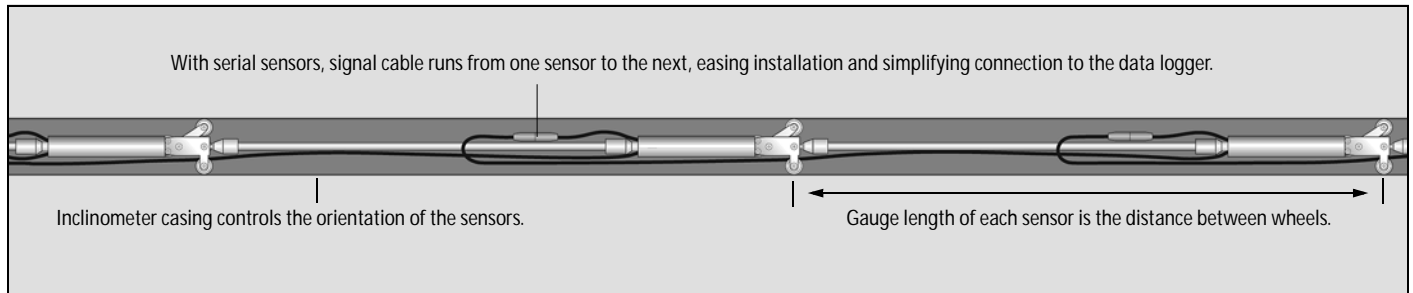


# Horizontal In-Place Inclinometer Sensors



## Applications

The horizontal in-place inclinometer is ideal for data logging and real-time monitoring. Typical applications include:

- Monitoring ground movements induced by tunnel construction and excavation.
- Monitoring stabilization measures such as compensation grouting and underpinning.
- Monitoring settlement under tanks and landfills and in embankments and dams.



## 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.

Casing is typically installed in a trench that crosses the area to be monitored. One set of grooves must be aligned to vertical, since the instrument is expected to monitor vertical movements (settlement or heave).

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 the casing profile, the displacement in mm for the gauge length of each sensor, and the cumulative displacement in mm for the entire string of sensors.

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 rates 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 and the sensor below, effectively reducing the number of signal cables to one. This eases installation and simplifies connections 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 wheels that make it practical to periodically remove the sensors, verify readings with a traversing probe, and then reinstall the sensors. Later, when the project is finished, the sensors can be recovered and reinstalled at another project site.

**Complete Solutions:** DGS I 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.

## SYSTEM CONFIGURATION

A complete IPI system includes inclinometer casing, IPI sensors, wheels, and gauge tubing, signal cable, placement tube, tubing clamp. Other components include a data logger, and software to process the data.

**Inclinometer Casing:** Choose 85 mm or 70 mm (3.34" or 2.75") inclinometer casing. The larger diameter is usually preferred.

**Standard or Serial Sensor:** Serial sensors are linked by a single signal cable and are easier to install and connect. Standard sensors have their own signal cables and a multiplexer is usually required to connect the sensors to a data logger.

**Wheels:** Choose wheels to fit the casing. Order sensor wheels for each sensor. Order a top wheel for each chain of sensors. The top wheel completes the gauge length of the sensor nearest to the borehole collar. The top wheel can be omitted if gauge tubing from the top sensor is held directly by the tubing clamp at the borehole collar.

**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 are supplied with signal cable to accommodate 3m gauge lengths. A jumper cable is used to connect the nearest sensor to the logger. The jumper cable consists of a jumper cable connector plus signal cable.

Standard sensors do not include signal cable. Order a specific length for each sensor. Length is the distance between the intended location of the sensor to the location of the logger.

**Placement Accessories:** Order one tubing clamp for each installation. If tubing clamp holds gauge tube of top sensor directly, top wheel can be omitted. If top sensor must be placed deeper into the casing, order placement tubing in addition to the clamp. In this scenario, clamp does not replace top wheel. Placement tube is supplied in 3m lengths. Order a coupling to create longer lengths.

**Data Logger:** The Slope Indicator M-Logger can operate up to 16 serial sensors. It can also operate an AM16/32 multiplexer to read up to 16 standard sensors. See separate datasheet.

The Campbell Scientific CR1000 data logger allows connection of up to 5 chains of serial sensors or 5 multiplexers with standard sensors.

**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

Horizontal Serial IPI Sensor . . . . .	57804623
Sensor Wheels for 85 mm Casing .	57805132
Horizontal Top Wheel, 85 mm . . .	57805031
Sensor Wheels for 70 mm Casing .	57805122
Horizontal Top Wheel, 70 mm . . .	57805021
Tubing for 1 m Gauge Length . . . .	17805221
Tubing for 2 m Gauge Length . . . .	17805222
Tubing for 3 m Gauge Length . . . .	17805223
Tubing for Custom Length . . . . .	17805240
Bottom Plug for Farthest Sensor .	57804511
Jumper Cable Connector . . . . .	56804510
Signal Cable for Jumper . . . . .	50613527

## PLACEMENT ACCESSORIES

Tubing Clamp, 85 mm Casing . . . . .	57805255
Tubing Clamp, 70 mm Casing . . . . .	57805252
Placement Tube, 3 m Length . . . . .	57804240
Coupling for Placement Tube . . . . .	57804245

## SERIAL SENSOR SPECIFICATIONS

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

**Requirements:** Accepts power input between 7.5 to 15 Vdc. Outputs  $\pm 2.5$  volt differential signal.

**Calibrated Range:**  $\pm 10$  degrees.

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

**Repeatability:**  $\pm 22$  arc seconds or  $\pm 0.1$  mm/m.

**Calibration:** 11-point calibration obtained at three temperatures from 4 to 20 °C.

**Max Gauge Length:** 3 meters.

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

**Housing:** Stainless steel, 38 mm (1.25") diameter, waterproof.

**Signal Cable:** Signal cable has seven 24 gauge conductors, shield, polyurethane jacket, and waterproof connectors.

## STANDARD IPI SENSORS

Horizontal IPI Sensor . . . . .	57804123
Sensor Wheels for 85 mm Casing .	57805132
Horizontal Top Wheel, 85 mm . . .	57805031
Sensor Wheels for 70 mm Casing .	57805122
Horizontal Top Wheel, 70 mm . . .	57805021
Tubing for 1 m Gauge Length . . . .	17805221
Tubing for 2 m Gauge Length . . . .	17805222
Tubing for 3 m Gauge Length . . . .	17805223
Tubing for Custom Length . . . . .	17805240
Signal Cable . . . . .	50613527

## PLACEMENT ACCESSORIES

Tubing Clamp, 85 mm Casing . . . . .	57805255
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Placement Tube, 3 m Length . . . . .	57804240
Coupling for Placement Tube . . . . .	57804245

## STD SENSOR SPECIFICATIONS

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

**Requirements:** Accepts power input between 7.5 to 15 Vdc. Outputs  $\pm 2.5$  volt differential signal.

**Calibrated Range:**  $\pm 10$  degrees.

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

**Repeatability:**  $\pm 22$  arc seconds or  $\pm 0.1$  mm/m.

**Calibration:** 11-point calibration obtained at three temperatures from 4 to 20 °C.

**Max Gauge Length:** 3 meters.

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

**Housing:** Stainless steel, 38 mm (1.25") diameter, waterproof.

**Signal Cable:** Signal cable has seven, 22-gauge conductors, shield, and polyurethane jacket.