process and analyse the data. In case any value breaches programmed alert level, the system sends an alarm to the stakeholders via SMS or email.

SPECIFICATION

IPI Sensor

Sensor	Uniaxial or biaxial sensor; with SDI-12 digital interface
Measuring range	$\pm 15^\circ$
Accuracy¹	$\pm 0.1\%$ fs
Resolution	± 0.05 mm/m (8 arc seconds)
Temperature range	-20°C to 80°C
Water protection	Up to 100 mwc
¹As tested under lab conditions	



Input	Sensor with digital output
Scan/upload interval	5 seconds to 168 hours
Memory capacity	Flash Memory (64-Mbit); 2 Million data points
Communication port	RS-232 (Standard) 115 kbps
Temperature limit	-30 to 70°C
Power supply	2 x D size 3.6 V/19 Ah Lithium cells, or 2 x D size 1.5 V Alkaline high power cells, or 12V SMF battery chargeable from AC mains or solar panel
Antenna	Built-in or separately mounted antenna
Housing	Corrosion resistant weather proof

ESSENTIAL CONSIDERATIONS

1. Manual readings:

Before installing the IPI chain, take initial x-y profile of inclinometer casing with Encardio-rite model EAN-26M manual inclinometer system. The inclinometer probe gives true x-y profile of borewell with a gage length of 0.5 m. In case any abnormal movement is observed later on from the installed IPI chain, the borehole profile can be verified by removing the IPI chain and taking a fresh set of readings manually (and comparing it with the reference readings to check any abnormality).

2. As-built coordinates:

Determine initial Northing (X), Easting (Y) and Elevation (Z) by surveying of top of inclinometer casing after the casing is set in the borehole.

The above two steps should never be ignored. The data observed should be stored properly for future reference. Refer to section 1.4 of User's Manual model EAN-52MV.



3. Gage tubes in tension state:

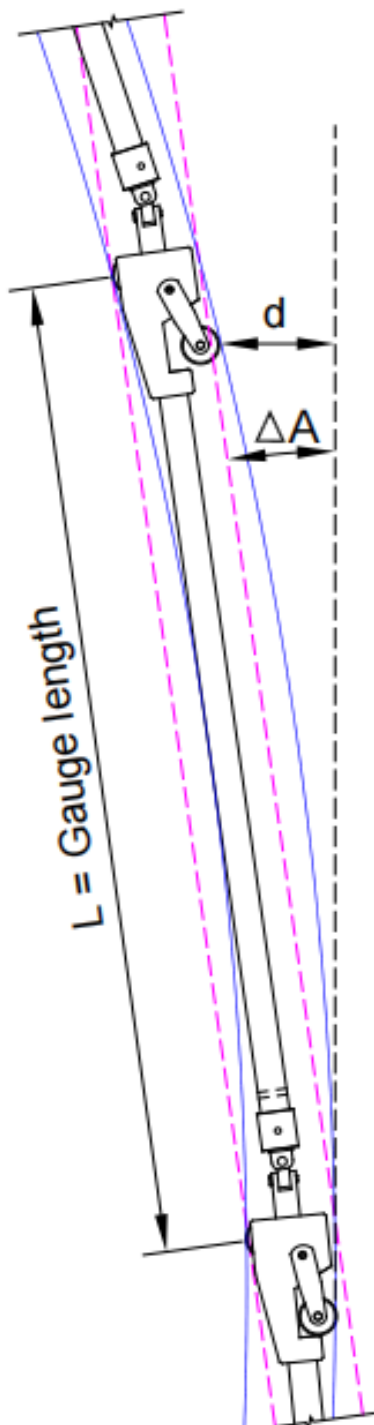
Never let the IPI chain rest on the bottom wheel assembly. It should always be hanging such that all the gage tubes are in tension.

4. Select gage lengths for the IPI chain judiciously:

Gage length is the distance between the wheel assemblies of adjacent sensors. For best profiling of the borewell, it should be ensured that the entire gage length at each sensor position remains perfectly straight. If the borewell (i.e. the casing) deforms much over the gage length of any sensor position, the curvature introduced in the casing will foul the gage length of the sensor at that particular

location. After a certain amount of allowed range of deformation, further deviation will cause the sensor gage tubing to touch the inclinometer casing and introduce a curvature in the gage tubing.

This will introduce an error while plotting the sub-soil displacement profile at that location, as the plotting assumes that each gage tubing is a perfect straight-line segment. The accompanying diagram shows at what deformation limit the gage tubing touches the casing and why.



Below we list the range of allowed deformation in the inclinometer casing (consequently the borehole itself) that will give proper result while plotting the displacement profile.

If the allowed casing deformation is exceeded, it will result in an error while plotting the displacement profile - more the deformation more the error.

Sensor Gage Length L (m)	Maximum measurable angular deviation ΔA (deg)	Maximum allowed displacement over 1 m borehole length ΔAm (deg/m)	Maximum allowed lateral movement d_{max} (mm per m)
1.0	9.6	9.6	167
1.5	6.4	4.8	111
2.0	4.8	2.4	84
3.0	3.2	1	56

The above values have been calculated using EAN-52 IPI chain in 70 mm od, 58 mm id inclinometer casing, assuming that the sub-soil movement is causing a circular bend in the inclinometer casing, for ease of calculation.

For 85 mm od inclinometer casing, please contact factory for suitable IPI sensors and recommended gage lengths.

The IPI chain measures displacement at the adjacent sensor points, considering that the gage tube is in a straight line. Any localized displacement between the sensor points will therefore not be measured by the IPI chain.

Designer should take the above factors into consideration while deciding upon the gage length. The shorter gage lengths normally give more reliable and accurate data as compared to larger gage lengths.

The gage lengths should be optimized depending upon site conditions and important zones to have a reliable as well as cost effective system. Gage lengths can vary within an individual installation;

for example - an IPI installed in an inclinometer casing in a landslide area may use 3 m gage lengths in the upper zone and 1 m gage lengths in the expected slip zone.

REAL-TIME WEB-BASED DATA MANAGEMENT SYSTEM

Drishti, our cloud-hosted data management software, is available to process and manage the data collected at project site for further analysis and evaluation.

The real time data is accessible to all stakeholders 24X7, with instant alarms on critical events.

The early warnings help in taking timely corrective action to prevent damages and minimize delays and operational costs.



Drishti is a powerful tool that gives the user complete control of their project data. It offers an interactive user interface, taking care of all database interactions automatically.

The real time display, graphs & reports can be viewed using popular web browsers like Microsoft Internet Explorer, Google Chrome or Mozilla Firefox amongst others. It allows multiple authorized users at different locations to view any data or report from the same project site simultaneously. Data can be accessed from any type of device, like a desktop, laptop, tablet or smart phone, that supports a standard web browser.

Drishti data-management system runs on secure cloud server or locally on a customer's server.

- Encardio-rite offers web based data management as a service through Drishti hosted on a reliable cloud server. Data is made available to multiple users with very low downtime. User has to pay a small setup fee for first time and then a monthly rental has to be paid for accessing the data over the cloud as long as required.
- Drishti is also available as a data management software where data is required on local server. Drishti is installed locally to store the data in-house with required security levels.

*All specifications are subject to change without prior notice

DATASHEET | 1182-12 R02



TUNNELS



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