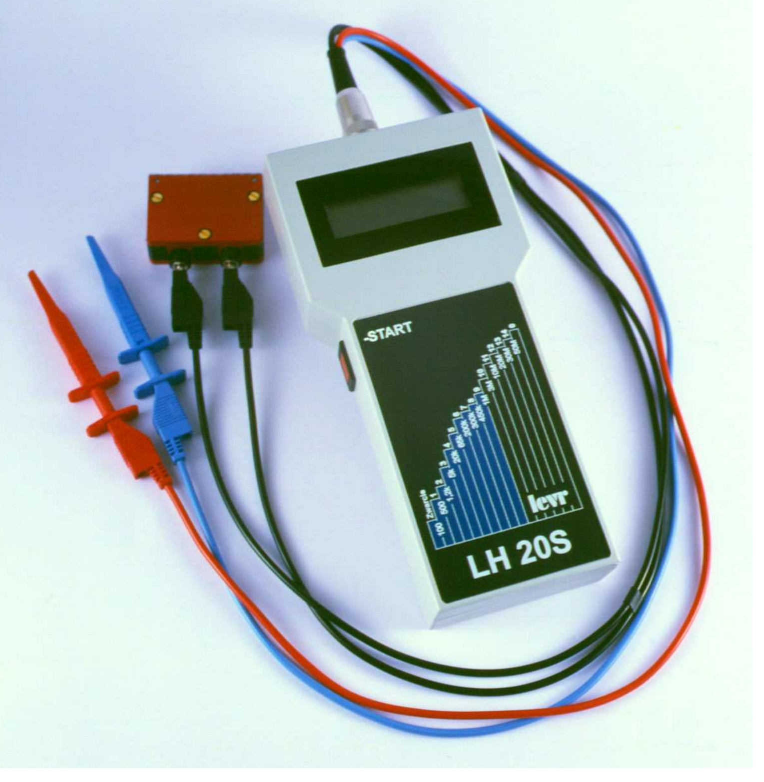
PORTABLE MOISTURE DETECTOR

LH-20S

(RESISTANCE ALARM SYSTEM)



USER MANUAL

levr

Ver. 2.6

1. Moisture Measurements of Pre-Insulated Heating Pipelines with the Resistance Alarm System

For the purpose of measurement, pre-insulated heating pipelines with resistance alarm systems can be regarded as consisting of the following elements: carrier pipe, polyurethane insulation, alarm loop, casing pipe. The alarm loop consists of the resistance wire (e.g. NiCr8020), bare or with perforated insulation, and of the insulated copper wire. The resistance of the resistance wire is given in Ω/m, and the resistance of the copper wire (serving as the return wire for electrical measurement signals) is so low that its influence is often omitted in measurements. The influence of the copper wire is further diminished by its complete electrical insulation from other elements of the alarm system. Both wires are located inside the polyurethane insulation between the carrier pipe and the casing pipe. In case of a leakage from either pipe, moisture penetrates the insulation, changing its electrical resistance. Resistance changes can be detected by periodic measurements of the resistance between the resistance wire and the carrier pipe. The measured resistance value corresponds to the level of moisture in the insulation. The resistance wire of the alarm loop is also used to locate the leakage (moisture).

2. Representation of Measured Values

The LH-20S detector is designed to measure the resistance of polyurethane insulation and the alarm loop. The resistance of the loop is used to automatically calculate the length of the tested pipeline section. Insulation resistance, in turn, is used to determine the MH moisture level or the C level of the short circuit between the alarm wire and the carrier pipe. Relationships between insulation resistance and the MH and C levels are presented in table 1.

MH moisture level of polyurethane insulation	C level of the short circuit between the alarm wire and the carrier pipe	Insulation resistance range
1	1	100Ω÷500Ω
2	2	500Ω÷1,2kΩ
3	3	1,2kΩ÷5kΩ
4	4	5kΩ÷20kΩ
5	5	20kΩ÷65kΩ
6	6	65kΩ÷200kΩ
7	7	200kΩ÷300kΩ
8	8	300kΩ÷450kΩ
9	---	450kΩ÷1MΩ
10	---	1MΩ÷3MΩ
11	---	3MΩ÷10MΩ
12	---	10MΩ÷20MΩ
13	---	20MΩ÷30MΩ
14	---	30MΩ÷50MΩ
0	---	>50MΩ

table 1

In resistance alarm systems, the alarm loop length and the pipeline section length are calculated along the length of the resistance wire. According to technical specifications, the maximum length of the resistance alarm loop is 1000m. For loops of such length, the MH moisture level should be equal to or higher than 12. Minimum polyurethane insulation resistance for sections shorter than 1km can be calculated on the basis of the following formula:

$$R = \frac{R_{min}}{L / L_{max}}$$

R [MΩ] – minimum polyurethane insulation resistance value for a heating pipeline with length of less than 1km

R_{min} [MΩ] – manufacturer's minimum polyurethane insulation resistance value in a heating pipeline section with the length equal to L_{max} = 1km

L [km] – length of the tested section ($L \leq L_{max}$)

L_{max} [km] – manufacturer's maximum length of a pre-insulated heating pipeline section with a resistance alarm system (L_{max} = 1km)

Attempts to locate the leakage (moisture) in heating pipelines are generally undertaken when the polyurethane insulation MH moisture level drops below 10.

Measurement and calculation results are displayed on the backlit alphanumeric LCD display. The display has 2 lines, 16 characters each. The first line displays the following information:

- MH moisture level of polyurethane insulation,
- polyurethane insulation resistance [kΩ, MΩ],

or

- C level of the short circuit between the alarm and the carrier pipe,
- short circuit resistance [kΩ, MΩ].

The second line displays the following information:

- length the heating pipeline section [m],
- resistance of the alarm loop [Ω].

The device can also display text messages. The first line of the display displays text messages which inform of possible problems with the measurement of polyurethane insulation resistance:

- **Brak kontaktu** (**No Contact**) – poor quality of the connection between the carrier pipe and the LH-20S detector.
- **Zwarcie** (**Short Circuit**) – metallic contact between the carrier pipe and the alarm loop.

The second line of the display displays text messages which inform of possible problems with the measurement of alarm loop resistance:

- **Przerwana pętla (Open Loop) –** there is a break in the alarm loop.
- **HI –** alarm loop resistance (length) measurement range exceeded.

Note that there is a logical connection between the type and location of displayed measurement results and text messages.

The LH-20S device also alerts the user when its batteries are low. Since the device is powered by two batteries, located one above the other, there are also two separate messages which may be displayed:

- **Górna bateria** (**Upper Battery**) – replace the upper battery.
- **Dolna bateria** (**Lower Battery**) – replace the lower battery.

3. Measurements

3.1. Primary Measurements

Primary measurements provide the most detailed information regarding the tested sections of a pre-insulated heating pipelines with a resistance alarm loop. Sometimes, particularly in emergency cases, the information gathered from primary measurements suggest performing secondary measurements to further identify the cause and location of the problem. Fig. 1 presents the connection diagram for primary measurements. Note that the wires of the alarm loop should be connected together at one end of the tested pipeline section. The wires can be connected together inside a terminal box, connector box etc.

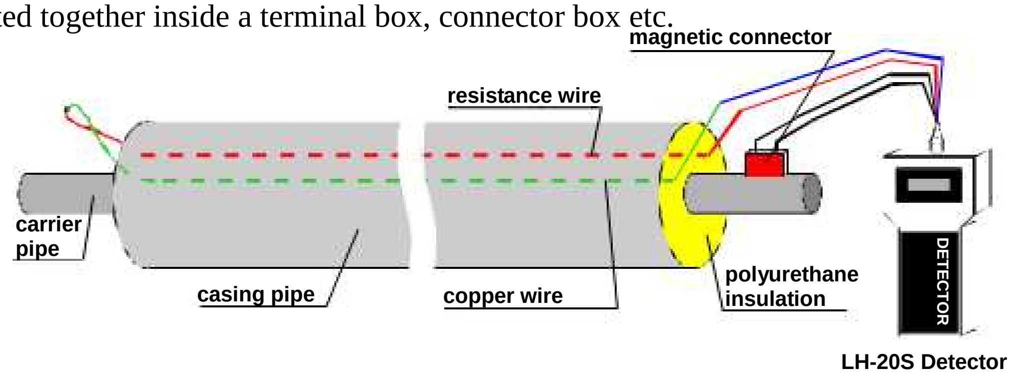


Fig. 1. Primary measurements

After making the connections shown in fig. 1, press and hold the START button of the LH-20S detector. The device will first display information about itself (type, serial no.) and then the results of measurements and calculations. Example results are given below:

MH=0 90MΩ
1000m 5736Ω

The first line of the display displays the calculated value of the MH moisture level and the measured polyurethane insulation resistance, while the second line displays the calculated length of the pipeline section in meters and the measured alarm loop resistance in ohms.

Practical Advice

Primary measurements should be performed regularly during the installation of the alarm system to ensure correctness of installation. Reasons for the importance of control measurements are illustrated in fig. 2 depicting three pipeline sections which are to be joined together. Measurement results of the MH moisture level and polyurethane insulation resistance are presented for each section. Consider two cases:

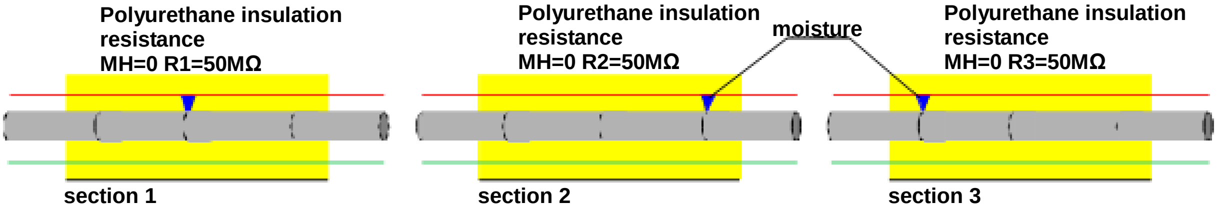


Fig. 2.

<u>CASE 1</u>. The person assembling the pipeline measures the MH moisture level and polyurethane insulation resistance.

Preliminary moisture measurements, performed individually for each section, suggest poor condition of the alarm system. MH=0 results are not satisfactory if the polyurethane insulation resistance of each section is only 50MΩ. The results of joining the sections together *are not difficult to predict. The resulting resistance of polyurethane insulation for two sections joined together will be equal to:*

$$Rz = \frac{R1 \cdot R2}{R1 + R2} = \frac{50 \cdot 50}{50+50}[M\Omega] = 25M\Omega \rightarrow MH = 13$$

and after joining section 3:

$$Rc = \frac{Rz \cdot R3}{Rz + R3} = \frac{25 \cdot 50}{25+50}[M\Omega] \approx 16{,}8M\Omega \rightarrow MH = 12$$

Person assembling the pipeline is not misled by the results, and does not try to correct the joints between the three sections. If the same person performed the installation works, they will regret not having performed enough control measurements of polyurethane insulation resistance, as a result of which they allowed moisture to be locked in the joint(s) of the installed sections.

*CASE 2. The person assembling the pipeline measures **only** the MH moisture level of polyurethane insulation.*

Measurements for sections 1 and 2 of the pipeline suggest very good condition of the alarm system (MH=0). After the two sections are joined together, however, their resulting MH moisture level equals 13. Still, the situation is not yet critical. The situation becomes critical after joining section 3, as a result of which the MH value drops to 12.

Three supposedly correct sections (MH=0) of the alarm system, after they are joined together, barely meet the technical specifications regarding moisture levels (MH≥12).

An inexperienced person will be misled by the results and will look for faults in the joints between the three sections.

3.2. Secondary Measurements when MH≤11 and when the ZWARCIE (SHORT CIRCUIT) or C Messages are displayed

Example measurement results are given below:

MH=9 0,8MΩ	Zwarcie	C =7 0,2MΩ
1000m 5736Ω	1000m 5736Ω	1000m 5736Ω

Each of the problems discussed in this section needs to be located and removed. Choice of action depends on the condition of the insulation of the copper alarm wire. If, as intended, the copper wire is not connected electrically to the carrier pipe, either directly (short circuit) or by the moisture between them, then the wire fault can be located using typical methods and devices (e.g. the LP-10S fault locator). The condition of copper wire insulation can be tested by performing a secondary measurement with the LH-20S device. Fig. 3 presents the connection diagram for the secondary measurement. Note that the alarm loop should be open at both ends of the tested pipeline section, and the blue wire of the LH-20S detector is not involved in the measurement.

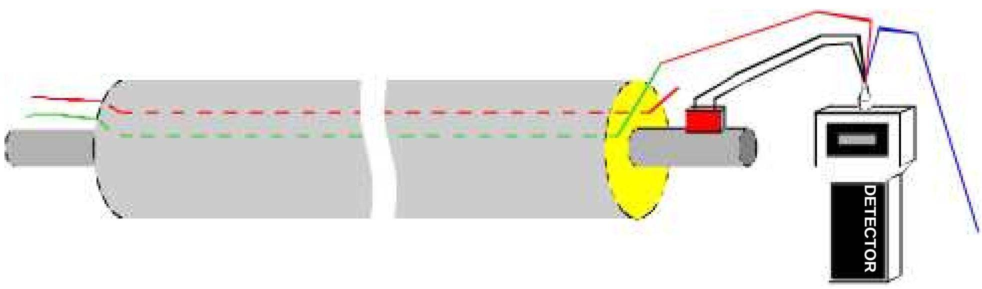


Fig. 3. Testing the insulation of the copper wire

Only the below measurement result confirms that the Teflon insulation of the copper wire is in good condition.

MH=0 >99MΩ
Przerwana pętla

The **Przerwana pętla** (**Open Loop**) message results from the adopted measuring method (without the blue wire) and is not significant in this case. If the measurement result is different from the one above, locating the fault using standard methods is going to be difficult or even impossible – particularly when the MH parameter has low values or when, instead of measurement results of the resistance between the copper wire and the carrier pipe, the device displays the **Zwarcie** (**Short Circuit**) message.

Practical Advice

The above observations strongly suggest the following conclusion: ***before attempting to locate the leakage (moisture) or short circuit in the pre-insulated heating pipeline, always test the insulation of the copper alarm wire.***

A typical symptom of the negative influence of faulty copper wire insulation during attempts to locate a leakage or short circuit are results which suggest that the fault occurs at exactly the opposite end of the pipeline section. After heading to the indicated location and performing a second attempt to locate the fault, the device, in turn, indicates that the fault occurs at the exact same spot where the first measurement was made, and so on.

Accidental shorting of the copper wire with the carrier pipe or damaged insulation in the moist location causes the wire to be no longer useful for measurements. The location of the short circuit or moisture between the copper wire and the carrier pipe can only be determined with the reflectometer.

Note, however, that the heating line consists of two identical pipelines: feed and return. It is possible, therefore, to locate the moisture between the resistance and copper wires and the carrier pipe by replacing the faulty copper wire with an undamaged wire from the twin alarm system. If by doing so you manage to find the location of the resistance wire fault, then it is highly probable that the indicated spot will also be the location of the damage (this does not usually apply in case of a short circuit) in the insulation of the copper wire.

During attempts to locate the moisture, the damaged copper wire can be replaced with the resistance wire from the second pipeline, as long as the second wire is not shorted with the carrier pipe (MH=0; >99MΩ). In such cases, however, the method of calculating the location of the leakage (moisture) is different. The length of thus formed alarm loop is twice as large as the length specified in the technical documentation. (The length of the heating pipeline and the alarm loop is calculated along the length of the resistance wire.)

Secondary measurements for the resistance wire of the alarm loop are performed in a similar way but for different reasons. Connection diagram is presented in fig. 4.

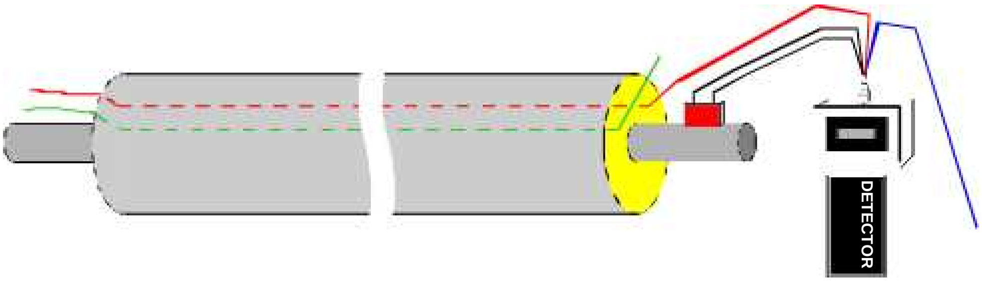


Fig. 4. Testing the moisture level between the resistance wire and the carrier pipe and detecting the short circuit

The primary reasons for performing this measurement will be explained later in Practical Advice. At this point, it should simply be noted that the measurement for the resistance wire is sometimes performed instinctively after detecting moisture between the copper wire and the carrier pipe in order to confirm the detected condition for both wires. In most cases, also after detecting moisture, the two results are compared. Although the comparison of the results is unlikely to produce useful conclusions, it should be performed just in case.

It happens very seldom that attempts to locate moisture in a branched pipeline system can be made directly after detecting the moisture. Even when the secondary measurement indicates that the insulation of the copper wire is in good condition, it is possible that there are several leakages, and proper actions need to be undertaken in order to locate them all. First, divide the moisturized alarm loop into separate sections by disconnecting the connections in terminal boxes (BS-AD; PPA) and everywhere else. Then, using the above-described secondary measurement method (fig. 4), measure the moisture level in each section. When moisture is detected in two or more sections, form alarm loops by connecting (e.g. in a terminal box) the end of the "moist" wire (MH≤11) from one pipe with the end of the twin "dry" wire (MH=0; >99MΩ) from the second pipe. Only after forming such substitute alarm loops you can attempt to locate the leakages (moisture). Note that the length of the alarm loop formed from two resistance wires located in separate pipes is twice as large as the length specified in the technical documentation. Furthermore, if the pipeline system is branched, the resistance wire in one branch may be extended with the copper wire in a separate branch. For these reasons, substitute loops should be formed with the help of the connection diagram.

Sometimes, moisture appears simultaneously in two parallel (located in separate pipes) sections of wires which are to be connected to form a substitute loop. In such cases, use an additional copper wire lined outside the tested sections of the heating pipelines.

3.3. Secondary Measurements when the Przerwana pętla (Open Loop) or HI messages are displayed or in case of Unstable Measurement Results of the length and resistance of the alarm loop

Secondary measurements need to be performed when one of the situations mentioned in the heading of this section occurs during primary measurements. When the **Przerwana pętla** (**Open Loop**) message is displayed, check the detector wires of the LH-20S and all other connections of the alarm loop (connection boxes, joints of the connectors welded to carrier pipes). Detector wires (red and blue) are in good condition if, after shorting them together, the second line of the detector display displays 0m and 0÷4Ω.

Presented below are some of the possible measurement results of the LH-20S detector which signal that the alarm loop is open.

1) MH=0 >99MΩ 2) MH=10 2,2MΩ 3) MH=0 >99MΩ

Przerwana pętla	Przerwana pętla	HI
4) MH=6 0,2MΩ HI	5) MH=4 12kΩ 653m 3745Ω ←	*highly unstable* *measurement results*

Under typical conditions, the above results should be interpreted as follows:

Result 1:

There is no moisture (MH=0; >99MΩ) in the area of the break in the alarm loop between the loop and the carrier pipe. It is impossible to establish the number of alarm loop faults. At least one of the two wires of the alarm loop is faulty.

Result 2:

There is moisture (MH=10) in the area of the break in the alarm loop. It is impossible to establish the number of alarm loop faults. At least one of the two wires of the alarm loop is faulty. The reasons for the fault are external: the casing pipe may be damaged, allowing external moisture (groundwater) to penetrate the insulation.

Result 3:

There is only one break in the alarm loop, caused by incorrect tightening of the sleeve connecting the ends of the alarm loop inside the joint. It is impossible to determine which of the two wires of the alarm loop is faulty.

Result 4:

It is impossible to determine the number of breaks in the alarm loop, although it is highly probable that only one break exists. The ends of the broken wire of the alarm loop are connected electrically by the moisture. The resistance of the connection is added to the resistance of the wires and is high enough to exceed the alarm loop resistance (length) measurement range. Simultaneous indication of moisture (MH=6) and displaying of the **HI** message suggests that the fault is caused by external reasons: the casing pipe may be damaged, allowing external moisture (groundwater) to penetrate the insulation.

Result 5:

There is only one break in the alarm loop. The ends of the broken wire of the alarm loop are connected electrically by the moisture. Since the resistance of such connection has no fixed value, results of the measurements of length and resistance of the alarm loop are highly unstable. It is impossible to determine which of the two wires of the alarm loop is faulty. The reasons for the fault are external: the casing pipe may be damaged, allowing external moisture (groundwater) to penetrate the insulation.

The break(s) in the alarm loop can be located when the problem is correctly recognized and after measurement conditions are properly prepared. The measurements should begin with a test of the copper wire, which is most prone to sustain such type of damage. Fig. 5 presents the connection diagram of the measurement circuit.

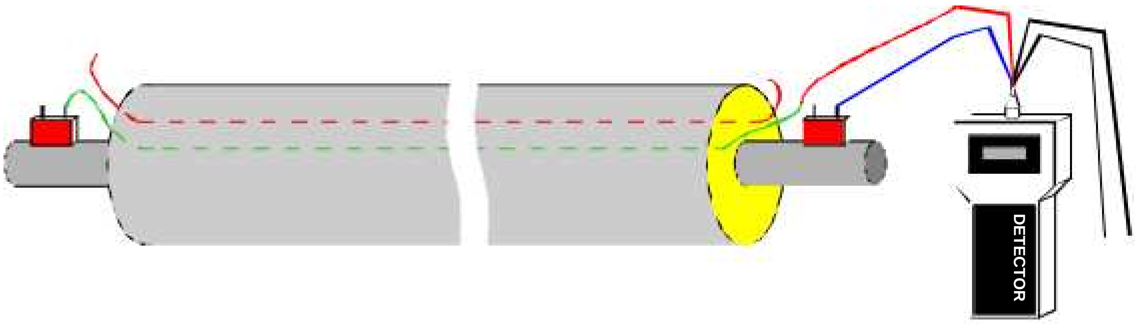


Fig. 5. Testing the copper wire for mechanical damage

As depicted in the figure, a magnetic connector is used to connect one end of the copper wire with the carrier pipe. Red and blue detector wires are connected respectively to the second end of the copper wire and the carrier pipe. A magnetic connector can be used for easier connection with the pipe. After making the connections, start the measurements. If the **Przerwana pętla** (**Open Loop**) or **HI** message appears in the second line of the display or if measurement results are highly unstable, then the copper wire of the alarm loop is faulty. The break in the loop can be located with a reflectometer. The copper wire is in good condition if the measurement results are between 0÷11m and 0÷60Ω. Measurement results depend on the length of the tested wire (0.036Ω/m) and on the resistance of the contacts between the magnetic connectors and the carrier pipe.

Practical Advice

Connections for secondary measurements need to be made carefully to ensure that they do not affect measurement results. Fig. 6 presents a method of testing the quality of the contact between the magnetic connector and the carrier pipe.

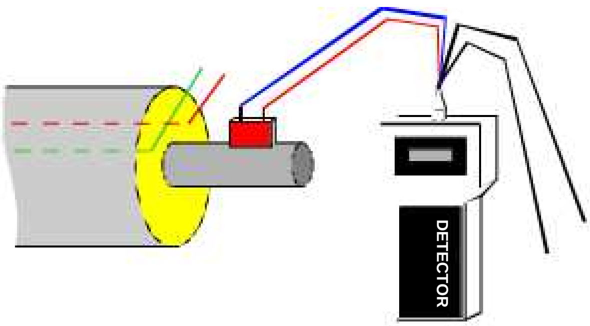


Fig. 6. Testing the quality of the electric contact between the magnetic connector and the carrier pipe

The quality of the contact is good if the device displays the following measurement results: 0m, 0÷3 Ω.

The resistance wire should be tested regardless of the measurement results for the copper wire. It is not uncommon for both wires to be faulty (broken). Appropriate connection diagram is presented in fig. 7.

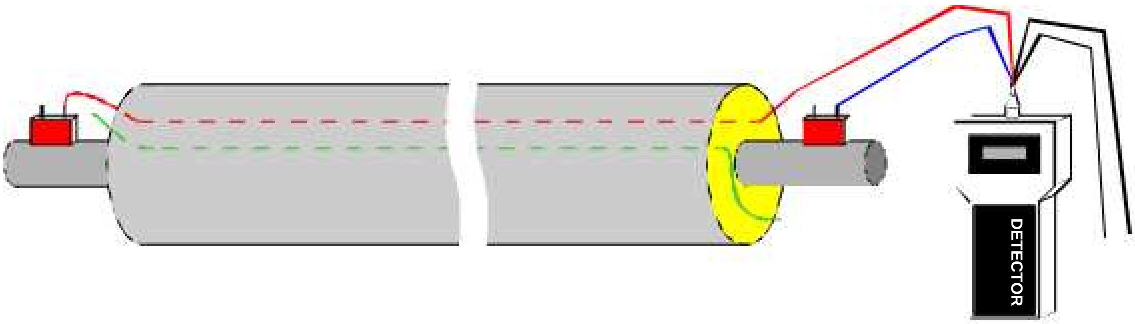


Fig. 7. Testing the resistance wire for mechanical damage

In order to test the resistance wire, first connect the resistance wire to the carrier pipe at one end of the alarm loop (e.g. in the connecting box or as shown in fig. 7). Then, connect the red and blue detector wires respectively with the second end of the tested wire and with the magnetic connector attached to the carrier pipe. Measurement results depend on the length of the tested wire (5.7Ω/m) and on the resistance of the contact between the magnetic connectors and the carrier pipe. If the connections are made correctly, then the detector simply displays the length and resistance of the tested wire. If the ***Przerwana pętla*** *(**Open Loop**) or* ***HI*** *message appears or if measurement results are highly unstable, then the resistance wire of the alarm loop is faulty. The displayed message and measurement results help to determine the type of fault. (See example results and comments.) If a break in the alarm loop is detected, then further actions depend on the structure of the heating pipeline system. If the pipeline has no branches, locate the fault with the reflectometer. If the pipeline has branches, first isolate the faulty section of the wire by disconnecting the connections of the alarm loop in all terminal boxes. Then, the condition of each section should be tested almost in accordance with the above-described method and fig. 7. The only difference is that, in the branches, the resistance wire may be extended with the copper wire. In such case, connect the end of the wire to the pipe.*

In general, breaks in the isolated sections of the alarm loop wire should be located with a reflectometer. Capacitive measurement method may be used to locate the break in the wire only if there is no moisture in the area of the wire break (result 1).

Note: In each of the above-described secondary measurements, any information displayed in the first line of the detector display is insignificant. The first line of the display may display the MH=0; >99MΩ result if the black detector wires are connected together or the ***Brak kontaktu*** *(**No Contact**) message if the detector wires are not connected together.*

When one of the wires of the alarm loop is connected to the carrier pipe, a substitute loop is formed. In such cases, the pipe serves as a reference point, because there are no breaks in it and because its resistance is almost equal to 0Ω. In making such substitute loops, it is crucial to achieve minimal resistance values of the contact with magnetic connectors (figs. 5;7). Sometimes, the difficulty in making connections is the distance between the end of the tested wire and the access point to the carrier pipe to which the connector is to be connected. It is easier to make the connections if you make substitute loops from wires located in two parallel sections of the heating pipeline system. First, however, ensure that the wires used as substitutes are not faulty. Connections between separate sections of the alarm loop should be made with the use of terminal boxes. For non-faulty sections, length measurement values are twice as high as specified in the technical documentation.

3.4. Determining the reasons for the Brak kontaktu (No Contact) message

The **Brak kontaktu** (**No Contact**) message signals the lack or poor quality of the connection between the LH-20S detector and the carrier pipe. When the above message is displayed, try rubbing the magnetic connector along the carrier pipe. If this produces no results, check the condition of the two black detector wires. To do so, connect the two wires together and start the measurement. If the **Brak kontaktu** (**No Contact**) message appears, the wires are faulty and should be repaired or replaced.

Often, the black wires are damaged because the magnetic connector was disconnected from the carrier pipe by pulling on the wires.

4. Technical Specifications:

1. Measurement results display .... alphanumeric LCD display, 2x16 characters, backlit
2. Measurement ranges:
   - polyurethane insulation MH moisture level .... 1 ÷ 14 and 0
   - polyurethane insulation resistance .... 0,1kΩ ÷ 99MΩ
   - metallic short circuit of the alarm wire with the carrier pipe .... 0 ÷ 100Ω
   - C level of the short circuit of the alarm wire with the carrier pipe .... 1 ÷ 8MH
   - short circuit resistance .... 0,1kΩ÷0,45MΩ
   - alarm loop length .... 1 ÷ 2000m
   - alarm loop resistance .... 1 ÷ 12042Ω
3. Measurement accuracy:
   - accuracy of the resistance measurement used in MH level determination .... ±5%
   - accuracy of the alarm loop resistance measurement .... ±0,2%
4. Text messages:
   - poor quality of the connection between the detector and carrier pipe .... Brak kontaktu (No Contact)
   - electric break in the alarm loop .... Przerwana pętla (Open Loop)
   - short circuit of the alarm wire with the carrier pipe C
   - metallic contact between the detector wire and the carrier pipe .... Zwarcie (Short Circuit)
   - measurement range exceeded during alarm loop length measurement .... ---HI---
   - low batteries .... Górna bateria (Upper Battery)
Dolna bateria (Lower Battery)
5. Power supply .... 2 x 6F22 (2 x 9V)
6. Working and storage temperature range .... 5 ÷ 50℃
7. Casing tightness class IP65
8. Dimensions 223x105x40
9. Weight with batteries 450g