

Introduction

This guide is a summary of the best practices currently available to install fiber optic probes in oil-filled power transformers. Although windings found in these transformers can take several forms, this guide addresses the installation in the most common type of windings; these windings can be characterized as follows:

- Core type transformers (shell type transformers are also made but are much rarer)
- Disc type windings. These have radial spacers. There exists also 3 other type of windings, for core type transformers:
 - Helical windings, which are quite like disc type windings, and have radial spacers
 - Layer windings; these are quite common for low voltage windings and have vertical spacers. Probe installation much be done on the winding machine, and probes must be inserted between layers, near the top of the winding (exact positions to be confirmed by design engineers). The probe should be embedded in pressboard material (to avoid cooling of the sensor by flowing oil) which will then be squeezed in cooling ducts
 - Sheet (or foil) windings, for low voltage only. Probe installation would be like layer windings.

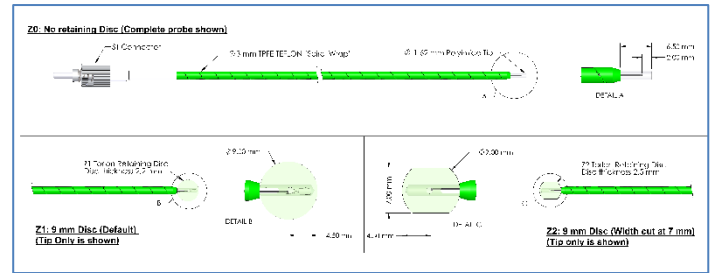
The rest of this guide will concentrate on disc type windings, in core type transformers.

Furthermore, it is good to know that the Rugged Monitoring Tsens probes are available in two configurations:

- 1- With disc. The disc version offers the following benefits:
 - a. It is easier to install (less installation skill required) and offers a more secure probe installation in spacers
 - b. It offers a well-defined sensor position (sensor is located at center of the disc)
 - c. It offers an excellent pulling force (above 80 N) without compromising the sensor position
 - d. No need to squeeze the probe cable in the radial spacer, as the disc will retain positively the probe tip into this spacer
 - e. It is recommended for all probe installations, even in locations other than windings
- 2- Without disc. Some manufacturers still prefer this version, as this version has been marketed for a long time (disc probes have a more recent history).

Rugged Monitoring recommends disc probe for ALL applications.

This drawing presents all variations into which Tsens probes are available.



General recommendations

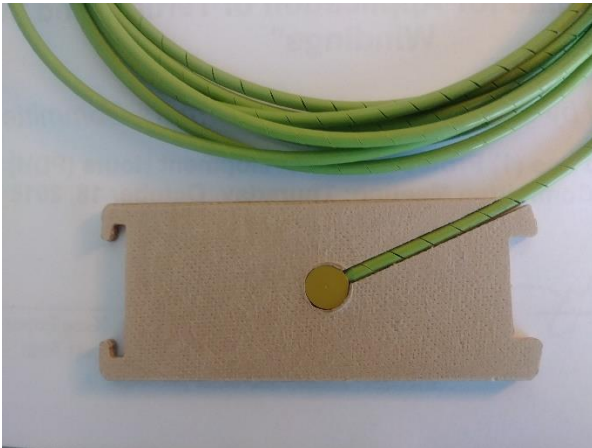
When installing probes, please keep in mind these points:

- Always respect bending radius
 - Minimum radius of 8 mm, and make sure these are kept to a minimum
 - If you coil unused fiber cable, make sure coil diameter is at least 250 mm
- Avoid squeezing the fiber cable anywhere
 - One exception: if you are using probes without disc, the probe cable will need to be squeezed in the radial spacer, near the probe tip
 - Warning: NEVER squeeze the tip itself!!!, this could damage the probe
 - To avoid these problems, probes with discs are recommended!
- Make sure the tip of the probe is covered with pressboard material or crepe paper, to ensure that no oil is flowing in the immediate vicinity of the sensing element (flowing could will unduly cool the sensor)
- Always test your probe with a suitable instrument (all Rugged Monitoring instruments can display % performance of probes). Recommended values are 100% for probe alone and 65% for probe, feedthrough and extension cable). Testing should be done according to each manufacturer practices; however, it is recommended to test them at least 5 times during transformer manufacturing:
 - Incoming inspection
 - Probe installation in spacer
 - After spacer installation in winding
 - After drying cycle
 - After tanking (from outside of tank, through the feedthrough and using an extension cable).

Radial spacer preparation

The following picture gives an example of a probe (with disk) installed in a radial spacer.

The procedure given here will work well for spacers that have a minimum thickness of 3 mm. If you intend to install probes in thinner spacers, contact rugged Monitoring for further recommendations.



The spacer should be machined as follows:

- Machine (or drill) a 9 mm diameter hole where calculated by your design engineers
 - Although not optimal, it would be acceptable in most cases to make the hole in the center of the spacer, as shown above
 - This hole should not be done if you are going to install a non-disc probe
- Machine or saw (with a band saw) a ~3 mm wide slot, as shown above
 - It is recommended to make the slot at an angle, as shown (20 to 30 °), as this causes fewer bending stresses as the fiber exits the spacer
- Optionally, you can wrap the spacer in crepe paper to ensure no oil flow is present near the sensor
 - This wrapping would be mandatory if you use the non-disc version of the probe
- Warning: for the non-disc version of the probe, you must be careful with:
 - Apply no pressure on the tip of the probe
 - Make sure the probe cable is well squeezed in the slot, to prevent it from getting out of the slot if the fiber cable is pull on by installers. Remember also that the Teflon sheathing of the cable will become softer at higher temperatures, so a good squeeze is recommended. To avoid these situations, the disc version of the probe is always recommended.
- If you need to use a spacer thicker than 3 mm, it is recommended to “build” a spacer using multiple layers of pressboard material, with the middle pressboard being 3 mm thick (with a slot and hole where the probe would be installed). For example, for a 5 mm thick spacer, use 2 pieces of 1 mm thick material and 1 piece of 3 mm thick (with the probe in it). All pieces should be glued together, like a sandwich. Do not drill or saw a slot in the outer layers of the pressboard material.

Spacer installation in the winding

As late as possible during your manufacturing process, a modified spacer (with pre-installed probe) should be installed to replace an existing spacer. Normally (subject to your design engineers calculations), this new spacer would be installed near the top of the winding, where the winding hottest temperature is expected to occur. This would normally be between the first and second winding disk or second and third winding disk.

You can use a wedge to help opening the winding to remove a spacer and to insert the new modified one.

Probe installation in other places than windings

Rugged Monitoring TSENS probes are completely dielectric and are immune to electrical and magnetic fields. As such they are ideal for sensing temperatures in windings, so the resulting temperature data could be used to evaluate the degradation of the transformer insulation material over time. However, users may be interested sometime to install probes in other locations, such as:

- Core (yoke) temperature. In this case, one can pre-mount a probe in a pressboard sandwich, as described above. For installation in a cooling duct.
- Top oil. In this case, the probe should be mounted also in some sort of pressboard sandwich and held above a winding.
- Any other places, such as the steel internal structure, etc.

Conclusion

As we have demonstrated in this guide, Rugged Monitoring probes can be mounted anywhere in a transformer, although their prime purpose would be to monitor temperature in windings. These probes, especially the version with disc, are very easy to use and are very robust; this should simplify their installation by the transformer manufacturer and ensure consistent *and* reliable temperature information for the transformer operator.

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