High Sensivity Settlement system

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STRUMENTI E MISURE GEOTECNICHE
E STRUTTURALI

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WARNINGS

This instrument must be utilized only for the application it has been designed for, OTR declines all responsability for any improper use.

Don't overload the balance;

Do not put the instrument in flammable liquids or potentially explosive gases.

Do not use the instrument in water where an electric dissipation is in progress.

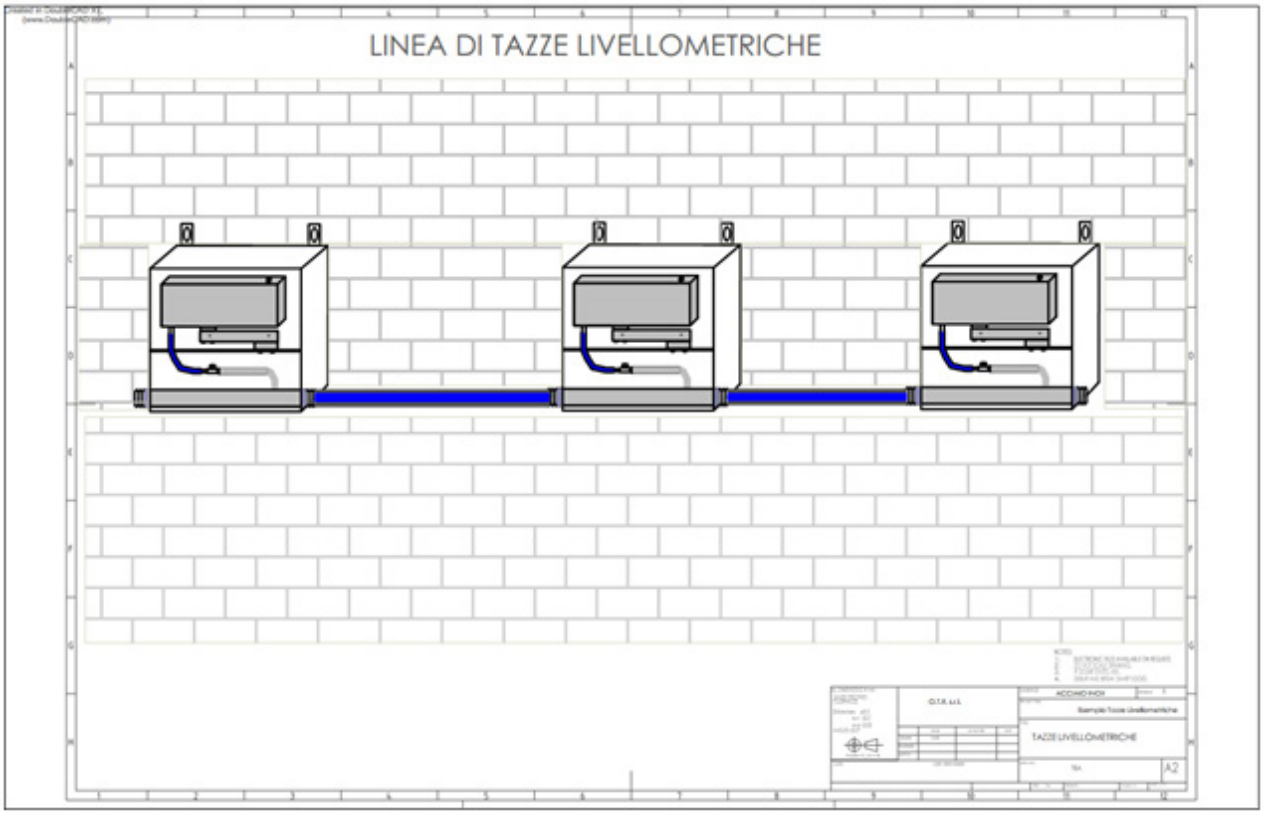
Use protective gloves.

Furthermore

- Do not open the instrument, contact the manufacturer for checks and repairs;
- Keep out of reach of children;
- Do not connect the instrument to the readout unit with wet hands;
- Clean the instrument and its cable with alcohol or water, do not use acetone or aggressive liquids for plastics or labels;
- Use surge arresters for installations with unprotected cables longer than 30 meters.
- Don't bend the balance, don't force it with hands, disassemble it from the tank during the transportation;
- Don't introduce in the hydraulic circuit higher pressure tham 0.5 Bar;
- Don't test the circuit with pressurized air.

Application

Structures and foundations' differential faillure, in Geotechnical, is important to define the security scale of the manufacts.
Where is needed an high level of displacement precision "High Sensivity Settlement system" should be utilize.
High Sensivity Settlement siystem is made up by cups' series containing liquid, spaced apart and delivered on an horizontal line and connected with a connection pipe.
This level meters are used to monitoring: dams, bridges, power plants, foundations, buildings; subjected to defomations caused by ground interactions.



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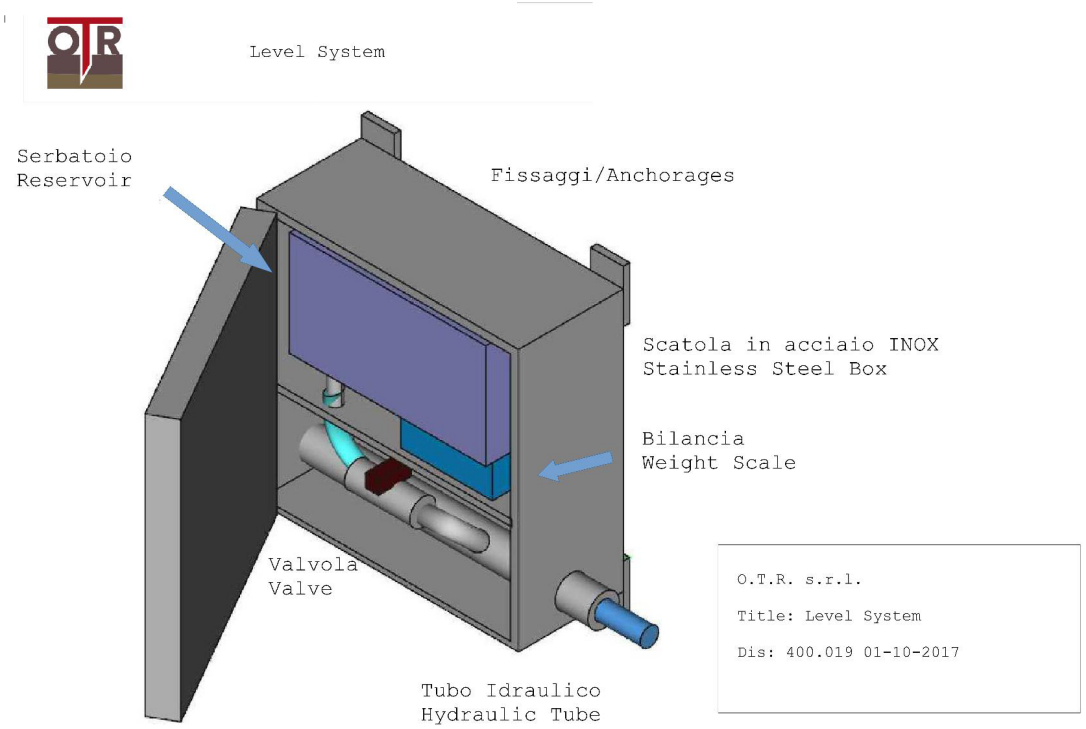
Description



High precision settlement system is composed by:

- A stainless steel box containing:
- a liquid tank;
- an electric trasductor to check the liquid level inside the tank;
- a termometer with thermistore PT100 to check the temperature (on demand);
- an inner hydraulic circuit;
- a terminal box to wire the instumental cable;
- An electric cable to connect the instrument to the datas' acquirer;
- Electric trasductor, detects the liquid weight, so the inner possible height variations inside the tank; his misuration range is about 50mm.

Circuit's liquid (a solution of water and glicerin) has got a costant density at various temperature and a low vapour pressure. It's chemical inert too to the sistem compounds.

Identification

High sensivity settlement sistems are accompanied by an ID label with:

- Serial number and calibration
- Model identification
- Full scale indications
- Output

Technical Specification

Full Scale	0-75 mm
Model	Balance
Output	~1 mV/V/FS o 4-20 mA
Thermistore	Aded on demand
Resolution	0.001°
Thermal Drift	±0.002°/K
Pace	1000 mm

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Installation

It's provided some instruction to instal level meters or settlement systems, suggesting to foresee a specialized technician assistence.
First of all, track the circuit on an horizontal line; it can be made with an optical leveling or with a water worksite tilt beam.
With the tracking you have to sign level meters or settlement sistems and some other important point of the circuit.
After that, is important to fix to the wall the insruments containing their tanks, paying attention to the previous point sign on the wall, and to the pipe lines' supportations: usually stretched steel cables at the same hieght of the cups.
To fix hydraulic pipe, it should be supplied (on demand) collars equipped with dowels if the coibentation is used.

Level meters and high sensivity settlement systems have to be fixed in vertical position on the wall, while reference point has to be placed external to the subsidence area, anyway in an easy optical traguarding position.

To fix the cups proceed like this:

- pose leveling the instrument to the wall
- sign on the wall holes' fixing position checking the horizontality of connection pipes
- drill the wall and fix the instruments with expantion dowels
- instal the hydraulic pipe between every cups suspending that with cable ties and the previal sterching steel cable.

Water filling

- Water filling hydraulic circuit should be done in two different way: pressure way (with pump) or free falling way, depending on circuit lenght and hydraulics connections.

Pressure filling

- If the circuit is filled with pressurized liquid, connect the nylon pipe's ends to the instruments excepting the ends that should remain free, and go on like this:
- Get a pump and a saturator with a closing valve and fill them with liquid,
- Put the saturator on the floor corresponding to one of the free circuit's end,
- Connect the saturator with a piece of tube,with a right lenght, and the saturator's valve to the free end of the circuit,
- Make sure the ball valves of the level meter are closed, except the ones external to the end of the circuit,
- Open the tap of the saturator and start to fill incessancy pumping to trasmit pressure to the liquid and promote liquid influx through the pipe,
- Let the liquid exit from the opposite free end of the tube taking care of saving it inside the vassel,
- Let the liquid flow inside the circuit till the disapparing of air bubbles,
- Connect the free end of the nylon tube where the liquid goes out, to the terminal cup (check if the tap is opened) and fill the tank till his three-quarters high. Than close the tap,
- Open, one at time, other level meters' valves and fil the tank till three-quarters of his capacity, than close the valve (pay attention to keep inside the saturatore a nice quantity of liquid and a minimal pressure of 1Atm),
- Once filled every level meters, except the one corresponding to the pump, dispel the saturator's pressure, disconnect the end to the saturator and connected it to the circuit's end. At this time, connect all the sytem to the last cup,
- Open all the cups' valves to make rebalance the liquid inside the circuit flowing from the tanks to the last connected level meter's cup,
- Check the absence of air bubbles inside the circuit (otherwise remove them with light knocks on the pipeline to bring them to the first near tank), wait the liquid stabilization.

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Gravity filling

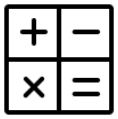
- With the gravity filling, connect all the nylon tubes' extremity to the level meters, except one end of the circuit, which will be left open to let the circuit be filled and proced in the following way:
- Check the seattlement systems' ball valves are closed,
- Get a tank with a tap, where you have to connect a piece of tube enought long (it can be the same of the hydraulic circuit) and fill it with liquid;
- Bring the tank with liquid over the top of the last settlement system previous linked to the circuit; open its box and thread the end of the tube of the filling tank inside the top hole of instrument's tank and procede with its filling,
- When half of the cup's tank is filled (checkable with refernece tube), open slowly the ball valve on the bottom of the instrumental's tank and let the liquid flows inside the circuit till the open end, taking care to save the liquid inside an other vassel,
- Add liquid inside the tank to offset how much flows inside the circuit (take care to leave the tank full to prevent air bubbles formation),
- Let the liquid flow till the shureness of no air bubbles presence,
- Connect to the level meter on the other side of the circuit, the hydraulic tube left open,
- Open time by time the others level meter's valves, waiting the balance of the inner liquid, which one is still put in by the tank, and wait to fill half of the tank's height before open next ball valve.
- When the inside level of all the tanks is reached, close the tap and remove the filling tube,
- Check the absence of the air bubbles inside circuit (otherwise remove them with light knocks on the pipeline to bring them to the first near tank), wait the liquid stabilization.

Ended the filling's circuit procedure, connect the electrical cable to the control unit or to the authomatical datas' acquisition system and make control mesurements to verify the other tanks' level is reached up.
Control should be done measuring every cup, with the information of the calibration sheet corresponding to the instrument. If the instrument is too much or too little full, add or remove liquid using a syringe.
If a cup will be still unbalanced it means that its position is inappropriate comparing to the horizontal line. So it has to be repositioned in the correct way.

Calculation e Formulas

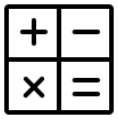
Just we have already told, a level metric's mesurement consist of reveling the output's Tension or Courrent from the electric trasductor, proportional to the liquid quantity inside the tank. Depending on the measure units the measure should be espressed in mV or mA, changable in mm using calibration sensibility (from the manufacturer) of every instrument:

E = Electric Read
K = Sensibility value
L = ExK



Once you have converted the measurements, displacement differential calculation from a raised tank to the reference one is the following:

(Les-Lo)Rif=difference between an operating reading and the initial reading ('zero') for the reference tank (R.);
(Les-Lo)Mis= difference between the operating and zero readings for the measuring vessel (M).



DH> 0 indicates the relative lifting of the tank Mis with respect to the tank Ref and vice versa for DH <0.

DH = (Les-Lo)Rif-(Les-Lo)Mis

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Measurement processing

4-20mA model

- Just we have already told, a level metric's mesurement consist of reveling the output's Tension or Courrent from the electric trasductor, proportional to the liquid quantity inside the tank.

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Calibration Chart

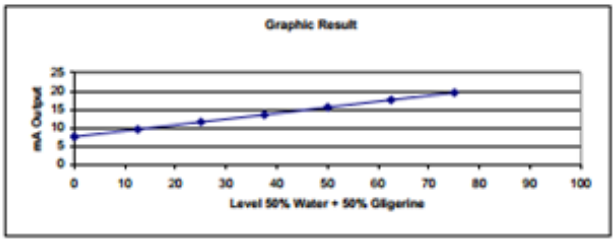
Model	:	Tazza				
Serial N.	:	xxxx		Customer	:	xxxx
Range	:	0-75	mm	Date	:	02/07/2017
Input Voltage	:	12-24	Vdc	Operator	:	xxxx
Output	:	4-20 mA		Temp.	:	26

Calibrato secondo la procedura interna SLI20, lettura eseguita con strumento primario interno Vivitor05 mA matricola EL08 sn 99831665 calibrato con Multimetro Agilent 34401A matricola EL04 6 cifre ½ sn MY41025873 con Rapporto di Taratura SIET 0479E17 eseguito con multimetro Fluke con tracciabilità standard CPE025 UKAS 0183 n. 059808 e pesi calibrati OTR Matricola PE01 controllati con Set di Pesi matricola PE03 SINERGIA con certificato ACCREDIA LAT 117 170698

Level mm	Output mA	Difference mA	Sensitivity mA/mm	Error* %
0.00	7.66			
12.50	9.66	2.00	0.160	0.01
25.00	11.65	1.99	0.159	-0.06
37.50	13.65	2.00	0.160	-0.04
50.00	15.65	2.00	0.160	-0.03
62.50	17.65	2.00	0.160	-0.01
75.00	19.65	2.00	0.160	0.00

Average sensitivity 0.160 mA/mm

* Error Calculated using Average Sensitivity



Zero Value : Reservoir
mm : mix water-glicerine 50/50 (specific weight = 1.13)

Nota: Parametri per D1600 CON SOLUZIONE 50/50 : 7660*19650*0*75
Parametri per D1600 per SOLUZIONE 60/40: 7660*19650*0*73.28. Peso specifico MIX 60/40 +2.3% quindi -2.3% di FS

Calibration exemple in mA:

- Average sensitivity: in mA/mm of the calibrated instrument;
- Output @ Level 0 mm: mA of the empty tank

Let's figure sensor's mA1 is equal to 12.45 mA with an empty tank of mA = 0 7.66 mA with an Average sensitity= 0.160 mA/mm. Let's calculate:

$$Livello = \frac{mA_1 - mA_0}{AverageSensistivity} = \frac{12.45 - 7.66}{0.160} = 29.93mm$$

mV/V Model

- Just we have already told, a level metric's mesurement consist of reveling the output's Tension or Courrent from the electric trasductor, proportional to the liquid quantity inside the tank.

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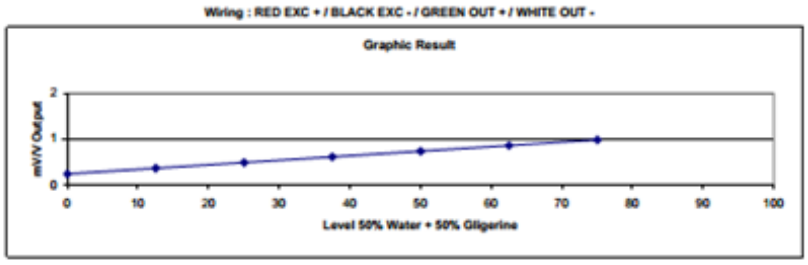
Calibration Chart

Model	:	Tazza				
Serial N.	:	xxxx		Customer	:	xxxx
Range	:	0-75	mm	Date	:	01/12/2017
Input Voltage	:	2-10	Vdc	Operator	:	xxxx
Output	:	mV/V		Temp.	:	20

Calibrato secondo la procedura interna SLI20, lettura eseguita con strumento primario interno Strain Meter Vishay P3500 sn 50267 calibrato con Multimetro Agilent 34401A matricola EL04 6 cifre ½ sn MY41025873 con Rapporto di Taratura SIET 0479E17 eseguito con multimetro Fluke con tracciabilità standard CPE025 UKAS 0183 n. 059608 e pesi calibrati OTR Matricola PE01 controllati con Set di Pesi matricola PE03 SINERGIA con certificato ACCREDIA LAT 117 170698

Standard Level	Output	Difference	Sensitivity std	Error*
mm	mV/V	mV/V	mV/V/mm	%
0.00	0.249			
12.50	0.372	0.123	0.00984	-0.05
25.00	0.495	0.123	0.00984	-0.09
37.50	0.618	0.123	0.00984	-0.14
50.00	0.742	0.124	0.00992	-0.05
62.50	0.865	0.123	0.00984	-0.09
75.00	0.989	0.124	0.00992	0.00

Average sensitivity std **0.00987** **mV/V/mm**
*** Calculated using Average Sensitivity**



Zero Value : Reservoir
mm Standard : mix water-glicerine 50/50 (specific weight = 1.155)

Calibration exemple in mV/V:

- Average sensitivity: in mV/V/mm of the calibrated instrument;
- Output @ Level 0 mm: in mV/V of the empty tank

Let's figure sensor's mV1 equal to 0.520 mV/V with an empty tank of mA0= 0.249 mV/V and an Average sensitity= 0.0987 mV/V/mm:

$$Livello = \frac{\mathrm{mV}_1 - \mathrm{mV}_0}{AverageSensistivity} = \frac{0.520 - 0.249}{0.00987} = 27.45\mathrm{mm}$$