ENGLISH

Mounting Instructions

FS63DTP, FS73DTP

Dielectric Temperature Probe

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1 GENERAL INFORMATION

The following instructions refer to the installation of FS63DTP Dielectric Temperature Probes.

These individual sensors (FS63DTP) are delivered as bundle of several sensors (FS73DTP) for easy installation of a setup for measuring temperature at multiple locations.

Material Numbers
K-FS73DTP

1.1 Environment Considerations

1.1.1 Packaging Disposal

The packaging of this equipment is designed to protect it from damage during transportation and storage. It is also made of materials that can be recycled or reused, in accordance with the European Union's waste management regulations to minimize its environmental impact.

If you plan to move your equipment to different locations it is advisable that you keep the original package for reuse. This will not only grant proper protection for transportation, but also ensure the reduction of waste creation.

Packing boxes include a label with information on the materials used on that specific package.

Fig. 1.1 Packing label example

Please follow the instructions below to dispose of the packaging properly and responsibly and contribute to the preservation of our planet. Thank you!

To dispose of packaging, you should:

- Remove any labels, adhesives, nails, staplers or caps that are not part of the same material.
- Rinse the packaging with water to remove any residues or dirt.
- Flatten or fold the packaging to reduce its volume and save space (except for glass that should not be crushed).
- Separate the packaging by material and place it in the appropriate recycling bin or bag.

Most of our packing are made of paper and plastic and aimed to be reused or recycled, but they are not appropriate for food containing. Please consult the chapter “Packing Symbols” for more detailed information about the packing materials used by HBK FiberSensing, marked in the packing label of each product delivered to customers.

Packaging Symbols

Packing materials are marked with the correspondent symbol for guidance.

Not appropriate for food

Recyclable

The recycling symbols for the different materials include numbers and letters that identify the material type. For example, PET (polyethylene terephthalate) is marked also with the number 1, and PE-HD (high-density polyethylene) is marked with the number 2. For paper (PAP) 20 corresponds to corrugated cardboard and 22 to paper as seen in newspapers, books,…

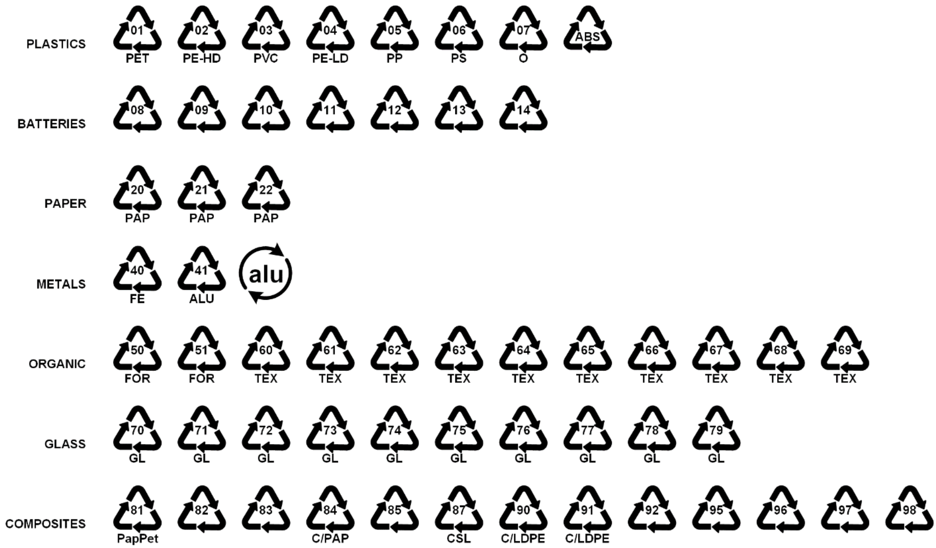

Fig. 1.2 Recycling symbols

Plastics

Plastic packaging materials are commonly bags, films, trays, blisters or containers.

Batteries

Batteries are not part of the packaging, but they may be included in the equipment or its accessories. HBK FiberSensing sensors do not include batteries.

Paper

Paper packaging materials are commonly boxes, cartons, envelopes, or labels.

Metals

Metal packaging materials are commonly cans, foils, caps, or wires.

Organic

Organic packaging materials could be wood, cork, or cotton and are made of natural or biodegradable materials that can be composted or reused.

Glass

Glass packaging materials are bottles, jars, or vials.

Composites

Composite packaging materials are made of layers of different materials, such as paper, plastic, and aluminum. They are marked with a recycling symbol and a letter that indicates the composition of the packaging. For example, PAP is for paper and plastic, and ALU is for aluminum.

1.2 Marking used in this document

Important instructions for your safety are specifically identified. It is essential to follow these instructions to prevent accidents and property damage.

Symbol	Significance
⚠ CAUTION	This marking warns of a *potentially* dangerous situation in which failure to comply with safety requirements *can* result in slight or moderate physical injury.
Notice	This marking draws your attention to a situation in which failure to comply with safety requirements *can* lead to damage to property.
! **Important**	This marking draws your attention to *important* information about the product or about handling the product.
Tip	This marking indicates application tips or other information that is useful to you.
i **Information**	This marking draws your attention to information about the product or about handling the product.
Emphasis *See …*	Italics are used to emphasize and highlight text and identify references to sections, diagrams, or external documents and files.
▶	This marking indicates an action in a procedure

2 INSTALLATION PROCEDURE

2.1 Introductory notes

When mounting FS63DTP temperature probes, please pay attention to the following:

- Handle with care.
  These are precision sensors and so their achievable accuracy highly depends on correct mounting.
- Do not overload the sensors.
- Avoid lateral forces or torque.
- Handle the cables with care before fixing to avoid damage.

Notice

The FS63DTP sensors are precision measuring elements and need to be handled carefully. Dropping or knocking the sensors may cause permanent damage. Make sure that the sensors cannot be overloaded, including while they are being mounted.

2.2 List of materials

Included Material
FS63DTP sensors

Needed Equipment
Optical Splitter (Optional)

Needed Material
Polyimide Tape. Recommended HBK: 1-KLEBAND

2.3 Sensor Installation

The FS63DTP Dielectric Temperature Probes are non metallic resistant sensors, designed to be immune to mechanical stresses. Nevertheless, limit pressure and bending radius of the sensor has to be observed during installation.

Depending on the device under test it might be needed that the sensor is secured either by gluing or taping. On other occasions, pressure around the sensor after installation is sufficient for securing it in place.

2.3.1 Unpacking

Carefully remove the bundle from the box.

- Cut the plastic tyes fixing the connectors.
- Cut the plastic tyes fixing the cables.
- Start uncoiling the bundle from the connectors end to the probes.
- Remove each probe from the foam with care.

Fig. 2.1 Packaged Sensor Bundle

Each sensor is covered with a tag containing its individual serial number. This cover identifies the sensor and its wavelength. The same reference is fixed on the corresponding cable next to the optical connector.

Fig. 2.2 Label over the sensor tip

2.3.2 Positioning the sensor

The FS63DTP has a 20 mm length tip. The center of the sensing element, however, is positioned at 8 mm from the probe tip (typical FBG length is 5 mm).

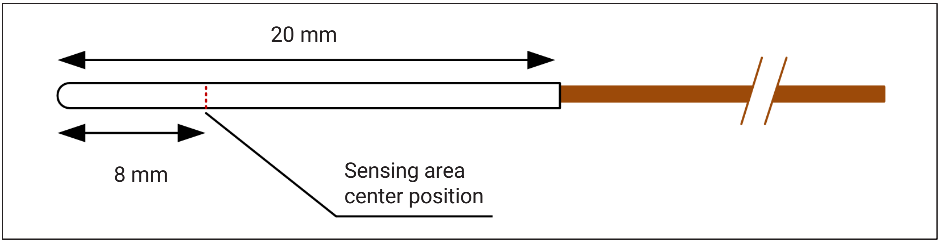

Fig. 2.3 Sensing point position

- Select the sensor location considering that the sensor head cannot be bent.
- Remove the sensor label from the probe.
- Place the sensor at the desired location.

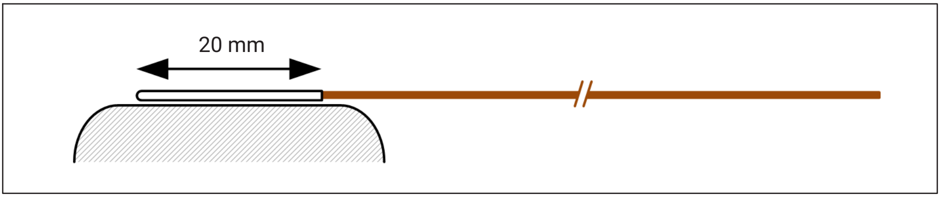

Fig. 2.4 Install the sensor on a flat surface

2.3.3 Fixing the sensor

To fix the sensor in place HBK recommends the use of polyimide tape (order number 1-KLEBAND).

- Apply a small piece of tape (~4 cm long) to secure the sensor head in place.

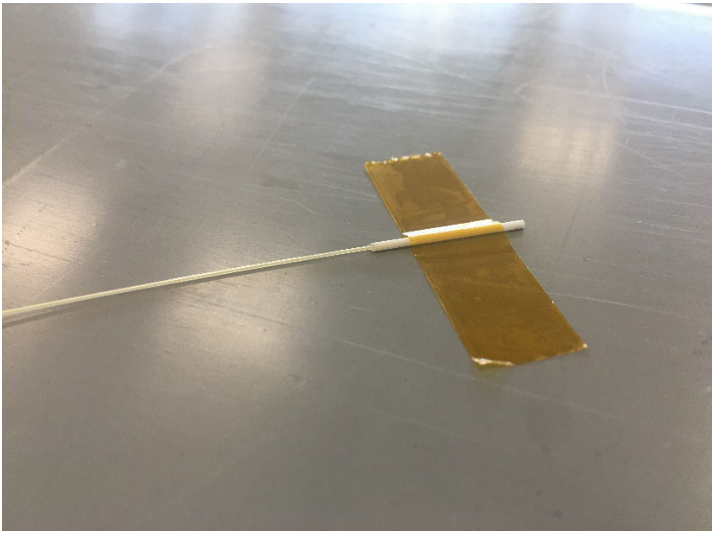

Fig. 2.5 Sensor fixed with Polyimide tape

2.4 Cable routing

The FS63DTP probe is a terminal sensor, meaning that there is only one cable exiting the sensor. The optical fiber is protected with submilimetric peek tube that, despite delivering a higher resistance to the fiber, has to be handled with care so that is is not damaged.

Cable routing must be chosen considering that curvatures are kept within the specified limits for the used cable and that sharp edges and kinks should be avoided.

Each FS73DTP (bundle of FS63DTP probes) can be delivered with a wrapping spiral that helps securing the cables together. The length of the spiral is customer-defined. It is a loose wrap, so that during installation its position can be adjusted.

Each probe's individual cable from the probe head to the spiral wrap should be fixed. The same tape type can be used. Probe lengths on the same bundle are the same. This means that, depending on the measurement position, differences can be accommodated on each side of the wrap (*Fig. 2.6*).

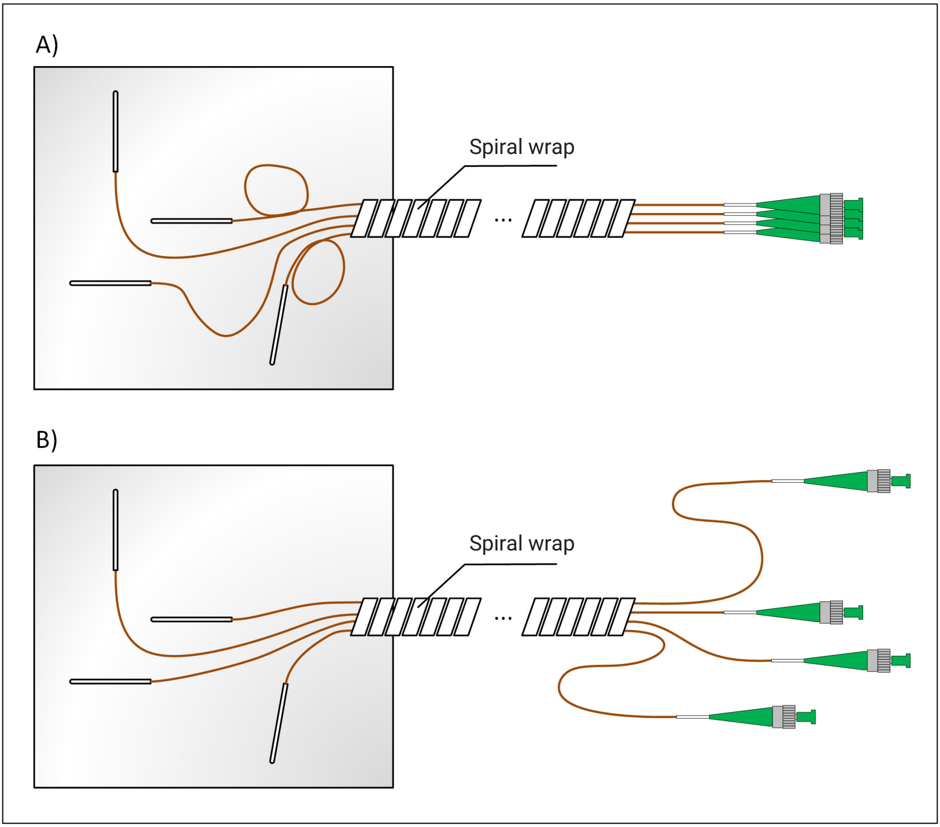

Fig. 2.6 Cable routing and excess cable accommodation options.

Important

In case the sensor and the cable are to be pressured (for example between battery cells), always consider routing the cables as presented in the option B above. Coiled cable will always have fiber crossing over one another that can create signal losses when compressed.

3 SENSOR CONFIGURATION

3.1 Sensor documentation

Calibrated HBK FiberSensing Sensors are delivered with a Calibration Sheet. The K-FS73DTP is a bundle of several FS63DTP Dielectric temperature probes, each with its individual characterization. The calibration sheet is, therefore, a table with with the relevant calibration information of each probe, identified by their individual Serial Number.

3.1.1 Measurement Computation

For enhanced accuracy FS63DTP dielectric temperature probes have a 3rd order polinomial calibration formula.

The calculations that should be performed for converting a wavelength measurement into temperature are the shown generally in *Fig. 3.1*. The temperature variation of each measurement point is given by a third order polynomial equation with coefficients obtained from the sensor calibration.

$$T = S_3(\lambda - \lambda_0)^3 + S_2(\lambda - \lambda_0)^2 + S_1(\lambda - \lambda_0) + S_0$$

Fig. 3.1 Temperature computation formula.

Where

- λ is the measured Bragg wavelength of each measurement point in nm
- λ_0 is the Bragg wavelength of the temperature at reference temperature in nm
- S_0 is the zero order sensitivity (reference temperature) in ºC
- S_1 is the first order sensitivity in ºC/nm
- S_2 is the second order sensitivity in ºC/nm^2
- S_3 is the third order sensitivity in ºC/nm^3

Measurement with Distance Effect Correction

When measuring with sweeping laser-based Optical Interrogators, such as the BraggMETER from HBK FiberSensing, the length of cabling between the interrogator and the sensor affects the measured reflected signal. This distance error is significant for sensors that rely on absolute wavelength values, such as temperature sensors.

The sweeping laser emits a varying wavelength over time. The method for measuring the reflected wavelength from the fiber Bragg grating (FBG) sensor identifies the wavelength being emitted at the time the reflected peak from the FBG is detected. As the acquisition rate increases, the delay caused by the distance the light travels both ways becomes more pronounced, reducing the accuracy of the absolute wavelength measurement. The same effect occurs with increasing distances.

The cable length effect manifests as a constant shift in the wavelength measurement, which depends on the sampling rate of the optical module and the distance between the sensor and the interrogator. The shift in the measured wavelength is negligible for low acquisition rates or short distances but becomes significant for high sampling rates or long distances.

$$\Delta\lambda_{error} = \frac{d \cdot 2 \cdot n \cdot RapRate \cdot FullRange}{SweepDirektion \cdot DutyCycle \cdot c}$$

Fig. 3.2 Wavelength shift due to sweeping laser speed

Where

- $\Delta\lambda_{error}$ is the wavelength “error”, in nm
- *d* is the distance (in m) between the sensor and the measurement unit
- *n* is the refraction index of the fiber (1.446 for standard SMF28 fiber)
- *RepRate* is the optical module actual acquisition scan (for BraggMETER interrogators in the selected acquisition rate, in S/s)
- *FullRange* is the length of the range of measured wavelengths (102 nm for BraggMETER interrogators)
- *SweepDirection* is the signal of the sweeping direction: 1 for sweeping from the lowest to highest wavelengths and -1 for sweeping from the highest to lowest wavelengths
- *DutyCycle* is the sweeping portion of the cycle without flyback
- *c* is the speed of light (3×10^8 m/s).

A fixed temperature error caused by the distance can be calculated:

$$T_{error} = S_3 \times \Delta\lambda_{error}{}^3 + S_2 \times \Delta\lambda_{error}{}^2 + S_1 \times \Delta\lambda_{error}$$

Fig. 3.3 Temperature error induced by the distance effect

The error can be applied to the calibration formula for correction:

$$T = S_3 \times (\lambda - \lambda_0)^3 + S_2 \times (\lambda - \lambda_0)^2 + S_1 \times (\lambda - \lambda_0) + S_0 - T_{error}$$

Fig. 3.4 Temperature computation formula with distance error correction

4 TYPICAL CONFIGURATION

Each FS63DTP probe can be connected directly to a single connector of an optical interrogator. However, as these are terminal sensors, they cannot be linked in series taking advantage of the intrinsic multiplexing capability of the technology. To overcome this situation optical splitters can be used. Splitters (as seen in *Fig. 4.2*) combine connected sensors signals into a single optical line. This way we can take advantage of the device full capabilities and measure several sensors on each optical connector of the device.

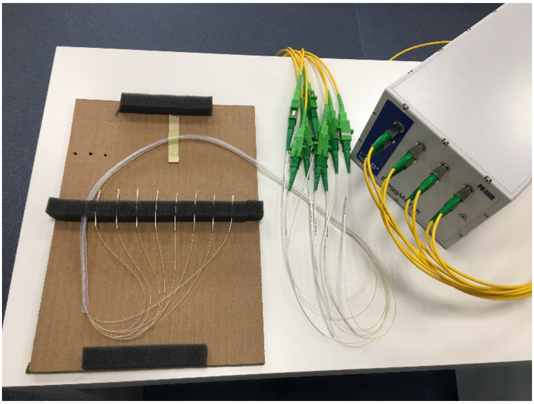

Fig. 4.1 8 Sensors connected directly to 8 connectors of the interrogator.

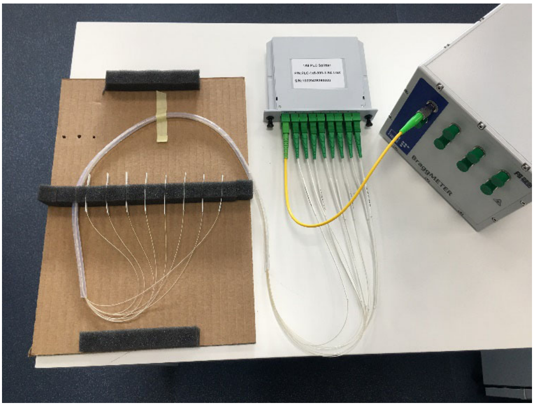

Fig. 4.2 8 Sensors combined through a splitter to a single connector of the interrogator.

16 FS63DTP Probes can be combined in a single optical connector of the device, which means that with a single instrument 128 temperature signals can be acquired simultaneously.

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