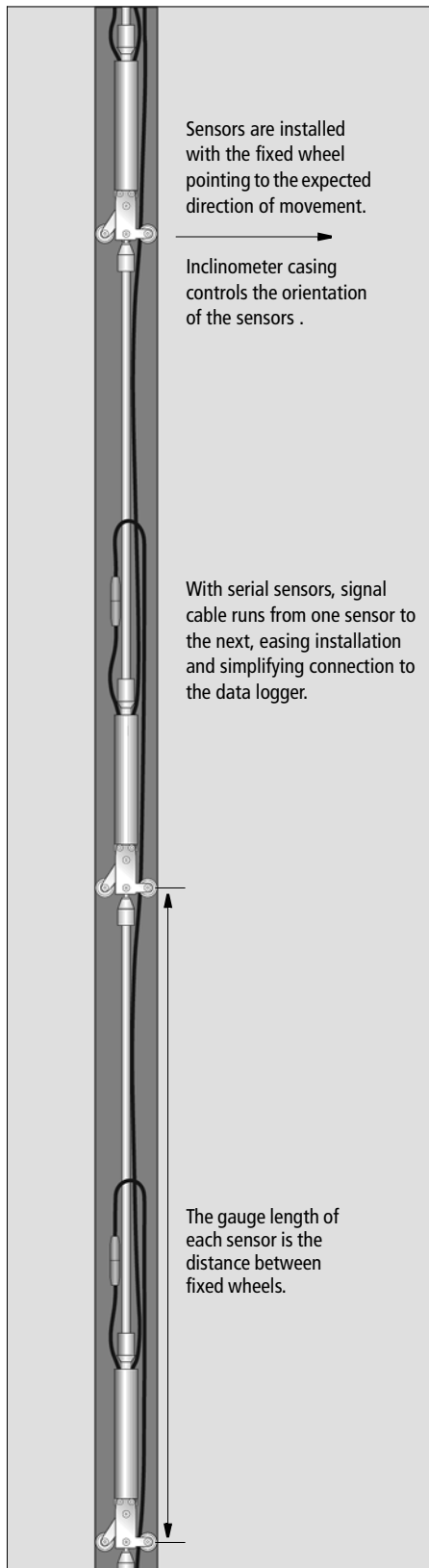


Vertical In-Place Inclinometer Sensors



Applications

In-place inclinometer sensors are ideal for data logging and real-time monitoring. Typical applications include:

- Monitoring deformation of the diaphragm walls that support deep excavations.
- Monitoring ground movements induced by tunnel construction.
- Monitoring deformations of embankments and retaining walls.
- Monitoring landslide areas above dams, highways, and railroads to provide early warning of slope failure.

Operation

The system consists of a number of in-place inclinometer sensors that are installed in inclinometer casing.

The casing provides access for subsurface measurements. Grooves inside the casing control the orientation of the sensors.

The casing is typically installed in a vertical borehole that passes through a suspected zone of movement into stable ground below. One set of grooves is aligned with the expected direction of movement, down hill or towards an excavation, for example.

The sensors are positioned inside the casing to span the zone of movement. When the ground moves, the casing moves with it, changing the inclination of the sensors inside.

Inclination measurements from the sensors are processed to provide graphs of the casing profile and changes in the profile. Changes indicate displacement (movement).

In most applications, sensors are connected to a data acquisition system, and readings are transmitted to processing software that can trigger alarms based on displacements or rate of change.



Advantages

Real Time Monitoring: The in-place inclinometer is ideal for continuous, unattended monitoring and can deliver readings in near-real time.

Single Cable Installation: Serial sensors are supplied with cable to connect to the sensor above, effectively reducing the number of signal cables to one. This eases installation and simplifies connection to the data logger.

Configurable Gauge Lengths: The use of varied gauge lengths can provide better measurements while reducing the total number of sensors needed for complete coverage.

Durable and Reusable: Sensors are equipped with durable and precise wheels that make it practical to withdraw the sensors temporarily for verification readings with a traversing probe or to redeploy the sensors in other casings.

Complete Solutions: DGSi offers complete monitoring solutions that include data loggers and Atlas web-based monitoring software. Atlas can check for alarm conditions in near-real time and can present plotted data immediately after the readings are obtained.

SERIAL SYSTEM CONFIGURATION

A serial IPI system requires inclinometer casing, serial sensors with wheels and gauge tubes, a suspension kit, and a jumper cable. Data reduction software is also required.

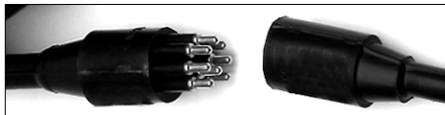
Inclinometer Casing: Choose 70 mm or 85 mm (2.75 or 3.34 in) diameter inclinometer casing.

Uniaxial or Biaxial Sensors: Uniaxial sensors measure tilt in the plane of the wheels. Biaxial sensors include a second sensor that measures tilt in the plane perpendicular to that of the wheels.

Wheels: Choose wheels to fit 70 mm or 85 mm casing. Order sensor wheels for each sensor, and one top wheel for each chain of sensors.

Tubing for Gauge Lengths: Order gauge tubing for each sensor. Tubing is sized to make exact gauge lengths of 1, 2, or 3 m. Custom gauge lengths can be special-ordered.

Signal Cable: Serial sensors include signal cable sufficient for gauge lengths up to 3m. Cables have connectors that allow them to be joined into a bus. A bottom plug is required for the bottom of the bus. A jumper cable connects the top of the bus to the data logger.



Serial IPI sensors incorporate heavy-duty waterproof connectors good for multiple connects/disconnects.

Top Suspension Kit: Order one top suspension kit for each installation. The kit includes hand ring, chain, hook, cable thimbles, and clamps. Requires stainless steel cable, not included.

In-Line Suspension Kit: The in-line suspension kit is used to suspend an independent chain of sensors from the chain above. This allows monitoring of two more widely separated zones of interest in the borehole. The kit includes cable thimbles and clamps. Requires stainless steel cable, not included.

Data Logger: The Slope Indicator M-Logger is specifically designed to read MEMS sensors. It can operate a single chain of up to 16 serial sensors. The M-Logger can also be used to verify proper operation of the sensors before they are installed downhole.

The Campbell Scientific CR1000 data logger allows direct connection of up to 6 chains of serial sensors, and the Campbell Scientific CR800 data logger allows direct connection of up to 3 chains of serial sensors. LoggerNet software will be required to retrieve data from the logger.

Data Reduction Software: Readings retrieved from the logger can be processed manually by spreadsheet or automatically by the Atlas web-based data management system.

SERIAL IPI SENSORS

Serial IPI Sensor, Uniaxial 57804621L

Serial IPI Sensor, Biaxial 57804622L

Sensor Wheels for 70 mm Casing . 57805122

Top Wheels for 70 mm Casing . . . 57805024

Sensor Wheels for 85 mm Casing . 57805132

Top Wheels for 85 mm Casing . . . 57805034

Tubing for 1 m Gauge Length 57805221

Tubing for 2 m Gauge Length 57805222

Tubing for 3 m Gauge Length 57805223

Tubing for Custom Gauge Length 97805240

Bottom Plug 57804510

Jumper Cable, 25 m 57804525

Splice Kit 50612515

STANDARD IPI SENSORS

Standard IPI Sensor, Uniaxial 57804221

Standard IPI Sensor, Biaxial 57804222

Signal Cable 50613527

Consists of seven, 22-gauge shielded conductors encased within a polyurethane jacket.

A standard (non-serial) IPI system requires inclinometer casing, standard sensors with wheels, gauge tubes, a signal cable for each sensor, and a suspension kit. Specify the cable length for each sensor: the distance between the sensor and the data logger. Wheels, tubing, and suspension kits are the same as those used with serial sensors.

SUSPENSION KITS

Top Suspension Kit 57804310

In-Line Suspension Kit 57804320

3.2 mm Stainless Steel Cable 50402310

IPI SENSOR SPECIFICATIONS

Sensor Type: MEMS (Micro Electro-Mechanical Systems) tilt sensor for inclination readings. Thermistor for temperature readings.

Requirements: Accepts power input between 8 to 15 V dc. Outputs ±2.5 volt differential signal. Biaxial version contains two tilt sensors.

Calibrated Range: ±10 degrees.

Resolution: 9 arc seconds or 0.04 mm/m using the CR1000 data logger.

Repeatability: ±22 arc seconds or ±0.1 mm/m.

Calibration: 11 angles at temperatures from 4 to 20°C. Other temperature ranges available.

Required Casing: Fits 70 or 85 mm (2.75 or 3.34") diameter casing.

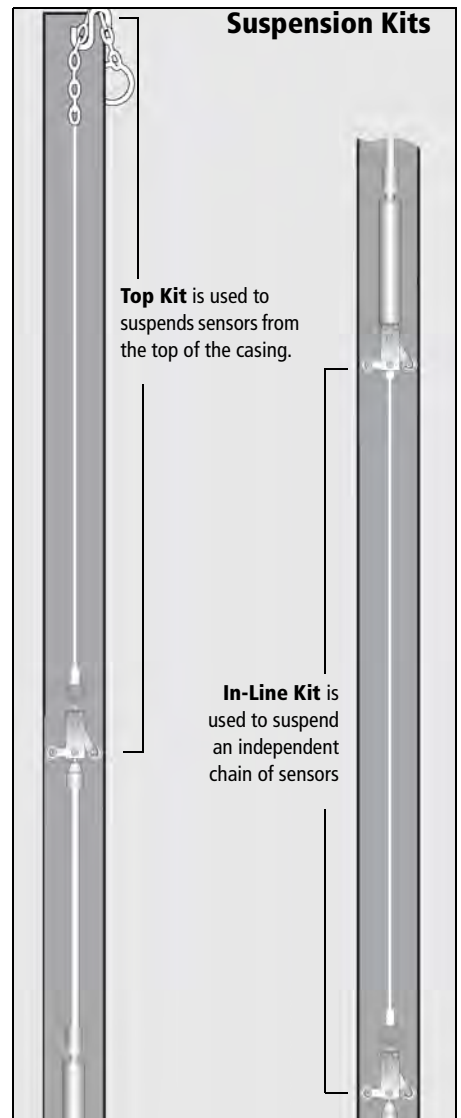
Housing: Stainless steel, 32 mm (1.25") diameter, waterproof to 2 MPa (300 psi).

Weight: Complete sensor with 2 m gauge length is about 1.6 kg.

Signal Cable: Each serial sensor is supplied with cable sufficient for 3 m gauge lengths. Connectors are rated to 70 MPa (10,000 psi).

NOMINAL LIMITS FOR IPI CHAINS

Jumper Cable Length (meters)	Number of Sensors	M-Logger	CR800	CR1000
40	50		✓	✓
75	43		✓	✓
115	37		✓	✓
150	32		✓	✓
190	27		✓	✓
225	23		✓	✓
265	19		✓	✓
300	16	✓	✓	✓
340	13	✓	✓	✓
375	10	✓	✓	✓



Top Kit is used to suspend sensors from the top of the casing.

In-Line Kit is used to suspend an independent chain of sensors