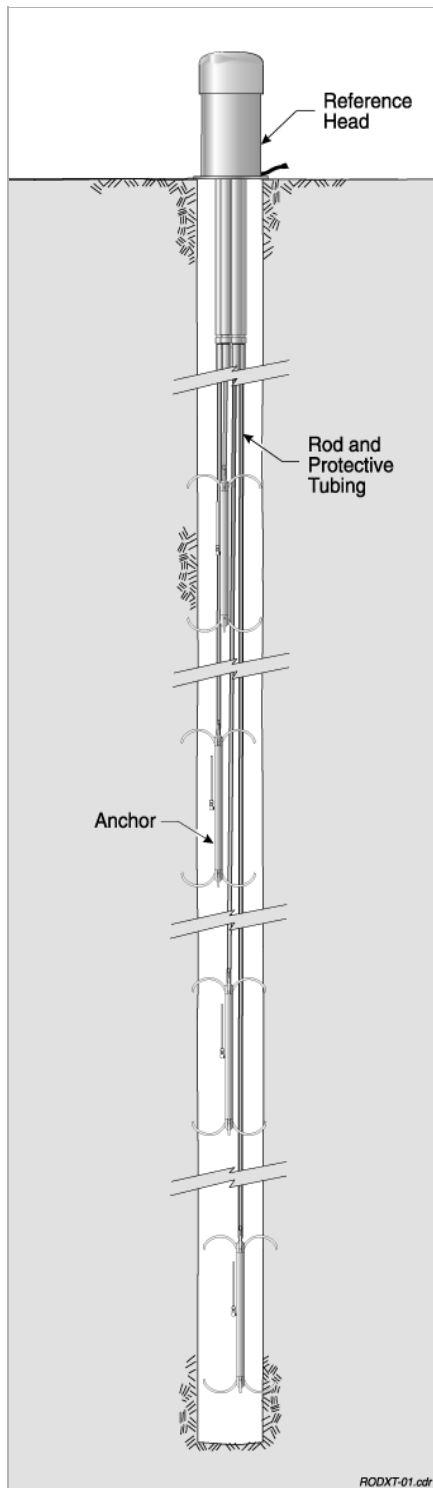


Rod Extensometer



Applications

The rod extensometer is installed in boreholes to monitor settlements in foundations, subsidence above tunnels, displacements of retaining structures, and deformations in underground openings.

Operation

The main components of a rod extensometer are anchors, rods inside protective pipe, and a reference head.

The anchors are installed downhole with rods attached. The rods span the distance from the downhole anchors to the reference head at the surface. The protective plastic pipe prevents bonding between rods and grout backfill.

Readings are obtained at the reference head by measuring the distance between the top (near end) of the rod and a reference surface. A change in this distance indicates that movement has occurred.

Movements are referenced to a stable elevation, typically a downhole anchor. The resulting data can be used to determine the zone, rate, and acceleration of movements, and to calculate strain.

Anchors

Anchors are selected to match field conditions. The groutable anchor is suitable for rock; the hydraulic anchor is suitable for soil; and the packer anchor can be used in either rock or soil. The packer anchor is especially convenient in jointed rock or non-cohesive soils, or where there is flowing water.

Rods

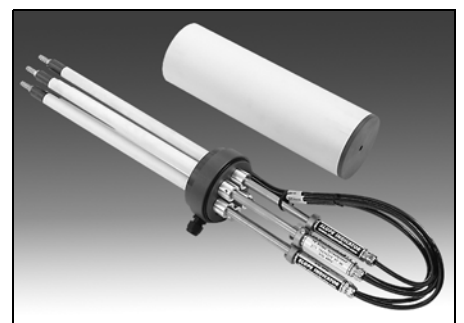
Rods are made of fiberglass or stainless steel. Fiberglass rod extensometers are assembled at the factory and shipped to the site, ready to install. The flexibility of these extensometers also makes them easier to install in confined areas, such as tunnels.

Stainless steel rod extensometers must be assembled on site. However, their stiffer rods can be used for deeper anchor depths. A table on the next page presents maximum recommended lengths for fiberglass and steel rods.

Reference Heads

Mechanical reference heads can be used when there is easy access to the extensometer. Measurements are obtained with a depth micrometer.

Electric reference heads are used when access to the reference head is difficult or where continuous monitoring is required. In this case, measurements are obtained with displacement sensors and a readout or data logger.



PERFORMANCE NOTES

System Accuracy: The main variables in system accuracy are site conditions and the quality of the installation. In general, the best performance is achieved when the borehole is straight and rods are held in tension to keep them straight while the grout backfill cures.

Maximum Recommended Rod Length: In general, rods in tension can be longer than rods in compression, and steel rods can be longer than fiberglass rods. In non-vertical installations, friction between rods and the protective pipe becomes a limiting factor. The table below suggests maximum lengths for rods in tension and compression.

Max Rod Lengths: Tension / Compression		
Orientation	Fiberglass	Steel
Vertical Down	20 / 15 m	40 / 30 m
Vertical Up	45 / 30m	60 / 45 m
45° Down	25 / 20 m	40 / 30 m
45° Up	35 / 25 m	55 / 40 m
Horizontal	35 / 20 m	45 / 30 m

Number of Monitored Points: The rod extensometer can monitor up to six points. In practice, the number of monitored points is limited by the size of the borehole, the type of anchor used, the diameter of the protective pipe, and the amount of tubing required for activating anchors and grouting. The table below shows typical borehole requirements:

Monitored Points	Borehole Diameter	
	1 to 6 groutable or hydraulic anchors; 1 to 3 packer anchors	76 mm
4 packer anchors	101 mm	4"
6 packer anchors	126 mm	5"

ANCHORS

Groutable Anchor51815852
Made from rebar, 19 x 365 mm (.75 x 14.5").

Hydraulic Anchor51703952
Double-acting hydraulic anchor drives 150 (6") mm prongs into soil. 32 x 620 mm (1.25 x 24.5"). Requires tubing & pump.

PACKER ANCHORS

- Packer Anchor, 1 to 3 points 51804361**
- Packer Anchor, 1 to 4 points 51804362**
- Packer Anchor, 1 to 5 points 51804363**
- Packer Anchor, 1 to 6 points 51804364**

The packer anchor employs a geotextile bladder that is inflated with grout. Grout tubing is required for each anchor.

FIBERGLASS RODS

- Fiberglass Rod51815855**
- Protective Tubing51815860**
- Rod Completion Kit51836240**

Fiberglass rod has a diameter of 5 mm (3/16") and is supplied in continuous lengths.

Protective polyethylene tubing is supplied in continuous lengths.

Rod completion kit includes components for top and bottom of rod. Order 1 kit per anchor.

STAINLESS STEEL RODS

- Stainless Steel Rod.51704310**
- Protective Pipe.51704321**
- Rod Completion Kit51836210**

Stainless steel rod has a diameter of 6.4 mm (0.25") and is supplied in 10' lengths, each threaded and tapped for assembly.

Protective pipe is supplied in 10' lengths and includes couplings. Requires PVC solvent cement, which can be obtained locally.

Rod completion kit includes components for top and bottom of rod. Order 1 kit per anchor.

MECHANICAL REFERENCE HEAD

- Mechanical Reference Head.51836120**
- Digital Depth Micrometer51809620**

Mechanical reference head accommodates up to 6 rods and anchors. Readings are obtained with depth micrometer.

Digital depth micrometer displays readings in inches and millimeters. 150 mm (6") range, 0.01 mm (0.001") resolution.

ELECTRIC REFERENCE HEAD

- Reference Head, Electric51836140**
- VW Sensor, 60 mm range52636305**
- VW Sensor, 100 mm range52636325**
- Potentiometer, 60 mm range 51836152**
- Potentiometer, 100 mm range 51836154**

Electric reference head accommodates up to six rods and anchors. Readings are obtained with a VW displacement sensor or a potentiometer.

Both types of sensor provide a resolution of 0.01% of full scale and a repeatability of ±0.5% FS. Sensors are supplied with 0.6 m (2') of signal

cable for internal attachment to signal cables below. Use one sensor per measured point.

VW sensors are read with a vibrating wire readout or a CR10X data logger. Potentiometers are read with the Extensometer Indicator or the CR10X data logger.

SIGNAL CABLE

- Signal Cable, 12-Wire50612512**

Used between the reference head and the readout station. Accommodates up to 6 VW sensors or potentiometers. Shielded cable has twelve 20-gauge tinned-copper conductors and a polyethylene jacket.

- Signal Cable, 4-Wire50613524**

For one VW sensor. Not required if 12 wire cable above is used.

- Signal Cable, 6-Wire53102900**

For one potentiometer. Not required if 12 wire cable above is used.

- Universal Terminal Box57711600**

For use with portable readout. Not required with data logger. Splashproof fiberglass box is 290 wide x 345 high x 135 mm deep (11.5 x 13.5 x 5.25").

INSTALLATION ACCESSORIES

- Pipe Adapter51835170**

Optional adapter for anchoring reference head to 3" diameter steel pipe installed at collar of borehole.

- Flange51836175**

Optional adapter for anchoring reference head to concrete pad at borehole collar. 190 mm (7.5") plastic flange with 152 mm (6") bolt circle.

- Grout Tubing50721008**

Used to deliver grout from grout pump to borehole or packer anchor. 1/2" polyethylene tubing rated for 425 psi at 23 °C.

- Grout Pump51815880**

Manually operated pump used to inflate packer anchors. 15 bar (225 psi) maximum pressure, 19 liters per minute (5 gpm), 23 kg, 51 lb.

- Hydraulic Tubing51702701**

Used to activate hydraulic anchors. 0.25" nylon tubing filled with oil.

- Hydraulic Anchor Tools51704600**

Hydraulic pump with gauge, T-connection, oil volume indicator, 1 gallon of oil, and adapter for filling hydraulic tubing.

- Spare Nut & Ferrule.51703950**

Replacement hardware for connecting hydraulic tubing to anchor.