ENCARDIO RITE

ONE STOP MONITORING SOLUTIONS | HYDROLOGY | GEOTECHNICAL | STRUCTURAL | GEODETIC
Over 55 years of Excellence through ingenuity

DATASHEET

DIGITAL IN-PLACE INCLINOMETER

MODEL EAN-56

INTRODUCTION

Encardio-rite model EAN-56 digital in-place inclinometer system (vertical) comprises of an array of tilt sensors with specific gage lengths that are installed inside a standard grooved inclinometer casing for real-time lateral movement monitoring in critical applications. The IPI system is commonly used to measure lateral movement of earthworks or structures. It provides significant quantitative data on magnitude of inclination (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.

The IPI with SDI-12 and ModBus output options can be connected to any suitable datalogger with either GSM/GPRS or RF wireless data transmission facility to send data to central/cloud server. The IPI system with real-time monitoring and instant alarms feature helps to provide early warning in case of failures, helping the authorities to take timely decisions and actions.

FEATURES

- Reliable, accurate and simple to read.
- Proven technology.
- Rugged and robust construction.
- Excellent temperature stability.
- The digital sensors have both SDI-12 and Modbus output options, making it versatile for commonly used digital datalogger

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-56 IPI SYSTEM

The in-place inclinometer (IPI) sensor array (chain) is used for determination of sub-soil ground displacement profile over a certain 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 a string of tilt sensors is positioned inside the inclinometer casing to span the movement zone.

Each tilt sensor with digital output (SDI-12 and Modbus) 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 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.

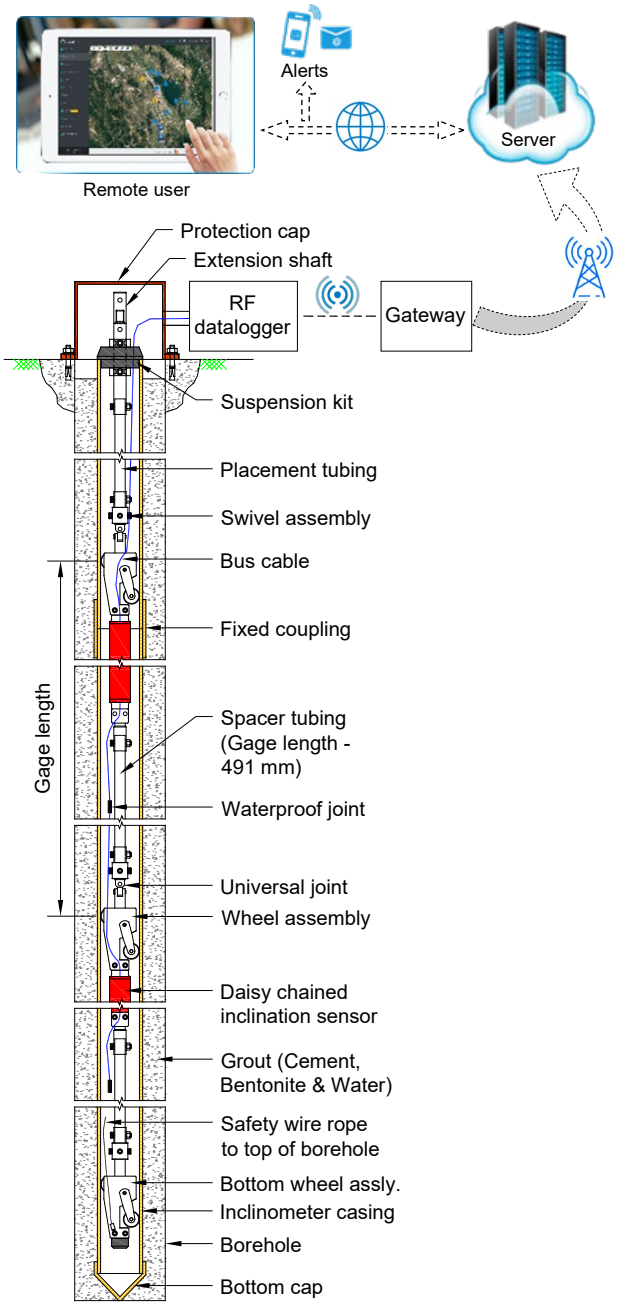
This results in change in output of the sensors, proportional to the tilt i.e the angle of inclination from the vertical. This tilt reading can be converted to lateral deviation - "L sin θ" where L is gage length and θ is angle of tilt from vertical.

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 model EAN-56 in-place inclinometer system:

EAN-56/1	Biaxial IPI sensor with SDI-12 and Modbus (RS-485) output, with pair of wheels.



EAN-56 In-place inclinometer system with RF datalogger and gateway

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 borehole
CS-0703	Bus cable
Casings	For casing refer to datasheet 1918-17 on "Inclinometer casing"

SPECIFICATION

IPI tilt sensor

Sensor	Digital biaxial IPI sensor
Measuring range	± 15°
Accuracy[1]	± 0.1% fs
Resolution	± 0.05 mm/m (8 arc seconds)
Output	Modbus (RS-485)
Temperature range	-20°C to 80°C

[1] *As tested under lab conditions*

DATALOGGER-GSM/GPRS DATA TRANSMISSION

EAN-56 digital in-place inclinometer system can be connected to any digital datalogger suitable for SDI-12 or Modbus (RS-485) sensors, for continuous real-time monitoring of the movements taking place.

SDI-12 Output

When used with SDI-12 output, a maximum of 61 sensors can be used in an IPI chain and maximum distance of datalogger from the IPI gagewell can be up to 200 m.

Encardio-rite model ESDL-30 datalogger can be connected 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.

If specifically requested, the datalogger at additional cost can be programmed to process inputs from different IPI boreholes. 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 has GSM-GPRS modem to transfer the recorded data wirelessly to a central/cloud server via cellular network. It is housed in a weatherproof enclosure making it suitable for harsh environment.

SPECIFICATION

ESDL-30 datalogger

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 enclosure

Modbus Output

When used with Modbus output, a maximum of 32 sensors can be used in an IPI chain and maximum distance of datalogger from the IPI location can be 1.2 km. Any suitable Modbus datalogger can be used.

Model ESDL-30 datalogger can also be used with an additional Modbus card, if specifically ordered. However, maximum limit of Modbus IPI tilt sensors that can be connected to this ESDL-30 datalogger version is seven.

DATALOGGER-RF DATA TRANSMISSION

IPI can be connected to any suitable RF datalogger that is capable to transfer the recorded data via long-range radio frequency to a gateway installed at a distance. A single gateway can support a number of RF dataloggers/nodes. The gateway uploads all the collected sensor data to the central/cloud server at desired intervals, via cellular network or internet line.

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 (Y) 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.

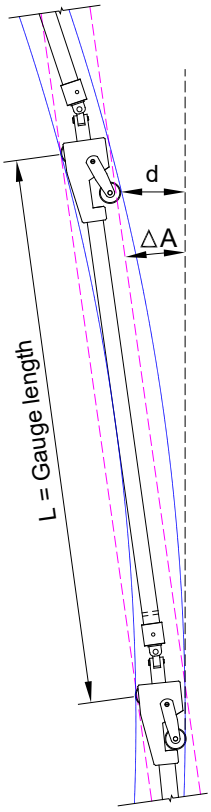
4. Select gage lengths for the IPI chain judiciously:

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 ΔA_m (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 these 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.

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