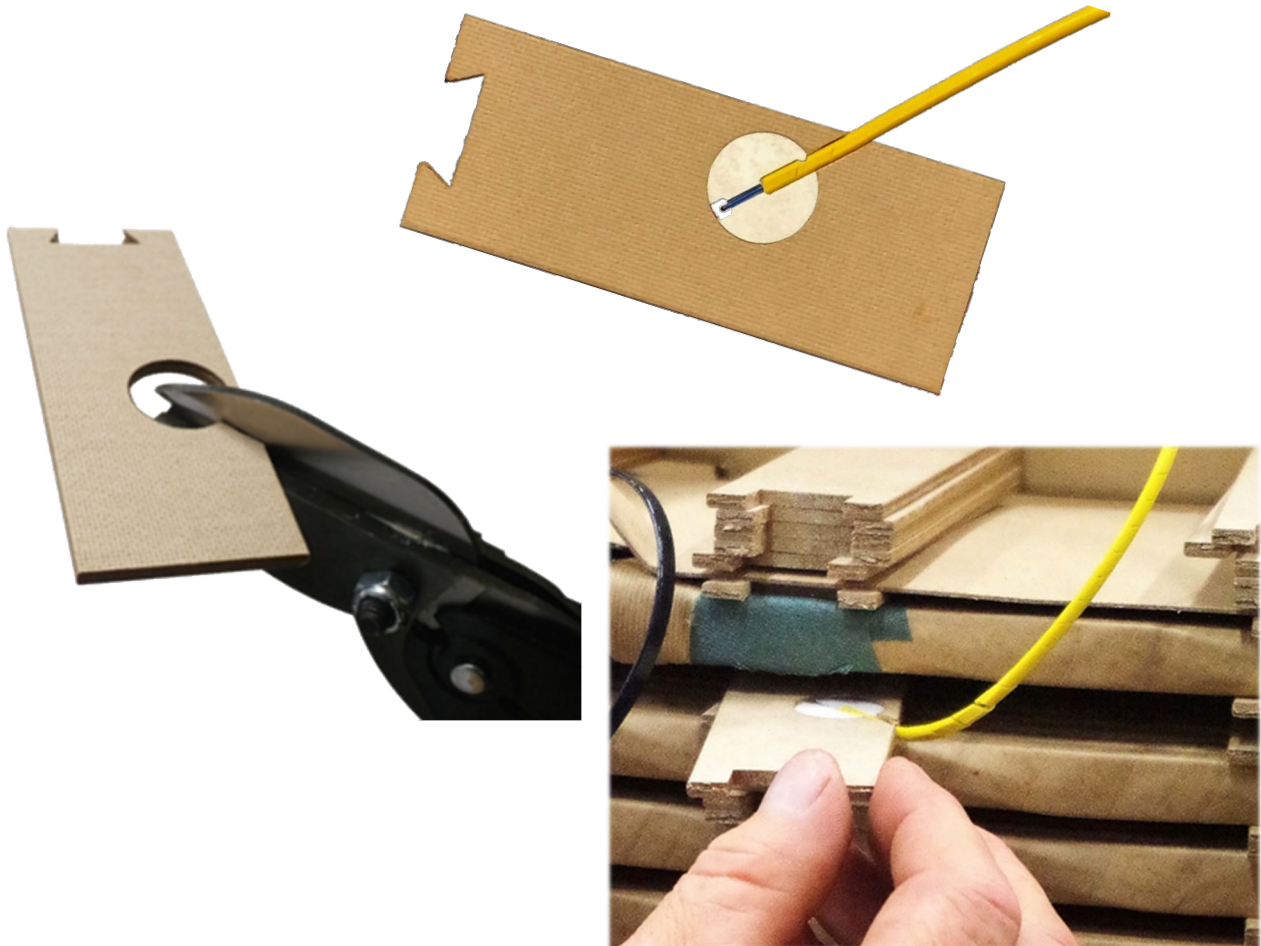




FISO Fiber Optic Hot Spot Temperature Sensor Installation Guide

MAN-00098 R2



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FISO thanks Transmag Energie for transformer's pictures.

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Content

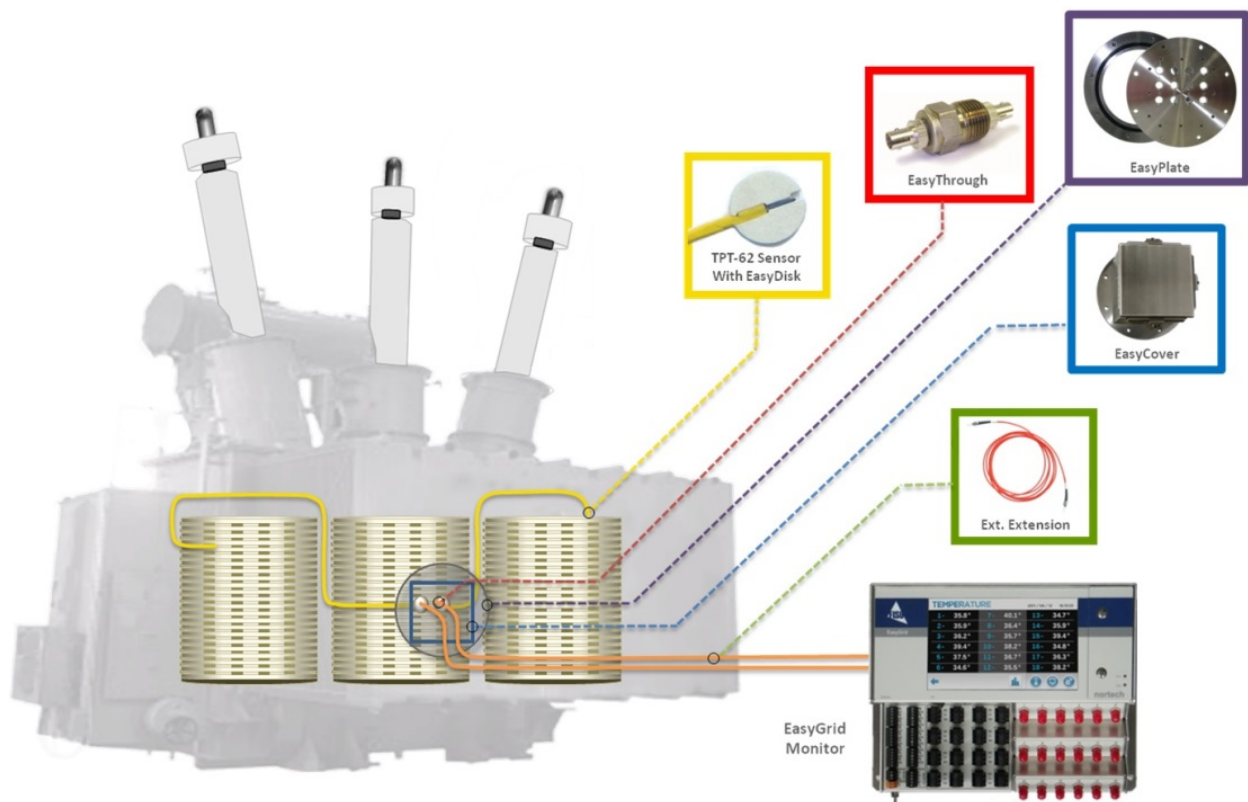
1	Introduction.....	4
1.1	System Overview	4
1.2	Planification of the sensors installation	5
1.3	TPT-62 Temperature Sensor.....	7
1.4	Handling Optical Cable	8
2	Sensor Installation in the winding.....	9
2.1	Installation of the sensors in the spacer	9
2.2	Installation of the instrumented Spacer in the winding.....	15
2.3	Sensor Handling until Routing	17
2.4	Test after each critical step of the transformer assembly	18
2.5	Probe Routing.....	19
2.6	Tank Wall Assembly Installation.....	20
2.7	External Optical Extension Installation.....	21
	Appendix A: Cleaning Fiber Optic Connectors.....	22
	Appendix B: LOG Sheet.....	25

1 Introduction

1.1 System Overview

The FISO Fiber Optic monitors are designed to monitor fiber optic Hot Spot temperature sensors installed inside high voltage power transformers. Immunity to electrical interference and the high dielectric constant procured by fiber optic sensors allow direct contact with high voltage components. It is the only technology that monitors the true winding Hot Spot temperature in real-time.

To be functional in its target environment, the FISO monitor is part of a system that includes the TPT-62 fiber optic Hot Spot temperature sensors and all the components in between. The figure below gives you a general idea of a typical installation.



1.2 Planning of the sensors installation

The sensor installation phase should be thoroughly planned before proceeding:

- ▲ **Where will the sensors be installed?**
- ▲ **How will the sensor tips be held in place?**
- ▲ **When should the sensors be installed?**
- ▲ **How will the sensor cable be routed out of the winding?**
- ▲ **How will the sensors cables be routed from the winding up to the tank wall feedthroughs?**
- ▲ **Where and how will the tank wall feedthroughs be installed?**
- ▲ **When to test the sensors?**

▲ **Where will the sensors be installed?**

The sensors should be installed to be in contact with the winding's hottest spot.

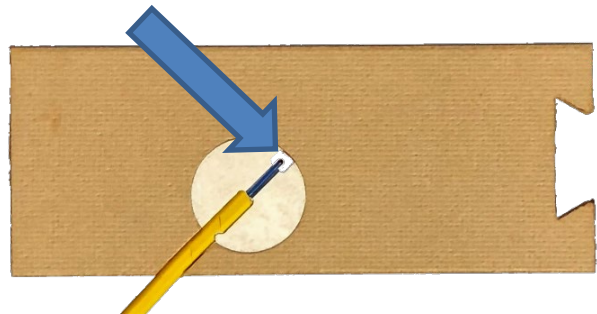
Fix it safely such that the winding cannot crush it if there is a sudden change in current or an abrupt contraction of adjacent coils.

We recommend installation of the sensors using the EasyDisk inside radial winding spacers as described in the Sensor Installation Section.

The following description assumes that this radial spacer method is being used.

The sensing element of the fiber-optic sensor is located at the end of the fiber-optic cable (sensing tip).

The transformer design engineer should determine the exact spacer in which to install the sensor and the position of the sensing element on the spacer. He must consider the dimensions of the EasyDisk to design the shape to be made in the spacer, and the minimum bending radius of the optical cable to draft how the cable will exit the winding.



Note

The winding's hottest spot is determined by the transformer manufacturer's calculations. Installation of additional sensors throughout the windings allows heat distribution data to be collected for calculation validation.

▲ **How will the sensor tips be held in place?**

The 3mm yellow cable is made of PTFE that is not affected by most of the chemical. This characteristic makes it very hard to glue or bond.

The EasyDisk is the perfect solution, as it acts as an anchor between the 3mm yellow cable and the spacer.

FISO introduced the EasyDisk tip in 2011 and Transformer manufacturers have rapidly adopted it. They now have an easy and reliable method to install and to hold in place the Fiber optic sensor.

▲ When should the sensors be installed?

In order to minimise the risk of damaging the sensors, it is preferable to install the sensors as late as possible in the winding manufacturing process. The winding should be manufactured as if no sensors were to be installed, i.e. all radial spacers should be put in place. It is easier and more efficient to simply remove normal spacers and replace them with spacers to which sensors have been attached just before the sizing/drying phase.

▲ How will the sensor cable be routed out of the winding?

The cable will exit the winding in the axial (vertical) duct delimited by the winding, the pressboard cylinder and the axial strip.

When the fiber optic cable changes direction, you must avoid making sharp bend. For example, simply cross the edge of the winding with a shallow angle.

▲ How will the sensors cables be routed from the winding up to the tank wall feedthroughs?

The sensors cables should be attached to supporting structures using cotton strapping just before or after the final drying of the core/winding assembly. Keep in mind the possible movement of the internal parts of the transformer during transportation or sudden change in current and keep some slack in the sensors cables. With the extra length of cable, make coils of about 20cm to 30cm in diameter and hold them on the supporting structure that will face the EasyPlate after the tanking.

▲ Where and how will the tank wall feedthroughs be installed?

The tank wall feedthroughs are installed on the EasyPlate at FISO factory. The EasyPlate is bolted to the tank wall via the EasyRing that is soldered to the tank wall.

Some manufacturers assemble the top plate of the transformer tank with the core/winding assembly and prefer to install the EasyPlate to the top of the transformer and finalize all the connections prior the final drying.

▲ When to test the sensors?

According to your quality control program, you could make incoming inspection test of the sensors. We recommend you to test and keep a record of the diagnostic values of the HotSpot sensors after each critical step of the transformer assembly: the installation in the winding, the compression/drying of the winding, the installation of the windings on the core, the drying of the winding / core assembly, the tanking, after the connection to the monitor (FAT).

You should also note the serial number, the position of each sensor and the optical port to which it is connected on the EasyPlate. See [Appendix B: LOG Sheet](#)

1.3 TPT-62 Temperature Sensor

The FISO heavy duty TPT-62 fiber optic Winding Hot Spot temperature sensor is specifically designed for permanent installation in oil-filled transformers.

The EasyDisk allows quick and secured installation in spacer without any adhesive. It ensures optimal sensor tip positioning on the conductor to allow reliable and accurate temperature measurements.

The Nomex™ EasyDisk also locks the PTFE Spiral-Wrap sheathing in the spacer to assure the sensors stay in place for the lifetime of the transformer.

The TPT-62 double PTFE oil permeable sheathing with transversal slits is designed to withstand installation stresses, harsh process conditions such as kerosene vapour, heat runs and induced vibration during all the transformer life. .

The TPT-62 can be used with all Nortech 62.5µm monitors (Sentinel II, EasyGrid, EasyGrid LT, EasyGrid Base and EasyTest). Neither the signal conditioner nor the TPT will require any calibration for the life of the transformer.

Temperature Range	-40°C to 225°C
Resolution	0.1°C
Accuracy	±1 °C
Sensor dimension	1.1mm
EasyDisk Diameter	18,55mm
Hole diameter in the spacer	19mm or ¾"
Cable Diameter	3mm
Cable slot width in the spacer	3mm
Short-term bend radius	≥10mm
Long-term bend radius	≥17mm
Certification	ASTM D-3426 ASTM D-149 IEC 243-1 IEC 243-3

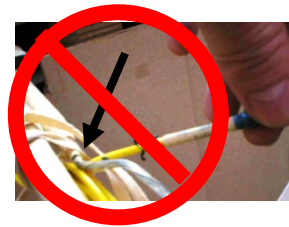


1.4 Handling Optical Cable

The core of any fiber optic cable is made of glass. For this reason, it should be handled with care and should not be viewed like a standard conventional electrical cable. If it is pinched, twisted, bent sharply or crushed, the glass core will break and the light attenuation will occur at this point.

Fiber optic sensors are pretty robust but...

- Avoid sharp bend
- Avoid kinking, twisting
- Avoid putting any tension on the cable
- Avoid dropping connector on hard surfaces



Like your car windshield or your glasses, the optical connector must stay clean to give good results.

Clean both connectors each time you connect them, because a small particle of dust on one connector could scratch both connectors. See [Appendix A: Cleaning Fiber Optic Connectors](#) for more details.

Always keep the protective cap on. It protects the optical connector when they are not connected.

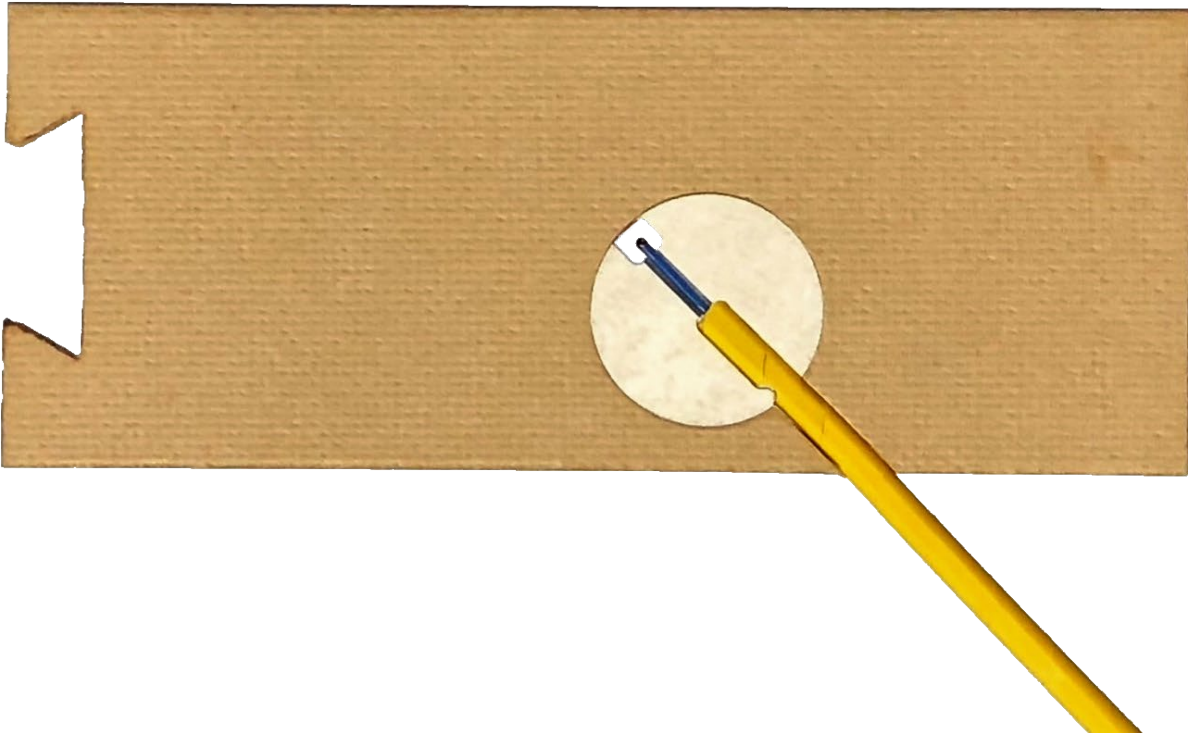


2 Sensor Installation in the winding

2.1 Installation of the sensors in the spacer

FISO strongly recommends the use of the EasyDisk for the installation of a TPT-62 sensor inside a winding spacer.

Additionally to the following steps, a video that shows an EasyDisk installation is available. Ask your FISO representative to get a copy or even better, an on-site live demonstration.



You should install the sensor in a 2,5mm thick spacer or more. You could stack some spacers.

The EasyDisk has a diameter of 18,55mm. We have found that with a hole diameter of 19mm (3/4 inch) it is easy to tightly insert the sensor in the spacer and it firmly stays in place until the installation in the winding.

The width of the slot for the cable should have 3mm, this will limit the oil movement around the sensors and give an accurate temperature reading.

2.1.1 Required Tools

The following tools are recommended to proceed with the installation.

19 mm Round Knockout Punch		 Both tools available in the EasyDisk Installation Kit PN: SEN-ESD-KIT
3 Blade Metal Snips with a 3mm Trace (if not available use a saw)		
Optical connector cleaner		EasyClean PN: SEN-CLEANER
FISO portable tester: EasyTest-II Or FISO GaAs monitor		EasyTest-II PN: E-TEST-II-01-A
Drill, wrench or ratchet with a 25mm Box		
10 mm Drill Bit		

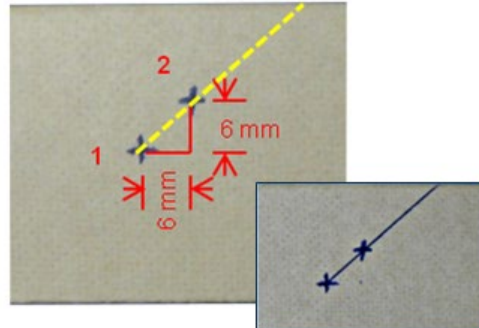
2.1.2 Pre Drilling

Mark the position where you wish to locate the sensor tip **1**.
Usually placed at the center of the spacer.

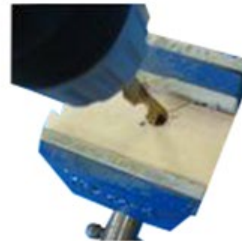


Offset mark **2** by the following:

- 6 mm vertically
- 6 mm horizontally



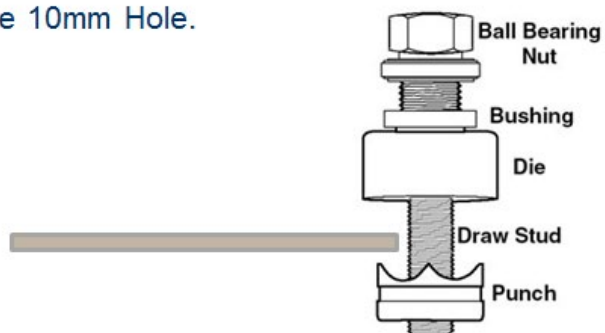
Draw a line that joins both marks and extend it to the edge. This becomes the position of the cable slot.



Drill a 10 mm hole using mark **2** as the center.

2.1.3 Using the Knockout Punch

Insert the Knockout Punch in the 10mm Hole.



Using a ratchet a wrench or a drill, rotate the knockout punch nut, while holding the spacer, until the punch goes through.



2.1.4 Cutting the Cable Slot



Using the 3 Blade Metal Snips cut a slot following the traced line.

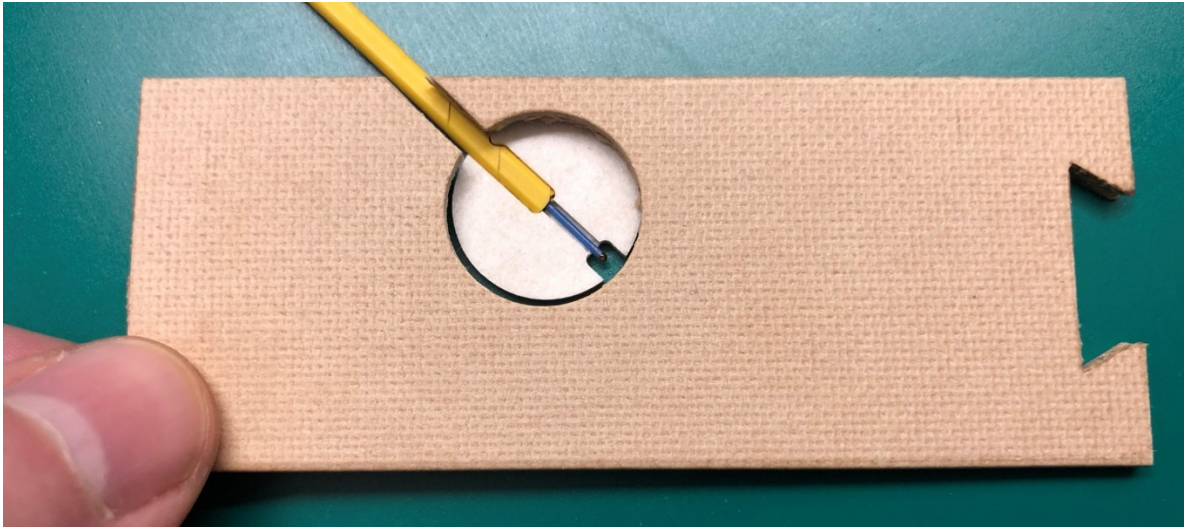


Take care that the cable slot cross the center of the hole, if the cable slot is offset from the center of the hole it could stress the fiber optic cable

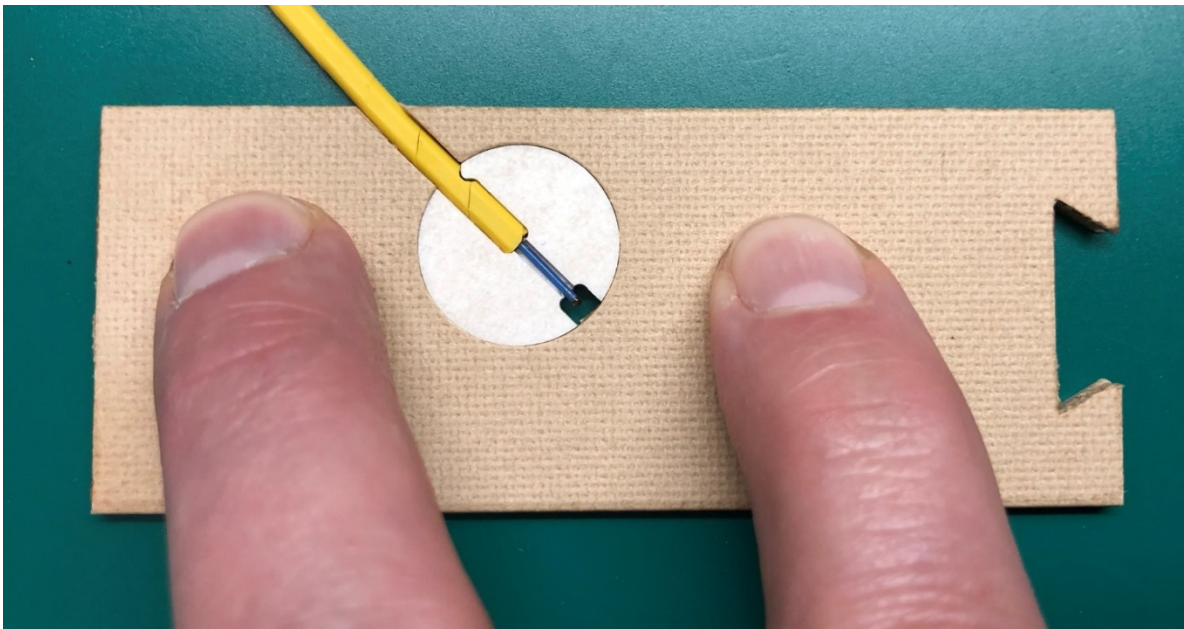
2.1.5 Inserting the Easy Disk

Laydown the sensor with EasyDisk on a clean flat surface.

Align the prepared spacer over-it:



Press down the prepared spacer on the sensors and disk:



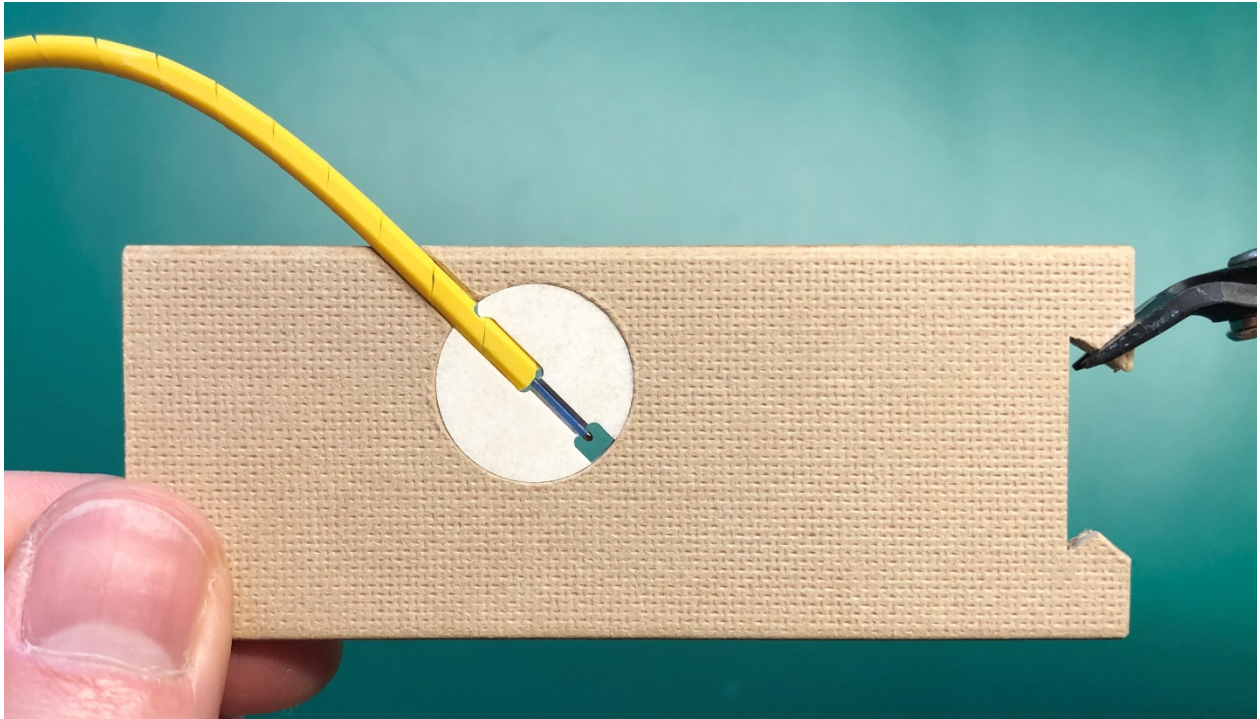
2.1.6 Preparing the dovetail

In order to insert the instrumented spacer in the winding, you must modify the dovetail.

You could remove all the dovetail undercut or remove only half of it.

You could use a saw or flush cutter.

If you remove only half of the dovetail undercut, you will be able to snap back the spacer in place on the axial strip.



2.2 Installation of the instrumented spacer in the winding

2.2.1 Open the winding

Locate the spacer you must replace by the instrumented spacer, then using wedges, open the winding on each side of it:



2.2.2 Remove the spacer

Remove the spacer by pulling and prying it to the left and the right.



2.2.3 Insert the instrumented spacer

Snap the instruments spacer in place on the axial strip. Take care of making the cable cross the edge of the winding with a shallow angle to have a large bending radius.



2.2.4 Test the sensor after installation steps

Remove the wedges; attach the sensors cable in a safe location on the winding to protect-it.

Using the EasyTest-II portable tester, test the sensor and record the diagnostic values: Light and Signal.

It is also the occasion to write down the position of each sensor.

You can download the Installation log sheet here: <http://fiso.com/2DScans/ETESTII/LogSheet.pdf>



2.3 Sensor Handling until Routing

The sensors are typically quite long (from 3m up to 15m) and it is advisable to keep them coiled in their original shape (in loop of about 20cm to 30cm) as much as possible for ease of handling.

Before the sizing/drying, you must remove them from the plastic bag and attach them with cotton strapping.

2.3.1 During Dry Out Phase

The winding vapor phase drying is an important step in the transformer manufacturing process.

At this step also, it is important to protect the surface of all optical connectors. FISO provides protective caps with all TPT-62 sensors. Only use the original caps, they are designed and made to survive the vapour phase drying.

Leave the protective caps on the connectors, during the whole process, including dry out.



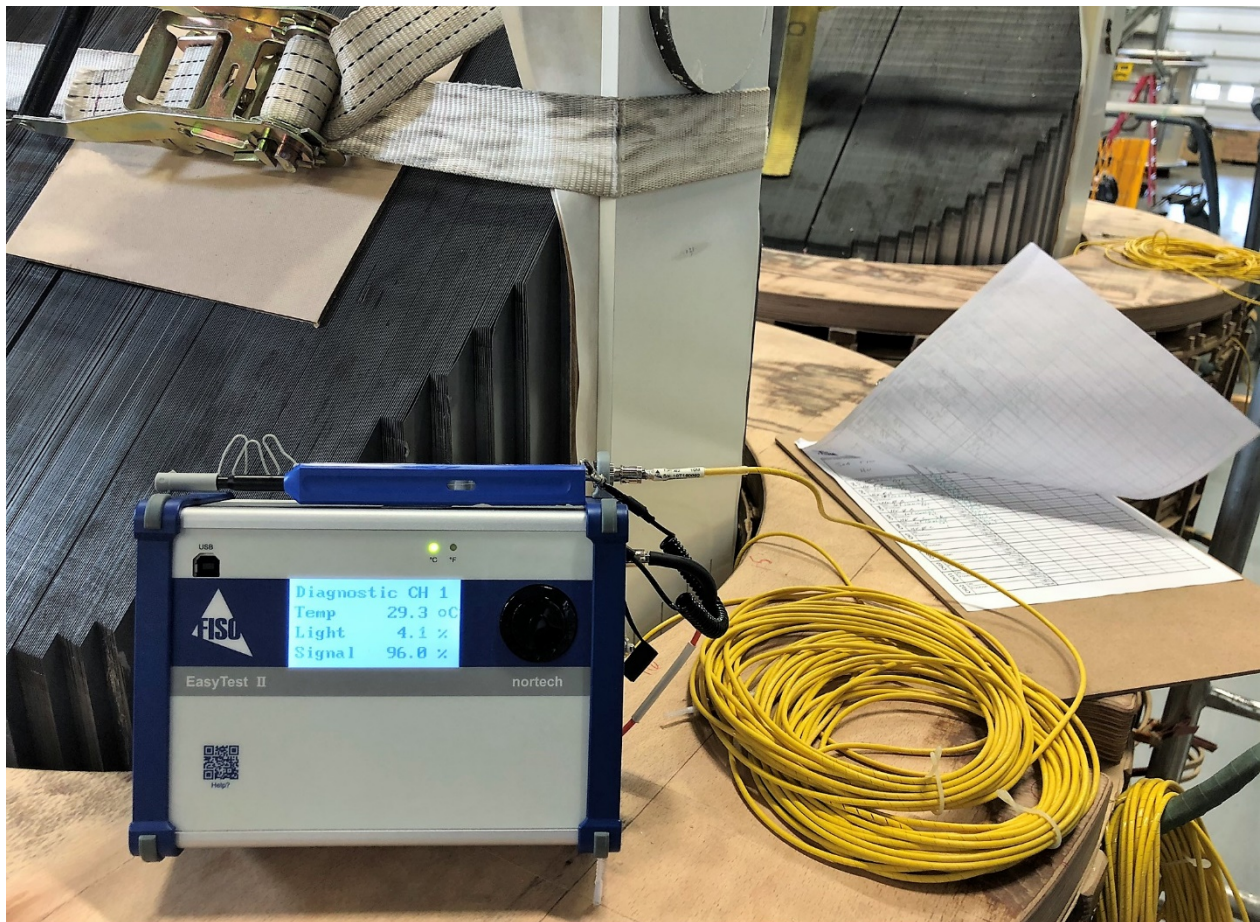
CAUTION

Do not use the patch cord vinyl dust cap (black dust cap) inside the transformer; it can melt during the kerosene vapor phase dry out.

2.4 Test after each critical step of the transformer assembly

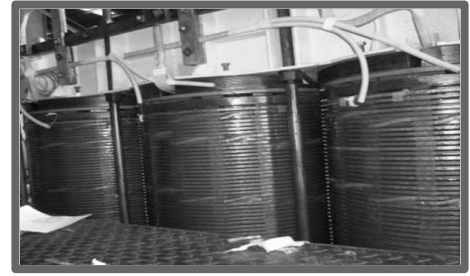
- ▲ The installation in the winding
- ▲ The compression/drying of the winding
- ▲ The installation of the windings on the core
- ▲ The drying of the winding / core assembly
- ▲ The tanking
- ▲ After the connection to the monitor (FAT)

You should also note the serial number, the position of each sensors and the optical port to which it is connected on the EasyPlate. See [Appendix B: LOG Sheet](#)



2.5 Probe routing

Assuming the sensor exits the winding along the winding leads, the sensors can all run along the top of the windings to one wall of the tank. Note that this routing should be done only after the winding and core assembly have been completed, just prior the final drying. The idea again being to keep as many sensor installation steps as possible until a maximum of the other fabrication steps have been done.



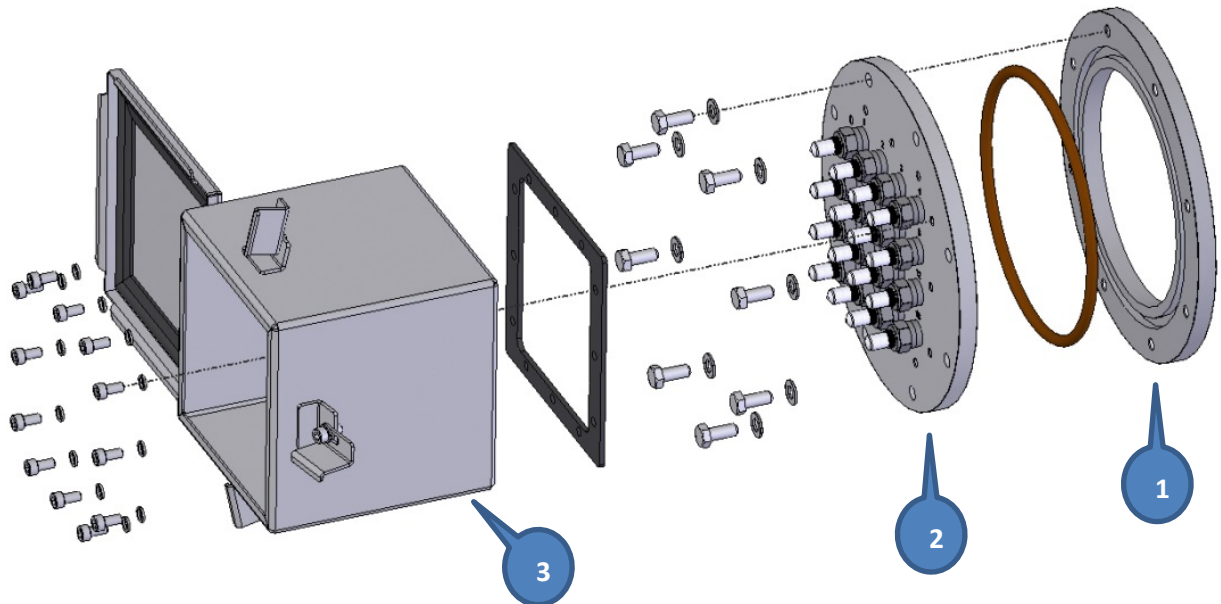
Whenever the sensor needs to be kept out of the way during a manufacturing step (for example, when the pressboard cylinder is being put around the winding or during dry out), secure the coiled sensor cables loosely using cotton straps.

The sensors can be run through rigid tubing or routed using cotton strapping (do not over tighten) to any support structure. Insulation paper can be used to route the cable along leads.



2.6 Tank wall assembly installation

The drawing below illustrates a typical tank wall plate assembly.



The EasyRing (1) is a carbon steel circular ring that can be welded to the tank wall to interface perfectly with the EasyPlate. Its Viton O-ring ensures that no leak is possible between the ring and the plate.

The EasyPlate is a stainless steel 316 circular plate that completes the integration of the Nortech direct winding temperature measurement system. The position of each connector is engraved on both side of the plate.

The EasyThrough allows linking of the optical sensor through the transformer tank wall. The EasyThrough consists of two ST-type mating sleeves, a 3/8" NPT stainless steel fitting with an optical fiber inside the fitting. When the EasyPlate is ordered with the EasyThrough, FISO installs them on the EasyPlate before the delivery.



The EasyPlate/EasyThrough assembly (2) is installed on the tank wall of the transformer and, once the core and windings have been installed in the tank, the sensors are routed and connected to the EasyThrough.

The EasyCover (3) is a stainless steel square cover that can be bolted to the EasyPlate. It is provided with the appropriate bolts and seal for installation on the EasyPlate



CAUTION

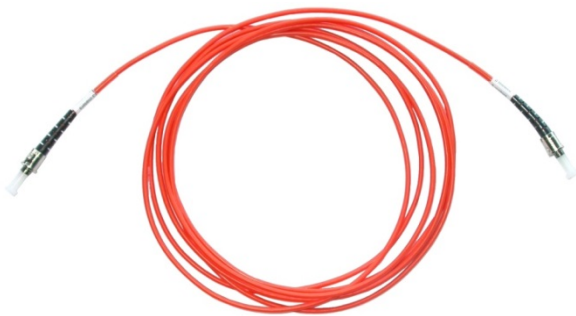
It is extremely important to clean all connectors thoroughly using recommended cleaning procedures (see [Annex A: Cleaning Fiber Optic Connectors](#)) before connecting sensors to EasyThrough.

2.7 External optical extension installation

The external fiber-optic cable (the patch cord or extension cable) acts as a link between the external EasyThrough connectors and the Nortech monitor.

To route the cable, you should use a conduit between the EasyCover and the monitor Marshaling box. Take care to not pinch the cable in sharp corners.

Cable diameter	3mm OD
Cable Length	1 to 100 meters Standard and stocked length : 3, 6, 8, 10, 12 and 15meters
Cable Jacketing	Polyurethane
Connectors	ST with 2.5mm ceramic ferule
Others	Fungus Resistant UV Resistant Water Resistant High Flexibility



Appendix A: Cleaning fiber optic connectors

The EasyClean is a high-performance device, designed to ease connector ferule end faces cleaning. Read carefully the instructions below before using the device.



Important

The EasyClean is designed to clean the fiber optic connectors. FISO is not liable for any damage caused in attempts to use this device to other applications. **Always keep the protection cap on when not in use to avoid contamination.**

EasyClean tool general operation

The EasyClean is easy to use, but you need to be careful not to do the following:

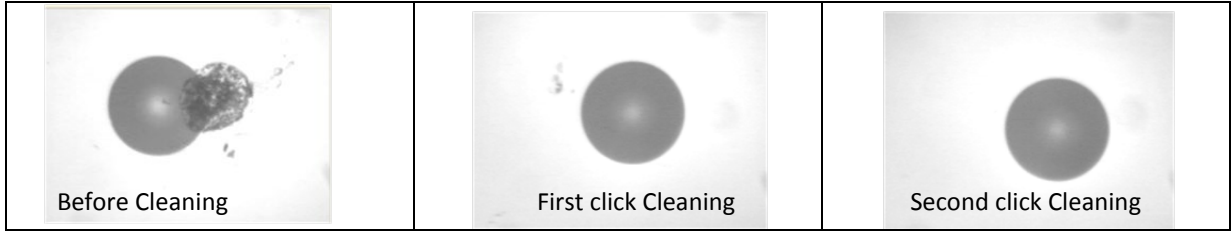
- Do not use this tool to clean oily connector, as this will cause contamination of the cleaning cloth.
- Do not touch the cleaning cloth, as this will cause contamination.
- Do not pull the cleaning cloth, use only the device body.
- Do not attempt to disassemble as this can cause damage to the device and make is inoperable.
- Do not try to re-use the cleaning cloth as this will eliminate the cleaner's effectiveness
- Do not use this cleaner when the cloth is empty. This may cause damage to the connector.

The amount of cloth left in the tool is shown in the window located in the body.

	View of Indicator	View of the Nozzle end
Full	Cloth (White)	Tip (Black) Cloth (White) Slide
Little	Cloth (White) Red	Tip (Black) Cloth (White) Slide
Empty	Red	Tip (Black) No Cloth (Black) Slide

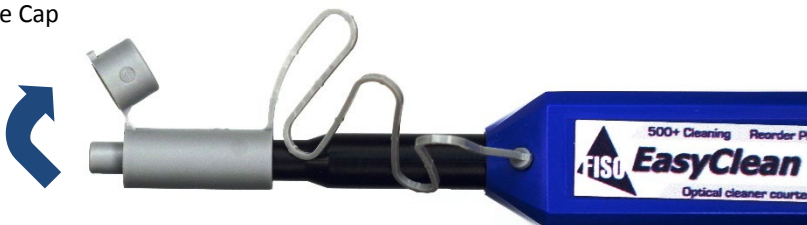


Here are typical inspection pictures of an optical connector made with a Fiber inspection probe



Cleaning the male ST connector

Step 1: Open the end-cover on the Guide Cap



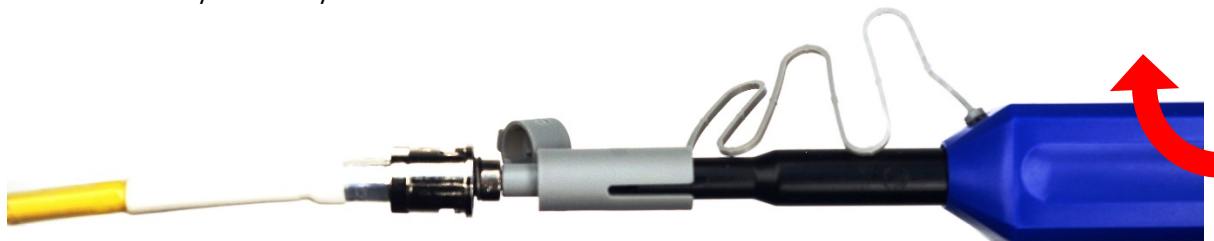
Step 2: Insert the Connector Ferrule into the Guide Cap



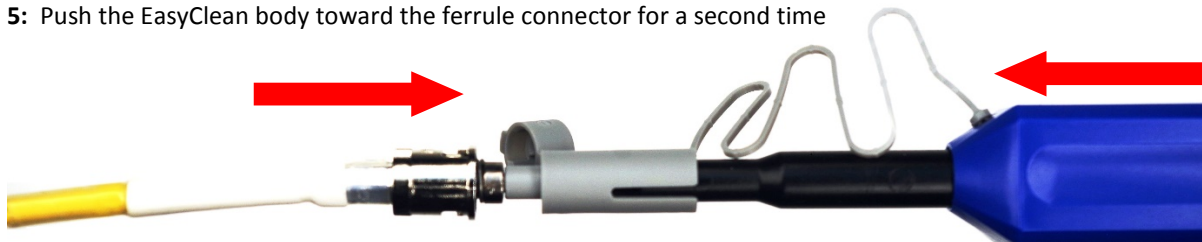
Step 3: Push the EasyClean body toward the connector ferrule, the black neck will enter into the blue body and you will hear a Click. This will wipe the cleaning cloth against the connector face and remove contaminant.



Step 4: Rotate the EasyClean body 90°

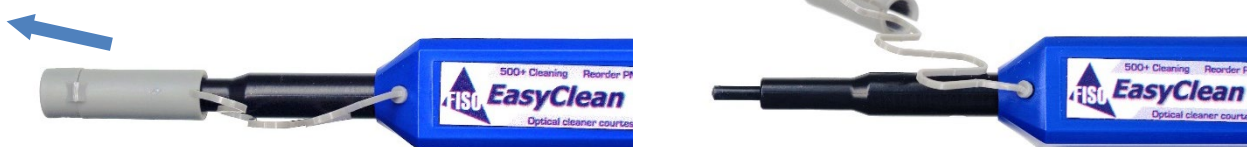


Step 5: Push the EasyClean body toward the ferrule connector for a second time



Cleaning the ST mating

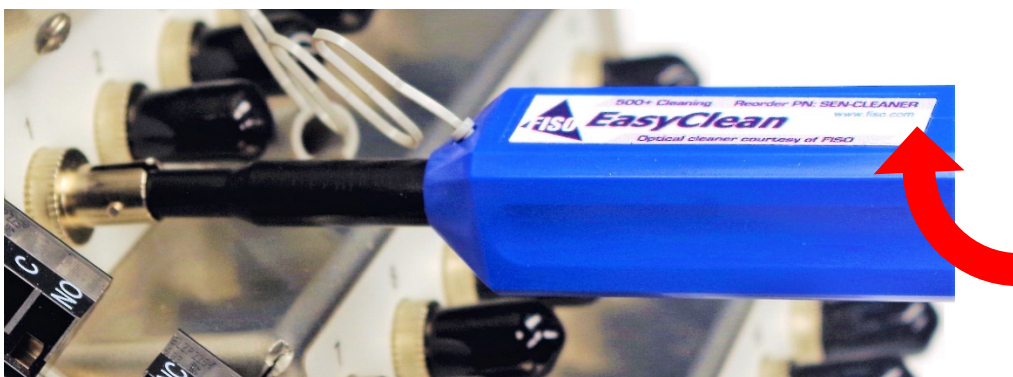
Step 1: Remove the Guide Cap from the Device



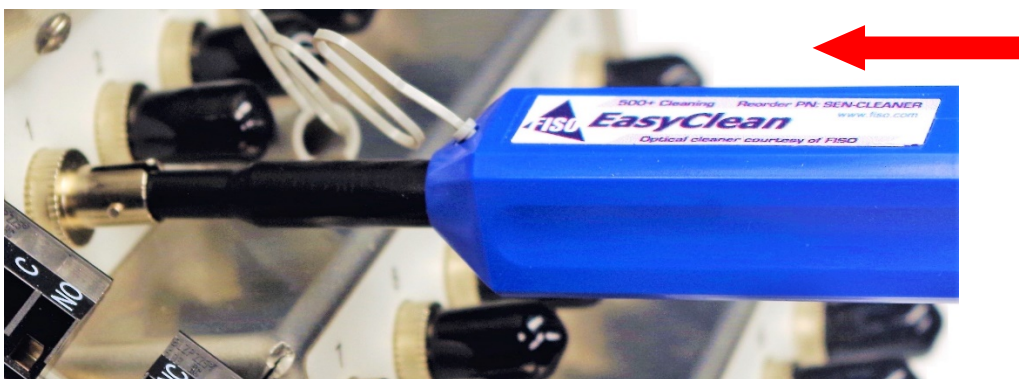
Step 2: Insert the EasyClean tip in the mating, and push the outer body to clean the connector face



Step 3: Rotate the EasyClean body 90°



Step 4: Push the outer body a second time to clean the connector face



Appendix B: LOG Sheet

We recommend you to keep a record of the diagnostic values of the HotSpot sensors after each critical step of the transformer assembly:

- 1- The installation in the winding
- 2- The compression/drying, of the winding
- 3- The installation of the windings on the core
- 4- The drying of the winding / core assembly
- 5- The tanking
- 6- After the connection to the monitor (FAT)

To help you in this, we enclose at the next pages a LOG sheet (MC-00284).

You can download the PDF of this LOG sheet at <http://fiso.com/2DScans/ETESTII/LogSheet.pdf>

You can also request the excel file to customize-it according to your needs.

Simply write us at info@fiso.com requesting the MC-00284 LOG sheet in excel format.


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Installation Log Sheet for Fiber Optic Hot Spot Temperature Sensors

Work order information:			After installation in winding	After the compression / drying, of the winding	After the winding is installed on core (just prior the final drying)	After the final drying	After the tanking and connection to the EasyThrough	After connection to the monitor / FAT	Other
CH1	SN:	Temp							
	Position:	Light							
		Signal							
CH2	SN:	Temp							
	Position:	Light							
		Signal							
CH3	SN:	Temp							
	Position:	Light							
		Signal							
CH4	SN:	Temp							
	Position:	Light							
		Signal							
CH5	SN:	Temp							
	Position:	Light							
		Signal							
CH6	SN:	Temp							
	Position:	Light							
		Signal							
CH7	SN:	Temp							
	Position:	Light							
		Signal							
CH8	SN:	Temp							
	Position:	Light							
		Signal							
CH9	SN:	Temp							
	Position:	Light							
		Signal							
CH10	SN:	Temp							
	Position:	Light							
		Signal							
CH11	SN:	Temp							
	Position:	Light							
		Signal							
CH12	SN:	Temp							
	Position:	Light							
		Signal							


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Installation Log Sheet for Fiber Optic Hot Spot Temperature Sensors

Work order information:			After installation in winding	After the compression / drying, of the winding	After the winding is installed on core (just prior the final drying)	After the final drying	After the tanking and connection to the EasyThrough	After connection to the monitor / FAT	Other
CH13	SN:	Temp							
	Position:	Light							
		Signal							
CH14	SN:	Temp							
	Position:	Light							
		Signal							
CH15	SN:	Temp							
	Position:	Light							
		Signal							
CH16	SN:	Temp							
	Position:	Light							
		Signal							
CH17	SN:	Temp							
	Position:	Light							
		Signal							
CH18	SN:	Temp							
	Position:	Light							
		Signal							

These are recommendations, manufacturers should test accordingly to their procedures / policies.

You may customize this log sheet to suit your specific needs.

This log sheet could be downloaded on the EasyTest II resource page: <http://fiso.com/2DScans/>

	Sensor connected directly at monitor		Sensors with EasyThrough and patch cord	
	Good value	Cleaning / investigate	Good value	Cleaning / investigate
Light	< 40%	> 40%	< 80%	> 80%
Signal	> 80%	< 80%	> 40%	< 40%

The Light and Signal values give an indication of the sensor health.

If they are in the yellow area, you should investigate, clean the connectors and check for sharp bend.

MC-00284R1