Sondex Settlement System

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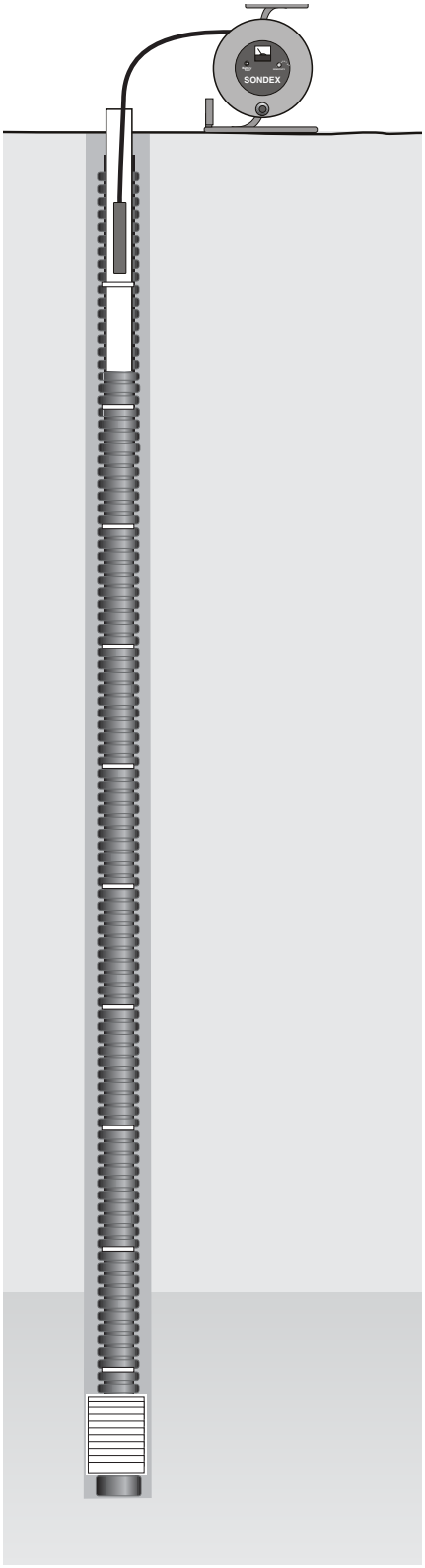


The Sondex Settlement system is used with inclinometer casing to measure settlement and heave associated with excavation, construction, backfill, or tunneling operations.

Corrugated pipe is installed around the outside of the inclinometer casing. Stainless steel sensing rings are positioned around the corrugated pipe. The annular space between the borehole wall and the corrugated pipe is backfilled with soft grout, coupling the pipe to the surrounding ground, so that the corrugated pipe and rings move with settlement or heave.

The probe is drawn through the center of the casing and a buzzer sounds when a ring is detected. A depth measurement is read from the survey tape. Settlement and heave are calculated by comparing the current depth to the initial depth.

Components

Overview

The Sondex Settlement system consists of a portable readout probe, sensing rings, corrugated Sondex pipe, and inclinometer casing.

Sondex Readout

The Sondex readout consists of a reel with a built-in voltmeter, a cable, and a probe. The reel also includes a battery test button, a buzzer adjustment, and a sensitivity adjustment

The probe contains an inductive coil, which is used to locate the sensing rings. The rings act like a shorted turn on the coil, sounding a buzzer on the reel.

Sondex Pipe, Sensing Rings and Accessories

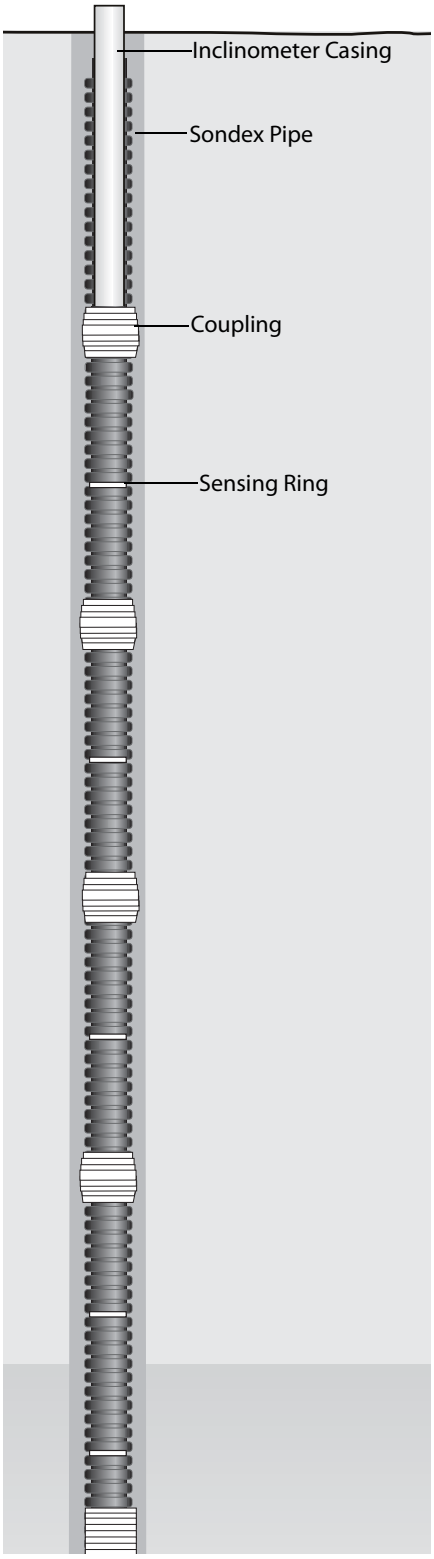
Sensing rings are attached to the corrugated pipe at the factory or out in the field.

If field installation is desired, mastic tape and PVC tape will be required.

A stainless steel survey tape is attached to the probe during readings.

Installation

Introduction



In a typical sondex installation, flush-joint, inclinometer casing is installed inside corrugated sondex pipe. The bottom section of corrugated pipe is attached to the casing. The remaining pipe is left unattached to move with settlement/heave.

Sensing rings are attached to the outside of the sondex pipe. They can be installed at the factory or in the field during installation. Field installation requires mastic and vinyl tape.

The borehole is backfilled with a soft, bentonite-cement grout. The grout will 'marry' the corrugated pipe to the surrounding soil. The pipe will expand and contract with settlement or heave.

The probe is lowered through the casing. When it crosses a sensing ring, a reed-switch closes inside the probe, sounding the buzzer on the reel.

Measurements are read from the tape. Settlement/heave is calculated by comparing initial and current readings.

Preparing for Installation

To begin the installation, you will need inclinometer casing, corrugated sondex pipe, sondex couplings, sensing rings, cable ties or wire, mastic tape, and vinyl tape.

A screw driver, pliers, and pipe clamp may be useful to have on hand during installation. You will also need a cutting tool for the corrugated pipe.

Cut an 8' section of corrugated sondex pipe. Cut the remaining pipe in 10' sections.

Attach sensing rings at specified intervals. The deepest ring should be several inches from bottom of casing. Pop-rivets are typically used to attach the bottom section of corrugated pipe to the inclinometer casing The pop-rivets will impede the probe from reading the rings installed below this area.

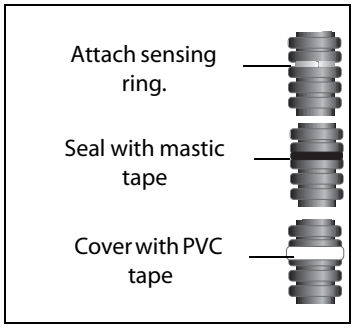
Seal the bottom section of inclinometer casing with the recommended bottom cap.

Installing Sensing Rings

The stainless steel sensing rings can be attached at the factory or out in the field. To install the sensing rings out in the field, you will need the stainless steel tie straps, mastic tape and vinyl tape.

It is important to protect the stainless steel ring from moisture intrusion. Field installation instructions are listed below.

- Wrap the stainless steel tie strap to the outside of the corrugated pipe.
- Seal with mastic tape.
- Cover completely with PVC or duct tape.



Typical Sondex Installation

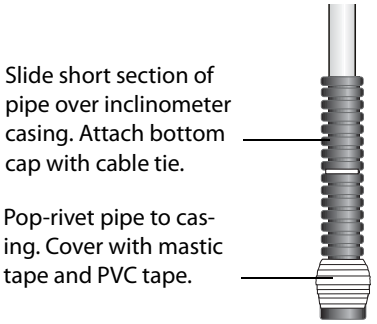
The inclinometer casing will provide a rigid support for the corrugated pipe. It is important to keep the space between the casing and the pipe free of grout and other obstructions.

The corrugated pipe must be able to travel freely along the casing. The bottom section of corrugated sondex pipe must be secured to the bottom section of the inclinometer casing to hold the pipe and casing together during grouting.

There are two ways to attach the pipe to the casing:

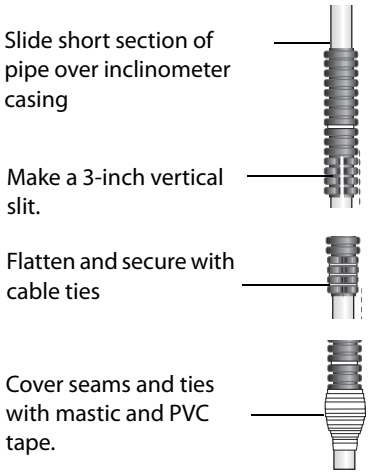
Method 1

- Slide 8ft section of corrugated pipe over casing.
- Attach bottom cap of corrugated pipe.Secure with cable ties or wire.
- Pop rivet pipe to the casing.Waterproof with mastic tape and vinyl tape.



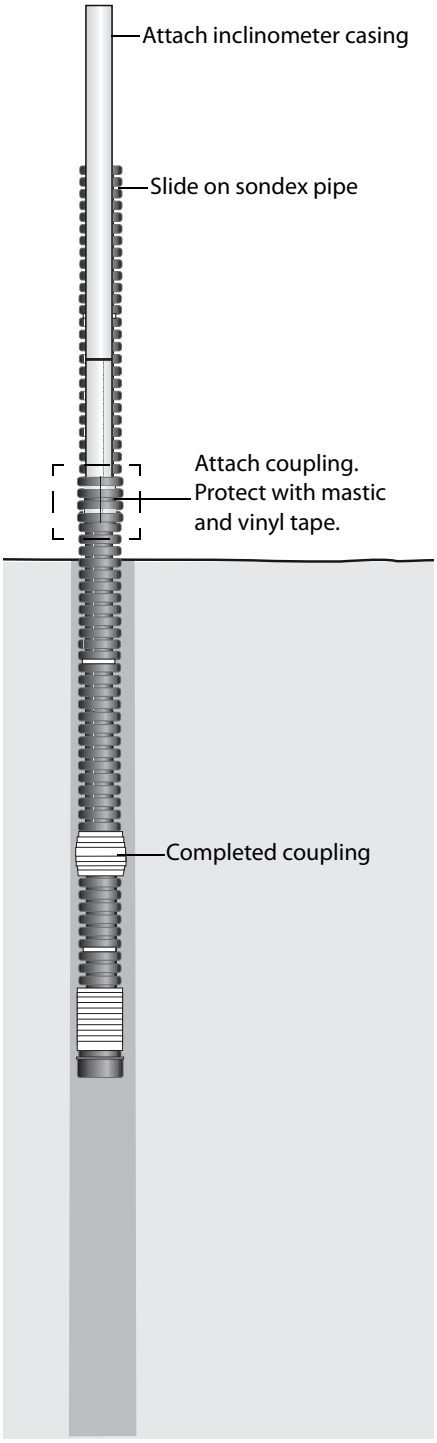
Method 2

- Slide 8ft section of corrugated pipe over bottom section of casing.
- Make a vertical slit in the bottom of the corrugated pipe 3-inches long.
- Flatten the slit pipe onto the casing and secure with cable ties or wire.
- Water-proof by covering seams and ties with mastic tape and PVC tape.



You may want to attach a grout hose to the bottom section as it may be difficult to work a grout hose between the corrugated pipe and the borehole wall.

Typical Sondex Installation continued



Once the bottom sections have been attached continue to add sections of inclinometer casing and corrugated pipe. Attach the corrugated pipe using sondex couplings.

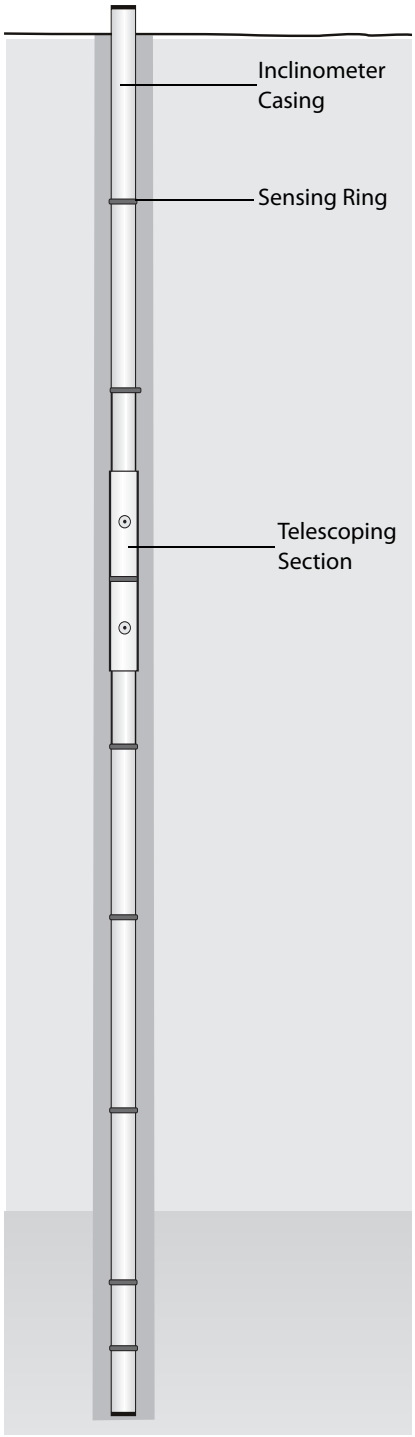
1. Lower the bottom section into the borehole. Hold the casing at the top.
2. Attach next section of inclinometer casing.
3. Slide a 10ft section of corrugated pipe over casing.
4. Wrap the sondex coupling around the outside of the corrugated pipe so it spans the seam where the sections meet.
5. Use cable ties or wire to close the coupling. Pull the cable ties tight to hold the coupling together.
6. Cover the seams along the top and bottom of the coupling, as well as, the slit down the middle, with mastic tape.
7. Use duct tape or PVC tape to cover and protect the mastic seal.
8. Lower and attach sections until casing and pipe are at depth.
9. To counter buoyancy, apply a down force to the bottom of the inclinometer casing or fill the casing with water.
10. Place protective caps on casing and pipe.
11. Backfill the borehole, around the outside of the corrugated pipe with the recommended grout mix on page 8.

Modified Sondex Installation

A modified sondex installation consists of attaching sensing rings directly to the inclinometer casing. Telescoping sections are used to accommodate for large settlement.

Each telescoping section allows six inches of compression or extension. The sliding sleeves of the section are equipped with mating ends to allow it to mate directly with the casing.

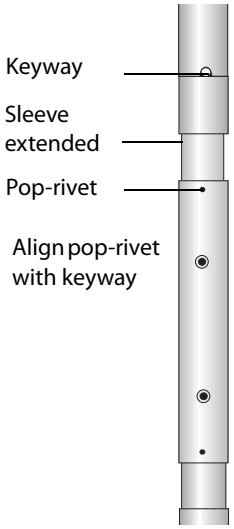
To install the telescoping section you will need pop-rivets, a pop-rivet gun, mastic tape and vinyl tape.



- Attaching rings to casing:
- Seal the ring with mastic tape.
- Cover mastic tape with duct tape or water-proof vinyl tape.
- Install bottom cap on inclinometer casing.
- Assemble casing and add telescoping sections where required. See instructions below for installing telescoping sections.
- To counter buoyancy, apply a down force to the bottom cap of the casing. The single rivets may not hold if you apply a down force from the top.
- Backfill with recommended grout mix on page 8.

Telescoping sections should be installed with sleeves extended:

- Extend each end of the telescoping section to its full range.
- Place the rivet about 1/2-inch from the edge of the section body and align with the key and keyway.
- Joints will mate directly with the casing sections.
- Protect pop-rivets with mastic and vinyl tape.



Recommended Grout Mix

Mix cement with water first. Then mix in bentonite. Adjust the amount of bentonite to produce a grout with the consistency of heavy cream. The final quantity of bentonite will vary with the type used, the method of mixing, and the pH of the water.

If you mix bentonite with water first, then cement, the mix will be too thick. Water must be added, resulting in a higher c/w ratio which lowers the strength and increases the permeability. There is also a high risk of a flash-set.

If the grout is too thin you will get shrinkage, or the solids and the water will separate.

The Marsh funnel number of the liquid grout should be about 55 seconds +/- a few seconds.

Grout Mix for Soft Soils

Materials	Weight	Ratio by Weight
Portland cement	94 lb. (1 bag)	1
Water	75 gallons	6.6
Bentonite	39 lb. (as required)	0.4

Taking Readings

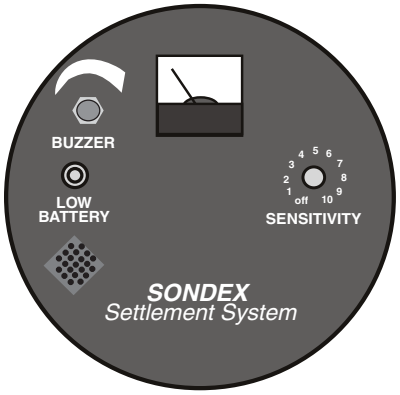
General Concerns

For consistent results, be sure that all technicians maintain the same reading procedures throughout the project.

Use the same probe for each installation. If different probes must be used in the same installation, take an initial reading with each probe and compare data. Apply any offset to later readings.

Controls

Battery Test. Sounds buzzer. Meter should indicate at least 12 volts.



Sensitivity. On/Off switch combined with the sensitivity adjustment. Pointer reaches peak when probe sensor is centered on a ring. Sensitivity should be adjusted so that peak is mid-scale.

Buzzer. Buzzer alerts operator when probe is in the vicinity of a sensing ring. Meter response is inhibited while buzzer sounds. Buzzer is factory set and should not be adjusted.

Initial Readings

Obtain a set of initial readings. Because the initial readings are particularly important, it is recommended that the user obtain three sets of readings from three separate passes through the casing. Average the readings for each ring. Alternatively, find two sets that are very close and use one of them as the initial set.

Taking Readings

Establish a zero reference point. This is usually a mark at the top of the pipe. Accuracy of the instrument is improved when a consistent reference is used for all surveys.

Attach a survey tape to the probe. Attach a weight to eyebolt at bottom of probe to keep line taut.

Turn sensitivity control clockwise to turn on readout. Expect short delay while circuit charges. Press battery test button. Buzzer sounds, then meter should indicate at least 12 volts. Set sensitivity to 5.

Lower probe to vicinity of deepest ring. When buzzer sounds, raise or lower probe, in increments of 0.1 inch, until pointer reaches peak. If necessary, adjust sensitivity so that pointer peaks mid-scale.

Determine depth of ring by observing depth marker at the reference. If survey tape is used, record depth mark that lines up with your zero reference.

Repeat steps until all rings have been recorded.

Data Reduction

Raw Data

Raw data is recorded on a data sheet indicating installation location and date of readings. Initial readings should be taken no less than 48 hours after installation.

The sample data sheet below shows raw data from measurement sessions spread over six months. Ten rings were initially spaced about 5 feet apart.

In each session, the depth of each ring was recorded. The raw data makes it appear that ring 10 has settled the most, but in fact, ring 10 was in stable ground and all the other rings have settled. The data summary sheet is used to format the data so that the readings are referenced to the bottom ring.

Sondex Data Sheet

Sondex Data Sheet

Slope indicator Company

Installation_____

Job Location_____

Depth	Date and Reading							
	1-7	2-4	3-3	4-7	5-5	6-2		
1	.62	.62	.62	.61	.61	.61		
2	5.58	5.58	5.57	5.52	5.51	5.51		
3	10.65	10.64	10.62	10.53	10.50	10.49		
4	15.61	15.59	15.56	15.42	15.38	15.37		
5	20.57	20.55	20.51	20.33	20.28	20.26		
6	25.63	25.60	25.55	25.34	25.28	25.26		
7	30.64	30.60	30.54	30.29	30.23	30.21		
8	35.59	35.55	35.48	35.20	35.14	35.11		
9	40.62	40.57	50.50	40.20	40.13	40.10		
10	45.58	45.53	45.46	45.14	45.07	45.04		

Data Summary Sheet

The Data Summary Sheet organizes the raw data so the measurements at each ring is referenced tot he bottom ring.

Use the raw data value for the bottom ring as the reference measurement in the 'Initial Diff' column.

Finding Difference Values

For the first survey, subtract the measured depth of each ring from the depth of the bottom' ring. Record this value in the 'Initial Diff'. Use the raw data value of the 'bottom' ring to calculate the difference values for each subsequent survey.

Finding Change Values

Movement is determined by the change in the difference measurements of each ring. To find the change for each ring interval, subtract the 'Diff' value from the 'Initial Diff' value.

A positive change indicates settlement and a negative change indicates heave.

Plot the change values to illustrate movement in the system.

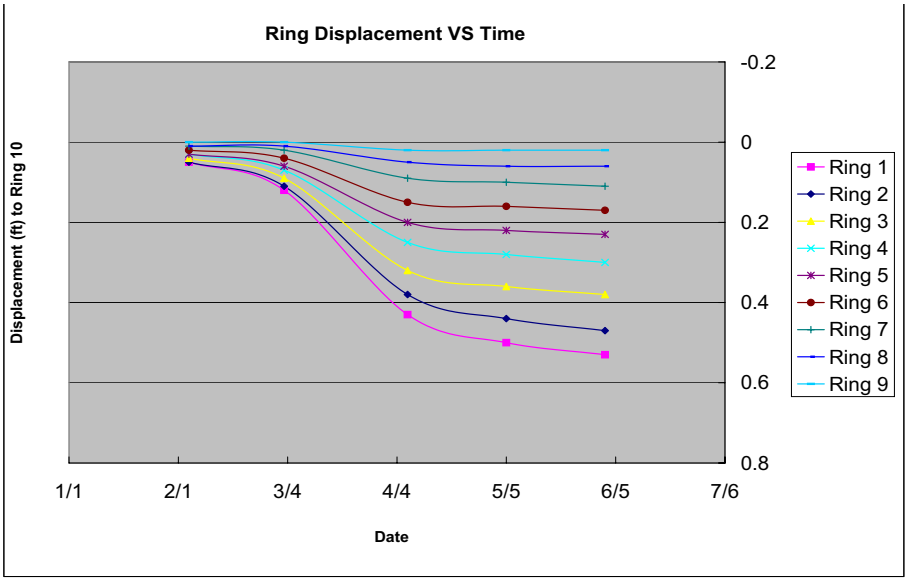
Ring Interval	1-7	2-4		3-3		4-7		5-5		6-2	
	Initial Diff	Diff	Change	Diff.	Change	Diff	Change	Diff	Change	Diff	Change
10-1	44.96	44.91	0.05	44.84	0.12	44.53	0.43	44.46	0.50	44.43	0.53
10-2	40.00	39.95	0.05	39.89	0.11	39.62	0.38	39.56	0.44	39.53	0.47
10-3	34.93	34.89	0.04	34.84	0.09	34.61	0.32	34.57	0.36	34.55	0.38
10-4	29.97	29.94	0.03	29.9	0.07	29.72	0.25	29.69	0.28	29.67	0.30
10-5	25.01	24.98	0.03	24.95	0.06	24.81	0.20	24.79	0.22	24.78	0.23
10-6	19.95	19.93	0.02	19.91	0.04	19.80	0.15	19.79	0.16	19.78	0.17
10-7	14.94	14.93	0.01	14.92	0.02	14.85	0.09	14.84	0.10	14.83	0.11
10-8	9.99	9.98	0.01	9.98	0.01	9.94	0.05	9.93	0.06	9.93	0.06
10-9	4.96	4.960.0	0.0	4.96	0.0	4.94	0.02	4.94	0.02	4.94	0.02
bottom	45.58										

Graphs

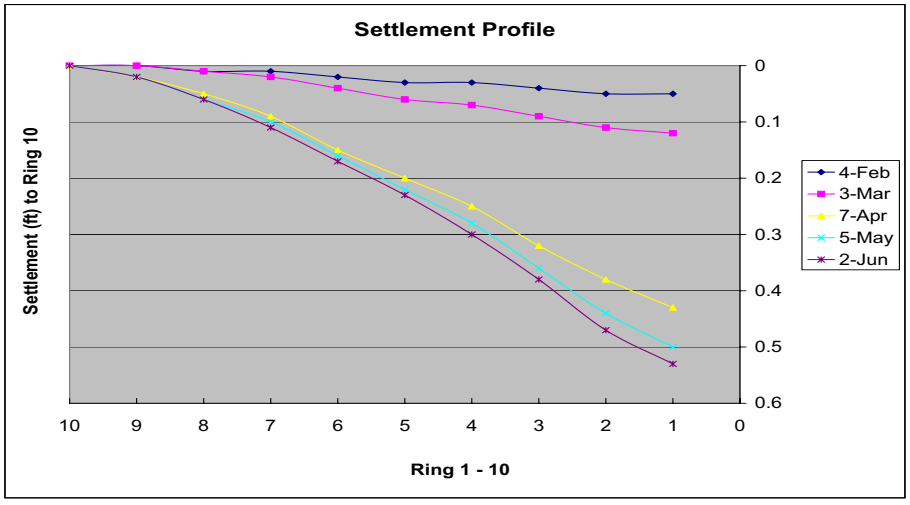
Graphs and diagrams based on the data summary can aid interpretation. When Sondex data is combined with digitilt data from the same installation, movement in two or three orthogonal directions can be analyzed.

Graph 1 illustrates the settlement of each ring over time. Notice very little movement on ring 10.

Graph 2 illustrates a profile of the settlement. The position of rings 1-10 are graphed on a given day.



Graph 1 - Ring Displacement vs. Time



Graph 2 - Settlement Profile

Maintenance

Probe Wipe the probe with mild detergent.

Reel Wipe off the reel with a damp cloth. Do not immerse in water.

Batteries The readout requires 3, AA batteries. Replace the batteries regularly. Remove batteries completely if unit is to be stored for a long period of time.

Test the batteries before each use. Press the battery test button. Replace battery when red battery light comes on.

To replace the batteries:

- Remove the four screws holding indicator assembly to cable reel. Carefully turn assembly over.
- Note polarity of batteries before removing.
- Replace indicator assembly. Be careful not pinch wiring.

Cable Wash the cable with laboratory-grade detergent such as Alconox or Liquinox. Rinse with distilled water.

Remove oily deposits with dish-washing detergent. Do not leave the cable immersed in detergent for a long time. Rinse with distilled water.

Do not use nitric acid, hydrochloric acid, MEK, Acetone, Toluene, or alcohol to clean the cable. Even short-term exposure to these substances can damage the polyurethane cable jacket.

Good Practices

Buzzer

The buzzer is factory set and should not require adjustment. To reset the buzzer to the factory default, turn the stem completely to the left, until it stops. From this position, make a 1/2 turn to the right. CAUTION: Adjusting the buzzer will alter the sensitivity of the readout.

Survey Tape

The survey tape is clipped onto the probe at the eyebolt on the top. Do not bind tape to cable, this will cause kinking in the lines and create erroneous readings. Sharp edges of the survey tape may nick the cable jacket.

Establish a stable and consistent reference to read the tape. Make sure the reference and the markings on the tape are easily visible by the operator.

Cable

Hold the cable up off the edge of the casing when you are raising and lowering the probe. Sharp edges of the casing may nick or cut the cable jacket.

Probe

The indicator may have a stronger reading if the probe is sliding up the side of the casing during readings. Make sure you adjust the sensitivity if the meter peaks full scale. Find the peak again, at mid-scale, and record the reading.

Appendix

Data Sheets

This appendix includes a blank copy of the field data sheet and the Data Summary Sheet.

SONDEX DATA SHEET

DGSI	Installation:							
	Job Location:							
Depths	Date and Reading							

Data Summary Sheet

Ring Interval											
	Initial Diff	Diff	Change	Diff	Change	Diff	Change	Diff	Change	Diff	Change