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Precision Liquid Settlement Array Manual

Document Number: SSS00067 A

Release Date: April 27, 2017

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1 INTRODUCTION

The Precision Liquid Settlement Array provides reliable, real-time monitoring of relative settlement and heave which may occur at excavation sites, tunnelling projects, underground openings and related applications. It is ideal for monitoring structures near underfills, preloads, embankments, and grouting.

The Precision Liquid Settlement Array provides wired or wireless remote monitoring. Users have real-time access through an internet connection on a computer and can also receive updates via email at chosen intervals.

The system is comprised of a sensor connected to liquid pressure and air compensation tube and an electrical cable with M12 connectors. Three settlement measuring ranges (0.6, 1.2, and 3 m) are available for ordering and are chosen based on site conditions and anticipated settlement by the site engineer.

Settlement is measured by comparing the changes in liquid pressure between the sensor at the zone of interest and to the reference sensor. All measured data is digitally received. Temperature compensation is possible.

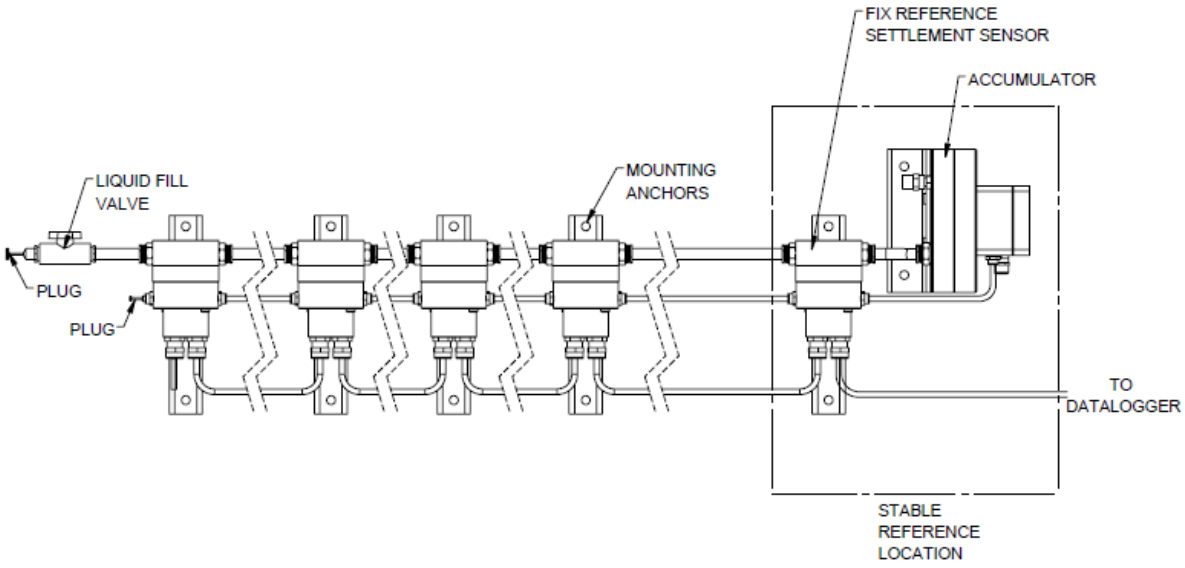


FIGURE 1-1 PRECISION LIQUID SETTLEMENT SYSTEM

2 PRACTICAL THEORY

A series of chambers (vessels) are hydraulically connected together by means of a liquid line (water-filled tube). The system is normally isolated from air.
A liquid leveling system requires two different types of sensors: settlement sensors installed at the different measurement locations, and a reference sensor that is acting as a reference and is coupled to the other sensors. All settlement data are obtained by subtracting the values of this reference sensor from the settlement sensor.

For accurate measurement in the mm range, a compensation tube network is used to equalize the air pressure at the location of each sensor.

Since the temperature affects the liquid density, changes in ambient temperature can influence the readings of the settlement. To minimize the effect of temperature changes, temperature is measured along with pressure in each sensor location. The fluid level change measurements are then compensated for temperature changes.

3 SAFETY

WARNING: USED WHEN AN OPERATING PROCEDURE OR PRACTICE, IF NOT CORRECTLY FOLLOWED, COULD RESULT IN PERSONAL INJURY OR LOSS OF LIFE.

CAUTION: USED WHEN AN OPERATING PROCEDURE OR PRACTICE, IF NOT STRICTLY OBSERVED, COULD RESULT IN DAMAGE TO OR DESTRUCTION OF EQUIPMENT.

NOTE: USED TO HIGHLIGHT SPECIFIC NON-SAFETY RELATED INFORMATION.

4 INSTALLATION

4.1 INSTALLATION TOOLS AND COMPONENTS

Ensure all tools and components required for the installation are present prior to installing the Precision Liquid Settlement System.

Tools and equipment required for a typical installation include:

- Precision Liquid Settlement sensors and fluid reservoir.
- Campbell Logger or RST DT2485 data logger.
- Digital cable with M12 4-pin male cable connectors.

- ½" O.D. HDPE liquid tube.
- ¼" O.D. Nylon 11 air tubing.
- Anchor kit with 25 mm M8 anchors. Hilti Flush anchor HKD M8x25 or equivalent.
- Anchor setting tool (carbon steel).
- Hex wrench.
- Level.
- Hammer drill and 10mm hammer drill bit.

4.2 INSTALLATION PREPARATION

Determine the installation location for the Precision Liquid Settlement System. The location must allow access for sensor connections after the system has been mounted.

CAUTION: AVOID CHOOSING AN INSTALLATION LOCATION IN AREAS OF RAPID OR EXTREME CHANGES IN TEMPERATURE, SUCH AS IN DIRECT SUNLIGHT OR NEAR HEATING OR COOLING EQUIPMENT. SUN SHADES AND/OR EXTERNAL INSULATION IS RECOMMENDED FOR EXPOSED UNITS. TUBING SHOULD NOT BE INSTALLED IN AREAS WITH TEMPERATURES BELOW -10°C.

General guidelines for installation planning include:

- Securely attach the mounting angles with the supplied hardware to a rigid structure that is free of vibration. The brackets are designed to be bolted to a wall or a pedestal and should be firmly attached with either anchor bolts or epoxy grouted studs.
- Minimize the height difference between the sensors. Remove unnecessary liquid tubing length to minimize the total height of the liquid column.
- Install the reference sensor in a location where minimal to no settlement is expected.
- Boil the 50% by volume ethylene glycol solution and then cool it down to less than 40 °C before use. Maintain air in front of the liquid in the tubes by filling the network from its lowest point.
- Connect the precision liquid sensor electronics one by one, or section by section. Run the accompanying software to ensure the connected sensors are functioning properly. This step-by-step approach will eliminate the potential for lengthy troubleshooting should the entire network be installed without intermediate checks.
- The installation of the sensors must be well within the measuring range of the system to allow for precise settlement measuring without risking an overload of the sensors.

4.3 INSTALLATION PROCEDURE

4.3.1 Mounting the Precision Liquid Sensors

NOTE: ALWAYS MOUNT THE SENSORS ON A FLAT SURFACE.

1. Mark the locations of where the precision liquid sensors will be mounted. Set the initial level of all points to be the same +/- 3 mm.

2. Place the concrete anchors for the sensors. Sensors should be vertical +/- 1.5 degrees.

3. Mount the sensors. Connect the liquid and air tubing. The tubing should be cleanly cut at 90º, and assembled by inserting about 10 mm into the fitting.

4. Install the connectors on 4 conductor cables. Assemble the connections.

CAUTION: FAILURE TO FOLLOW STEPS 5 – 11 CORRECTLY WILL RESULT IN DAMAGE TO THE CONNECTOR AND STRING.

5. Tighten the coupling nuts to a tightening torque of 0.6 Nm (hand-tight) to ensure the connectors are properly sealed. Turn the nut one notch further to a tightening torque of 1.5 Nm (approximately another ⅛ turn using a 14 mm wrench). Only apply torque on the flats of the metal coupling nuts to prevent damage on the connectors.

CAUTION: ONLY APPLY TORQUE ON THE FLATS OF THE METAL COUPLING NUTS TO PREVENT DAMAGE ON THE CONNECTORS.

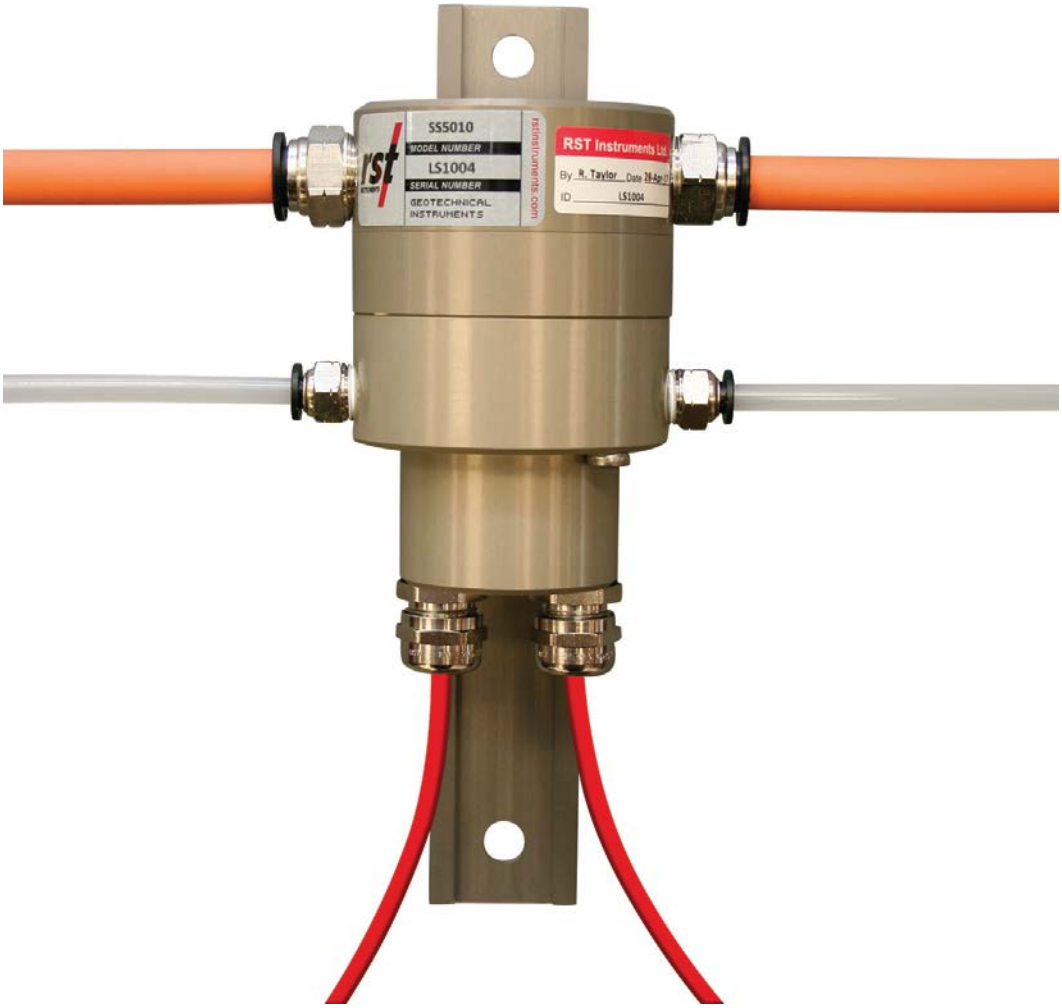


FIGURE 4-1 PRECISION LIQUID SETTLEMENT SENSOR

4.3.2 Mounting the Precision Liquid Reference Sensor

The reference sensor acts as a reference for all the other sensors in the system. It is mounted and tested in the same way as the other sensors, but preferably in a fixed location that does not allow for movement, or in a location that is frequently surveyed.

4.3.3 Mounting Fluid Expansion Chamber

The fluid expansion chamber is typically installed near the reference sensor.

1. Use proper anchors to attach the mounting bracket to a flat surface.
2. Connect the liquid and air tubing to the reference sensor.

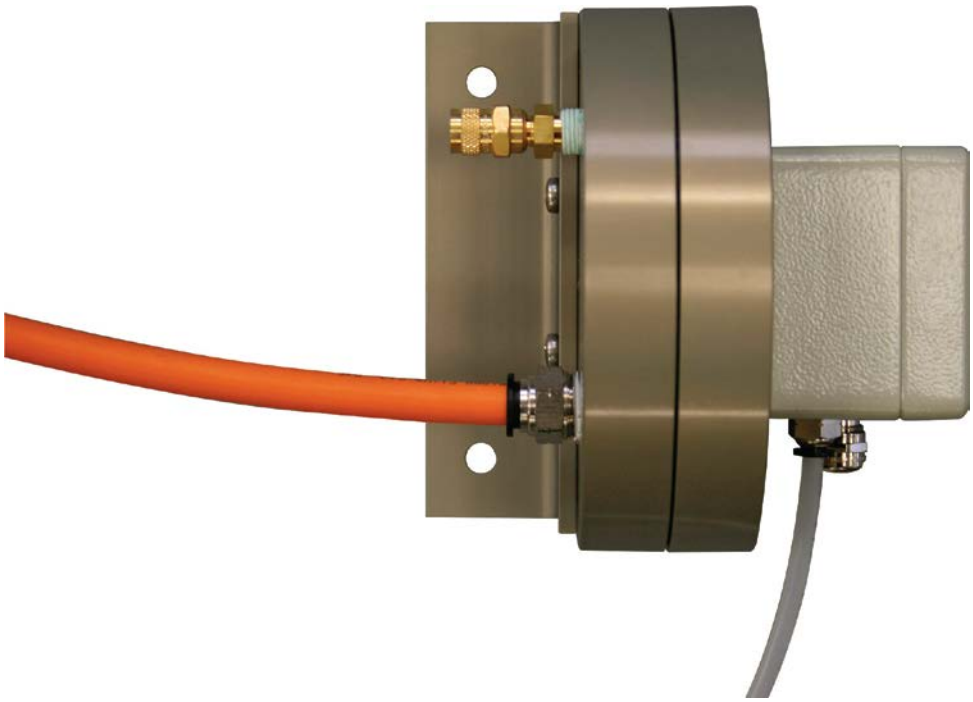


FIGURE 4-2 PRECISION LIQUID SETTLEMENT FLUID EXPANSION CHAMBER

4.3.4 Filling the System with Liquid

The filling operation should be done very carefully to exclude air bubbles from the lines.

1. Fill the system from the non-reference end with 50/50% water ethylene glycol solution, siphoning from the non-reference end. Control the flow rate by raising the source tank up to 1m above sensors.

2. Purge all bubbles out of the system. Never exceed 10 kPa water pressure. Raise the liquid line ahead of the first settlement sensor and allow the liquid to flow, chase the air ahead of the liquid by manually controlling the elevation of the liquid line as the liquid flows. Make sure there are no air bubbles in the liquid line.

CAUTION: NEVER EXCEED 10 KPA WATER PRESSURE.

3. Allow the system to stabilize. Close the fluid expansion chamber purge valve.

5 OPERATION

5.1 SURVEY THE REFERENCE CELL

Ensure that the reference cell readings are stable and did not change since installation.

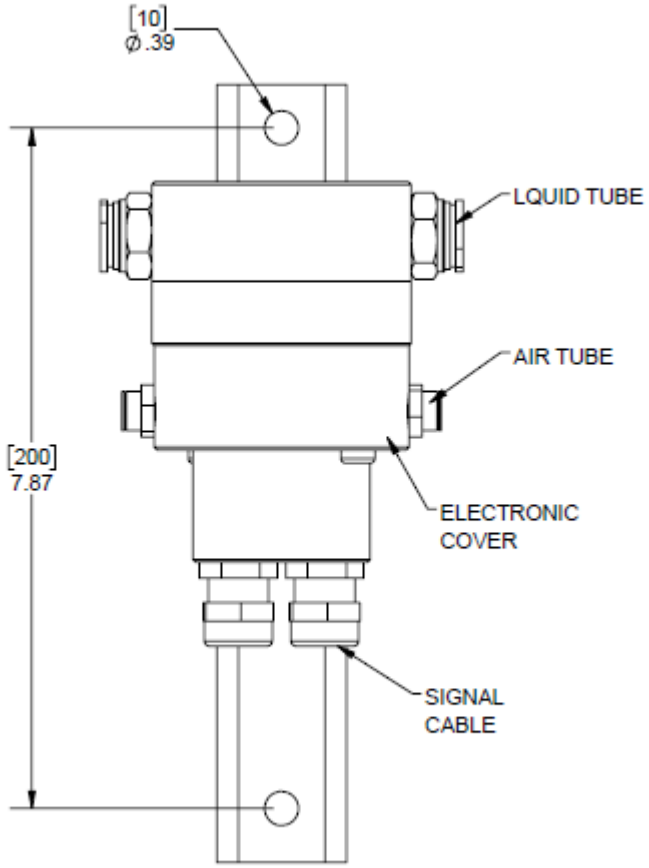
5.2 COLLECT READINGS

Collect readings with a Campbell logger or a RST DT2485 data logger. The output of the Precision Liquid Settlement sensors are in mm H_20 and are corrected for temperature.

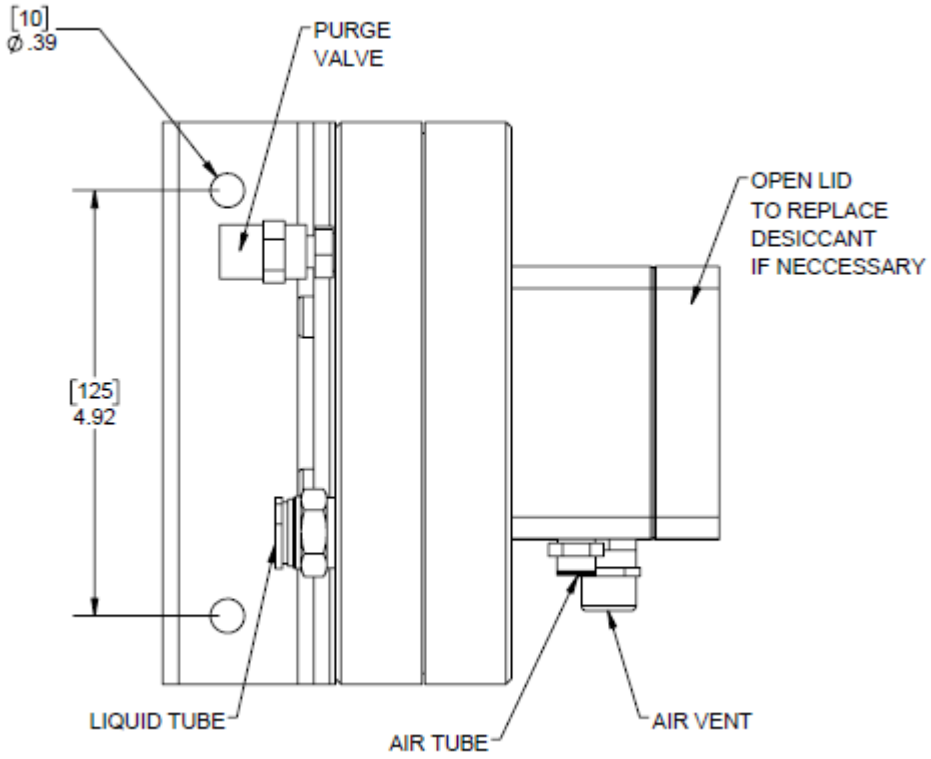
6 SERVICE AND REPAIR

The product contains no user-serviceable parts. Contact RST for product service or repair not covered in this manual.

Appendix A PRECISION SENSOR DETAILS



Appendix B FLUID EXPANSION CHAMBER DETAILS



Appendix C SAMPLE CALIBRATION CERTIFICATE

Calibration Record

200 - 2050 Hartley Ave., Coquitlam, British Columbia, Canada V3K 6W5
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Precision Liquid Settlement Array Sensor

Customer:	RST
Order Number:	123467
Model Number:	SS5010
Serial Number:	**LS1001**
Range:	600 mm
Calibration Date:	04-May-17
Cable Type:	M12

Wiring:

Colour	Function	Pin
Brown	Voltage +	1
White	Ground	2
Blue	RS485 A +	3
Black	RS485 B -	4

References: Pressure Controller CPM6050: 41000EJJ
Referenced to National Standards Annually

Applied Displacement mm	-15.5 °C Output mV	9.5 °C Output mV	38.9 °C Output mV
0	621.05	681.89	756.65
100	1176.40	1247.84	1323.48
200	1731.41	1812.54	1891.57
300	2286.98	2377.74	2458.95
400	2841.96	2941.63	3026.11
500	3397.69	3507.36	3594.17
600	3951.51	4070.94	4160.74
Max Error %	-0.02	-0.02	0.01

Cal Factor (mm/mV):	0.18013	0.17704	0.17623
Regression Zero (mm):	-111.90	-120.86	-133.32

Calculated Displacement = (Cal Factor * Output) + Regression Zero

Calibrated By: E. Akpoviroro