

_ BH PROFILE IPI



USER MANUAL



INCLINOMETERS
& TILT METERS

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Notes on the use of product

For safe and efficient use of the product, please read carefully the following instructions before starting any operation.

Any use of the product other than the one described in this manual shall be considered the user's full responsibility.

The same applies for any unauthorized modifications.

In addition to the hereby listed standards, the user must comply with the provisions of the current legislation regarding personal safety and health together with all other persons in the workplace.

SISGEO is not responsible for any accident, breakdown or other problems due to lack of knowledge and / or non-compliance with the requirements contained in this manual.

Check that the product has not been damaged during the transport.

Verify that the package includes all items as well as any requested optional accessories; if anything is missing, please promptly contact SISGEO.

The user must strictly follow all the operations described in this manual.

Maintenance or repair of the device is permitted only by authorized operators.

These operators must be physically and intellectually suitable.

For information about instrument or to order spare parts, always specify the product information which can be found on the identification label.

When replacing parts, always use ORIGINAL SPARE PARTS.

Symbols



Pay particular attention to the following instruction.

Identification

Instruments can be clearly identified by

- the batch number (written on the Compliance Certificate)
- the serial number (s/n) engraved on the instrument
- the label on the instrument
- the label on the cable

Note

The present Manual is issued by SISGEO in English Language and should be available in other different languages.

In order to avoid discrepancies and disagreements on the interpretation of the meanings, Sisgeo Srl declares that English Language prevails.

All the information in this document is the property of Sisgeo S.r.l. and should not be used or reproduced without permission from Sisgeo S.r.l.

We reserve the right to change our product without prior notice.

For any further information regarding inclinometers, please refer to the International Standard ISO 18674-3.

INTRODUCTION



BH Profile inclinometers are designed for automatic monitoring of critical locations where horizontal displacement and deformations monitoring need a continuous and accurate borehole profiling.

They are used in many application: diaphragm walls, landslides, dams, tunneling, deep excavations, unstable slopes, piles.

BH Profile are installed within the inclinometer casing like a "chain," suspended by a stainless steel wire fixed to the protection cap or with a stiff steel rod and connected to readout or datalogger with single cable (digital model) or with one signal cable from every inclinometer (analog model).

A previous survey with removable vertical inclinometer probe could be useful to determine depth monitoring to define the inclinometer tube set up for future maintenance.

BH Profile measure the angular local variation compared to the reference reading.

Mainly, BH Profiles are available in digital model (RS485 output), but also 4-20mA output is available under request.

In agreement with the Customer, BH Profile probes are configured in factory for:

- RS-485 address
- power supply configuration
- measuring unit



In a Ø 60 mm casing can be installed up to 10 analog BH Profiles (cable dimension issue) and up to 70 digital BH Profiles.



Sisgeo suggests that the digital chain isn't longer than 250 m (to avoid voltage drop in the powering) in case of "always-on" powering.

~ 1m

BH PROFILE IN PLACE INCLINOMETERS EN_03_19

DESCRIPTION



Digital BH Profile inclinometer consists of:

1. A differential MEMS sensor housed in a waterproof stainless steel body (A). The sensor can be uniaxial or biaxial;
2. electrical board for signal digitalization with included a thermal sensor;
3. wheels assembly (B) to slide along the grooves of the inclinometer casing;
4. male and female connectors (C) are assembled at factory on the cable (D);
5. termination resistor (for last BH Profile in the chain).

The available accessories could be:

- stainless steel wire (stiff steel rod on request);
- stainless steel clamp, screw, clevis and redance;
- suspension pin with ring;
- copper clamps;
- plier for copper clamps;

Digital BH Profile note

Principal parameters configured at factory:

- Serial number;
- Calibration parameters;
- RS485 address. Each BH Profile has an univocal address also reported in a label on the cable.
- Powering type :
 - A) always-on (all BH Profile switched on together)
 - B) timed (only one BH Profile switched on at time)
- Unit of measurement: the standard output is $\sin\alpha$. Upon request it is possible to configure BH Profile with $\sin\alpha$ multiplied by a constant factor $K \neq 1$ or another unit of measurement (° , mm/m, inch/feet).



In "always-on" the consumption is higher (and the voltage drops could be heavy) but the reading times are lower.

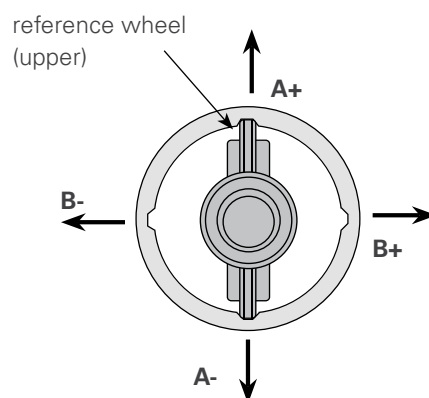
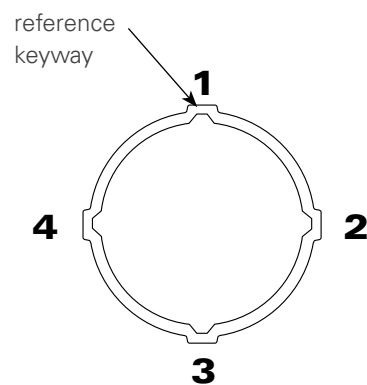
In "timed" the incremental delay [sec] and the warm-up time [sec] are set. Every BH Profile is turned on, read and then turned off from the Modbus master.



Inclinometer's casing keyways, once installed, are identified with numbers 1-2-3-4, clockwise; the reference keyway is the keyway 1 and is the one closer to the geographic North or the one turned towards the expected movement.



BH Profile model, serial number and "A" channel are marked on the reference side. The pictures below shows the BH Profile sign convention.



PRELIMINARY CHECKS

Before starting the installation we recommend to check the casing with a common dummy inclinometer probe and check instruments by connecting them to a portable readout (see "Taking Measurements").

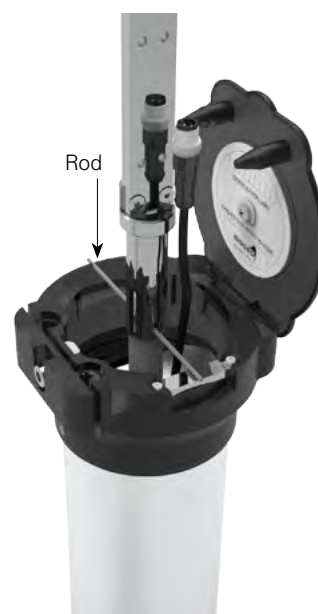
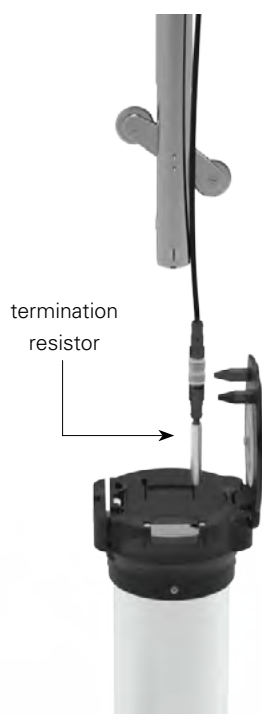
Useful tools (not supplied):

- allen key SW2
- flat tip screwdriver
- Ø8 mm rod or screwdriver to temporary suspend the chain into the borehole during assembling
- steel cutting nippers
- adhesive tape, plastic tie

INSTALLATION

The inclinometer casing must be already installed and the grouting must be cured.

DIGITAL BH Profile



Identify the BH Profile according to the project scheme. Insert the bottom BH Profile into the casing checking that reference wheels are in groove 1.

The BH Profile must have the termination resistor; be sure it doesn't touch the lower part of the casing.

Using a strong rod or a screw driver (not supplied), hang the BH Profile probe to the top cap.



special screw



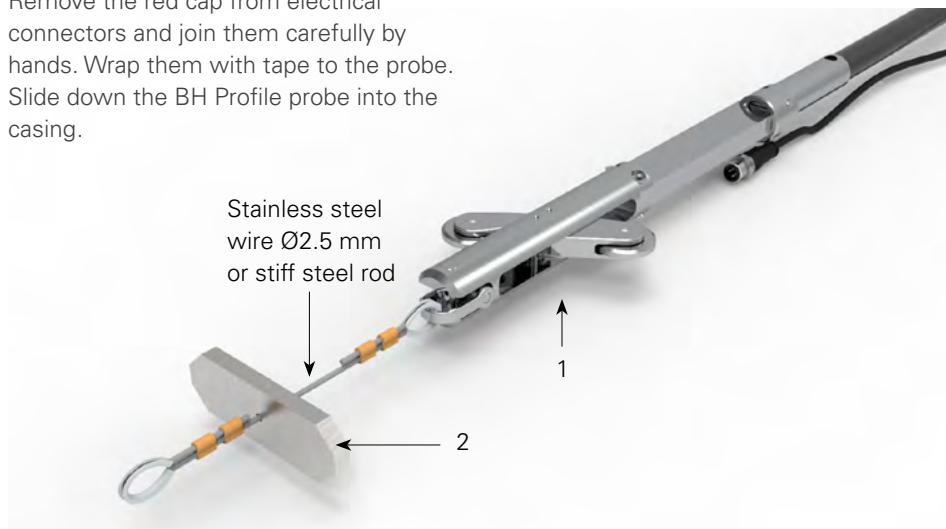
Connect the second BH Profile screwing the supplied special screw. Take care during the connection to the reference wheel that shall run in the reference keyway.

To obtain a correct connection align the key references. Do not strain or screw tightly to avoid damaging the connectors. Protection IP68 (1MPa) is guaranteed only with a good connection.



NOTE: a proof that all the probes are installed in the right direction is the special screw that must be inserted always in the same direction.

Remove the red cap from electrical connectors and join them carefully by hands. Wrap them with tape to the probe. Slide down the BH Profile probe into the casing.



Stainless steel wire Ø2.5 mm or stiff steel rod

1

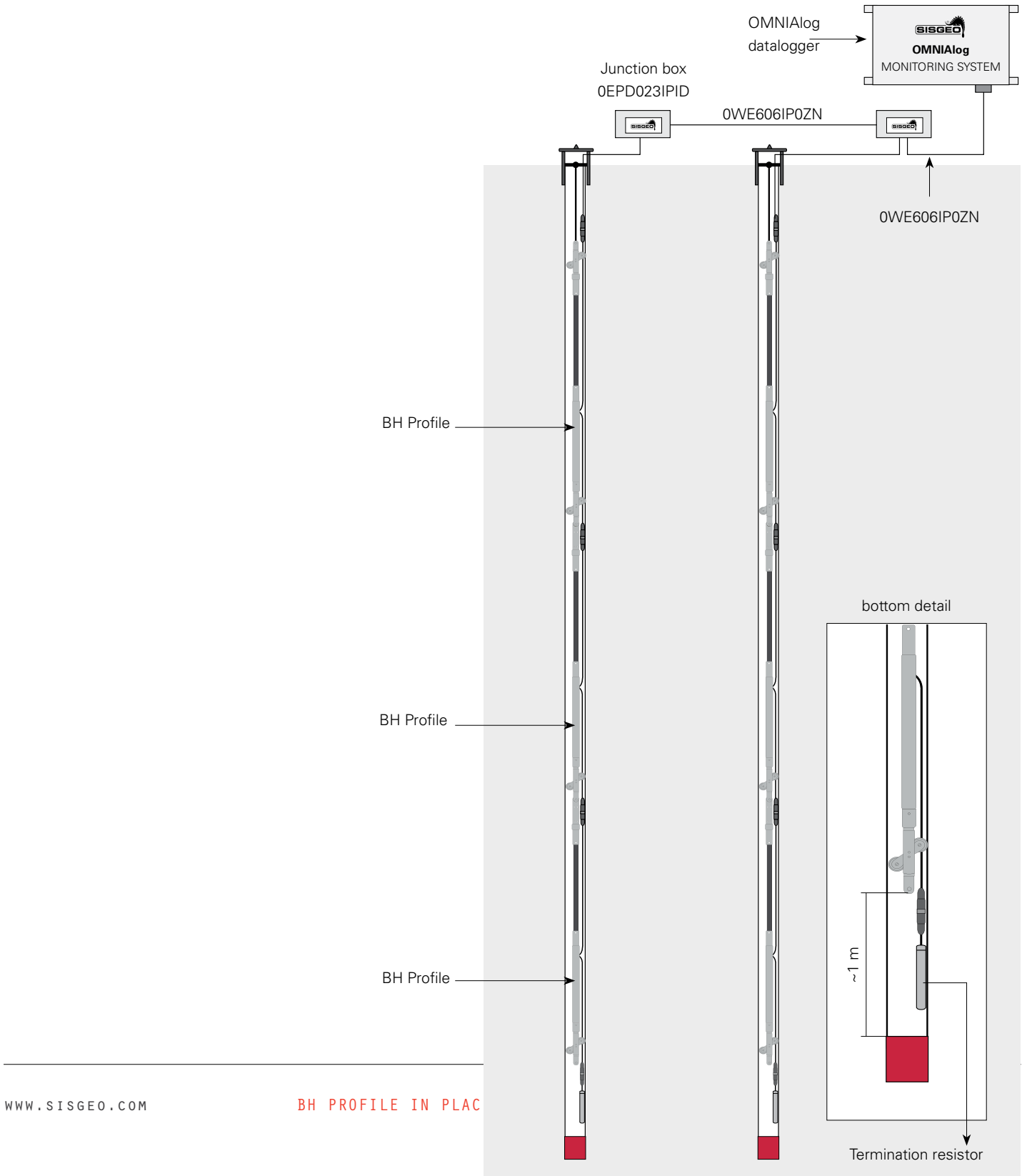
2

Continue with the other BH Profile probes until completing the whole chain. All reference wheels must be positioned into reference keyway. Connect the terminal wheel carriage (1) and cable at the upper BH Profile probe. Assemble the suspension system (2) according to the above draw (see also "Appendix 2"). Connect the upper cable with female connector to the male connector of the upper BH Profile probe.



Block the cable with the plate on the terminal cap. Protect the cable from mechanical damage and the end side from the water.
Could be useful also to protect the inclinometer head from big thermal fluctuation using insulation covering.

Example of installation



ANALOG BH Profile

Proceed as described for digital BH Profile model.

Analog model has no connectors and termination resistor is not needed.

Each BH Profile probe has its own signal cable. While you are lowering the probe into the casing, pay attention to the signal cables. Fix the cables to the probe body with tape or plastic tie every 2 or 3 meter.

TAKING MEASUREMENTS

The last digital BH Profile gauge of every chain must have a termination resistance with value as for the following table. A spare kit of ending resistance is available (product code 0ERESKIT00 including one 120 Ohm, two 240 Ohm, three 360 Ohm and four 480 Ohm resistances).

Number of chains to a single datalogger	Resistance
1	120 Ω
2	240 Ω
3	360 Ω
4	480 Ω

Manual readings are taken connecting the conductors to a readout according to the following schemes:

Digital BH Profile (5 pins connector)	Standard cable	Function	Cable WE606IPDZH
	Brown	+Vdc	Red
	Black	GND or -Vdc	Black
	Blue	Data + (RS485 A)	Green
	White	Data - (RS485 B)	Green/White
	Grey	Grounding	Shield (3 conductors)

Uniaxial BH Profile 4-20 mA current loop	0WE1060LSZH cable	Function	
	Red	+ V (A)	
	Black	OUT (A)	
	White	Thermistor	
	Green	Thermistor	
	Shield	Groundingd	

Bi-axial BH Profile 4-20 mA current loop	0WE1060LSZH cable	Function	
	Red	+ V (A)	
	Black	OUT (A)	
	White	+ V (B)	
	Green	OUT (B)	
	Yellow	Thermistor	
	Blue	Thermistor	
	Shield	Grounding	



Note : The shielded ground system must be put as near as possible to the borehole/support head. Put the 3 conductors shield at datalogger's side in order to provide grounding. To obtain reliable measures, with 4-20 mA BH Profile, we recommend a warm up time not less than 10 seconds.

Readings are taken connecting the end cable to a readout with RS485 interface (DCE, Half duplex, no Echo) able to manage communication protocol SISGEO Modbus RTU.

The power supply [W] must be chosen according to the BH Profile probe quantity and power supply mode.

Communication protocol is downloadable from Sisgeo Website (to be used when MODBUS Master is not supplied by SISGEO).

The Modbus master (readout unit) must be set according to the factory's BH Profile configuration.

DATA MANAGEMENT

Inclinometers data treatment is well described in ISO 18674-3 standard in ANNEX A "Measuring and evaluation procedure".

The following formulas allow to convert the electrical measurements of 4-20mA gauges into engineering value:

$$\begin{array}{ll} \text{Linear factor} & L_{\text{eng}} = (A \times L_{\text{el}}) + B \\ \text{Polynomial factor} & L_{\text{eng}} = (L_{\text{el}}^3 \times A) + (L_{\text{el}}^2 \times B) + (L_{\text{el}} \times C) + D \end{array}$$

L_{eng} = Reading in engineering unit

L_{el} = Reading in electric unit (output of the gauge)

S, A, B, C, D are stated on Calibration Report.



The digital BH Profile gives reading directly in engineering units. No conversion is needed.

The relative readings refer to the initial reference reading (zero reading).

$$\Delta L = L_i - L_0$$

ΔL = relative reading

L_0 = Reference reading

L_i = Follow up reading

Reference reading shall be taken carefully once the installation is performed and the system is stable (no vibrations etc...). Usually are enough 24/48 hours for a complete stabilization. We suggest to consider only the relative and not the absolute measurements.

Example

Uniaxial inclinometer; measuring range $\pm 10^\circ$; mA readings

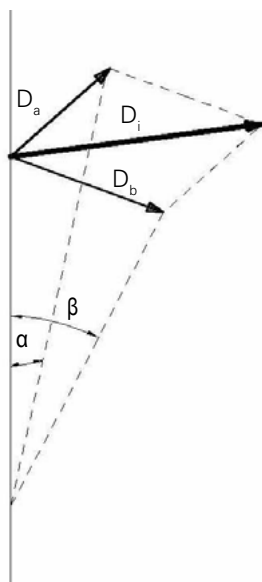
$A = -1.483\text{E-}06$, $B = 5.232\text{E-}05$, $C = 2.108\text{E-}02$, $D = -2.789\text{E-}01$

$L_0 = 12.965\text{mA}$, $L_i = 17.006\text{ mA}$

Using polynomial factor

$$[(L_i^3 \times A) + (L_i^2 \times B) + (L_i \times C) + D] - [(L_0^3 \times A) + (L_0^2 \times B) + (L_0 \times C) + D] = 0.08742 - (-0.0000352) = 0.08746 \text{ [sin}\alpha\text{]}$$

The relative displacement, where the BH Profile is installed and determined by the wheels assembly distance, is obtained using the following formula:



$$Da_i = P \times \Delta \sin \alpha_i$$

$$Db_i = P \times \Delta \sin \beta_i$$

Where:

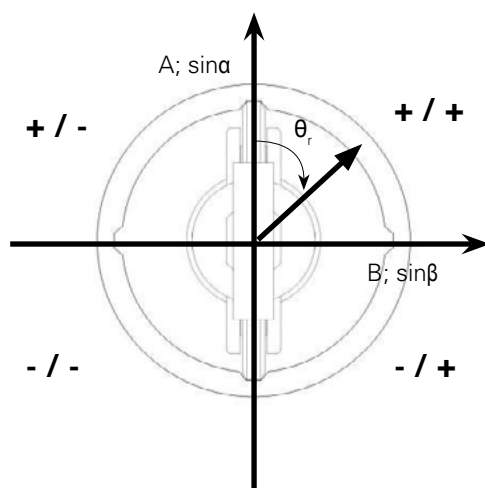
P = Gauge length (distance between wheels)

$\Delta \sin \alpha_i$ = Relative sin of the angle in A direction

$\Delta \sin \beta_i$ = Relative sin of the angle in B direction

$$D_i = \sqrt{D_a^2 + D_b^2}$$

It is possible to identify biaxial BH Profile azimuth following the scheme below ($\sin \alpha / \sin \beta$) :



$$\theta_r = \tan^{-1} \left(\frac{\sin \beta}{\sin \alpha} \right) + 2k\pi$$

$\sin \alpha$	$\sin \beta$	k
+	+	0
+	-	$\frac{1}{2}$
-	-	$\frac{1}{2}$
-	+	1

Temperature Reading (for analog BH Profile)

Using readout units, temperature will be displayed directly in °C ; if the resistance value is read, the conversion formula or the table in "Appendix" 1 can be used.

TROUBLESHOOTING

Problem	Possible cause	Solution
No BH Profile read by Modbus master	Modbus master configuration	Verify the right Modbus master configuration (RS485 interface included)
	Wrong BH Profile power supply	Verify the correct power and power supply according to the BH Profile quantities (see FAQ.#073 on Sisgeo web site)
Only one BH Profile can't be read from Modbus master	Modbus master configuration	Verify the right Modbus master configuration (RS485 interface included)
	Electronic board problems	Check the BH Profile with a SISGEO portable datalogger. Contact SISGEO assistance for replacement if problem persist.
A whole BH Profile chain can not be read by Modbus master	Short circuit	Check the fuse on the wiring clamps. If it is burned check the cause.
The Modbus master doesn't read the last BH Profile of the chain	Voltage drop too high	Split in more than one chain to limit cable lenght
Unstable measure	Sensor powering not correct	Check that the voltage value is >10V (*)

(*) Normal voltage value is between 12 Volt < voltage < 24 Volt



MAINTENANCE

After-sales assistance for calibrations, maintenance and repairs, is performed by SISGEO's Customer Care Department.

The authorization for shipment shall be activated by requesting an RMA ticket (Return Manufacturer Authorization).

Please create your account and then fill in the RMA form clicking on:

<http://www.sisgeo.com/assistance.html>

Please read carefully the instruction published on Sisgeo's web site.

Send back the instrument/equipment with the complete accessories, using suitable packaging, or, even better, the original ones.

The shipping costs shall be covered by the sender.

Please return to the following address with correct delivery documentation reporting the RMA code received:

SISGEO S.r.l.
Via F.Serpero, 4/F1
20060 MASATE (MI)

Customer Care Department e-mail: ***assistance@sisgeo.com***

APPENDIX 1

THERMISTOR TEMPERATURE CONVERSION (FOR ANALOG PROBES ONLY)

Resistance to temperature equation:

$$T = \frac{1}{A + B (\ln R) + C (\ln R)^3} - 273.2$$

Where:

T= temperature in °C

LnR= natural Log of the thermistor resistance

A= 1.4051×10^{-3} (coefficients calculated over the -50°C to +70°C span)

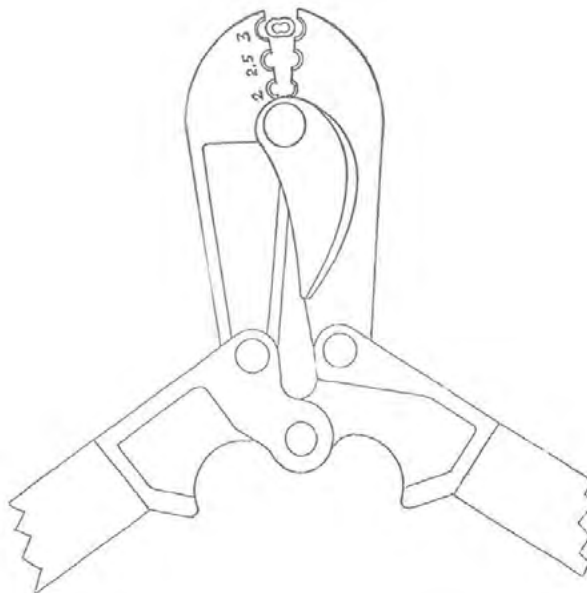
B= 2.369×10^{-4}

C= 1.019×10^{-7}

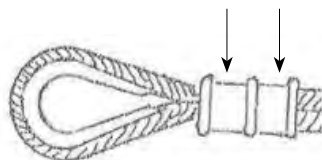
Ohms	Temp	Ohms	Temp	Ohms	Temp	Ohms	Temp
16.60K	-10	5971	10	2417	30	1081	50
15.72K	-9	5692	11	2317	31	1040	51
14.90K	-8	5427	12	2221	32	1002	52
14.12K	-7	5177	13	2130	33	965.0	53
13.39K	-6	4939	14	2042	34	929.6	54
12.70K	-5	4714	15	1959	35	895.8	55
12.05K	-4	4500	16	1880	36	863.3	56
11.44K	-3	4297	17	1805	37	832.2	57
10.86K	-2	4105	18	1733	38	802.3	58
10.31K	-1	3922	19	1664	39	773.7	59
9796	0	3784	20	1598	40	746.3	60
9310	-1	3583	21	1535	41	719.9	61
8851	2	3426	22	1475	42	694.7	62
8417	3	3277	23	1418	43	670.4	63
8006	4	3135	24	1363	44	647.1	64
7618	5	3000	25	1310	45	624.7	65
7252	6	2872	26	1260	46	603.3	66
6905	7	2750	27	1212	47	582.6	67
6576	8	2633	28	1167	48	562.8	68
6265	9	2523	29	1123	49	543.7	69
						525.4	70

APPENDIX 2

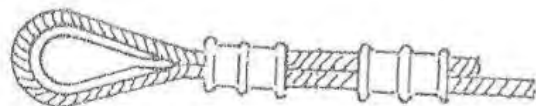
CORRECT USE OF PLIER AND COPPER CLAMP



Plier for copper clamps mm 2, 2.5, 3. Use only for supplied copper clamps.



Execute 2 pressing



For better safety, use 2 copper clamps

Analog BH Profile	Digital BH Profile
ø 2 mm steel wire	ø 2.5 mm steel wire