



Analysis - Example 1

Transmission transformer
15 mva, 3 phase - 66/22 kv
17,000 litres (4500 gallons) of Oil
40 years old, ONAF.

Objective

The transformer was suspected to be wet from historical oil sampling methods. A sensor that records the relative saturation of the oil (with dissolved water) and the oil temperature was inserted into the bottom of the radiator through a valve, at the point just before the oil returns to the bottom of the main tank. This gave the oil at its coldest, highest relative saturation and lowest dielectric. The objective is to

- Interpret the Analysis data
- Diagnose the water in cellulose using two reference points.
- Provide a dielectric profile based on relative saturation.

During the 17 day Analysis the transformer was active over a wide temperature range which provides good water activity. On average the top oil temperature was 15°C above the bottom oil value. The bottom oil is displayed on all charts.

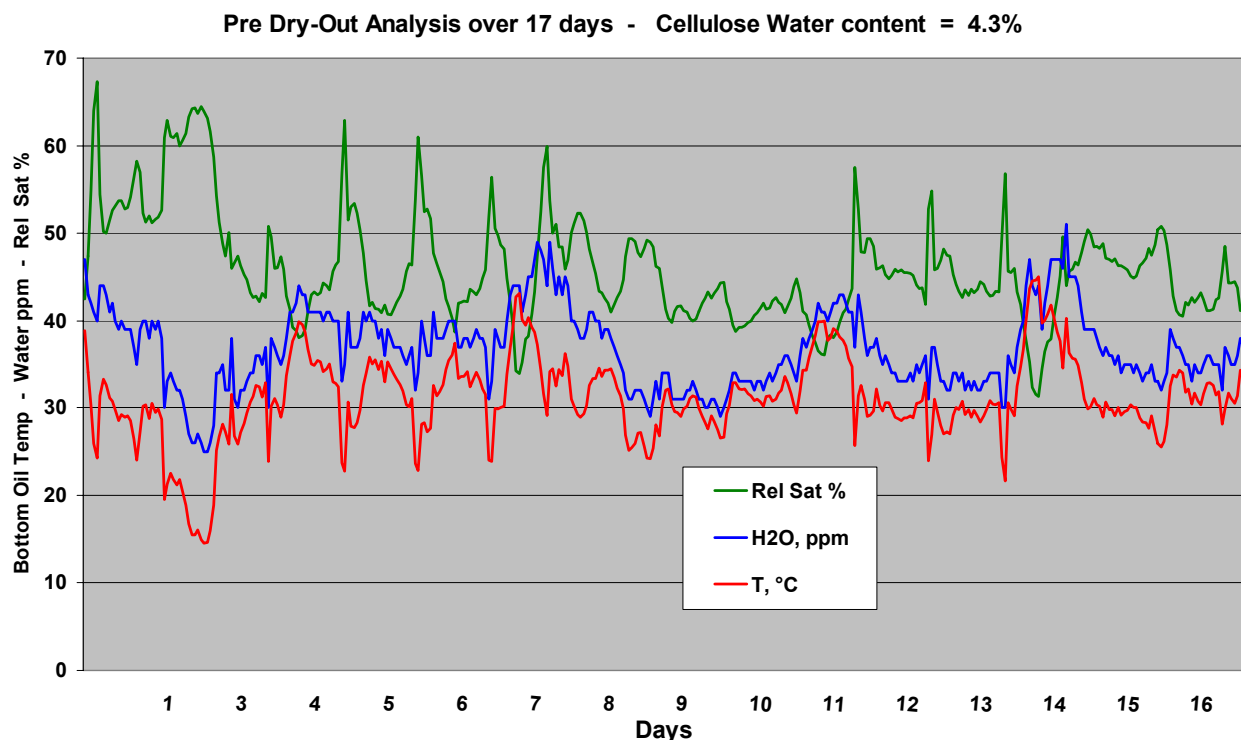


Fig. 1 – results of 17 days of online Analysis

Early in the graph when the oil temperature drops to 15°C the water in oil is 26 ppm and the relative saturation peaks at 68%. If the oil was particle free the calculated dielectric of the oil at 68% saturation is only 28 Kv (2.5mm). The oil is aged and particle contaminated, a high proportion will be cellulose particles. These particles will have a very high water in cellulose content at the 15°C temperature because the oil is highly saturated. Particles are known to be held in the electromagnetic band in the oil created around the coils under load. These very wet particles held in suspension in highly saturated oil pose a significant dielectric threat.

During temperature drops the oil cools faster than the water in the oil can return to the insulation cellulose to maintain the equilibrium. The cellulose that the water is trying to return to is still being kept warm by the residual heat in the windings. These high relative saturation peaks are common in very wet (4% + water in cellulose) medium load transformers. If the transformer was subjected to a

Analysis - water in cellulose Diagnostics

higher load cycle, the relative saturation peak would be higher after the load peak. If the relative saturation is peaking above 30% action is required, above 50% urgent action should be taken. This transformer is wet and requires immediate online water reduction.

Calculating the water in cellulose

Two sets of values will be used to calculate the average water in cellulose content (%).

1. The averaged values – all data collected over the period is averaged
2. The peak values - at the highest temperature point.

	Averaged	Peak
Top Oil temp	45°C	62°C
Bottom Oil temp	31°C	45°C
Water in Oil	36.7 ppm	40.5 ppm
Relative Saturation	46%	31%
Water in cellulose (ave)	4.61%	3.78%

Fig. 2 – Values used for water in cellulose diagnosis

Using these two sets of values gives a good cross reference when calculating the water in cellulose value. The averaged values may overstate the cellulose water content if during regular operation, the load drops quickly, has a cool ambient and good thermal dispersion, and adsorption of the water back into the cellulose is slow.

At the peak temperature we see clearer values. The volume of available water for interchange between the cellulose and oil is being stretched as the transformer spends very little time at this load. The calculation drops to 3.78% from the 4.61% of the averaged values. This variance is normal, and the two are within 0.83%. The actual average water in cellulose is more likely 4.25% in this transformer. But continue to use the two values, and as the transformer has the water progressively removed the variance between the two values will reduce considerably. Other Trojan Analysis examples provide a wider understanding of water in cellulose diagnostic methods, interpretation, and the effects of winter and summer and oil pumps.

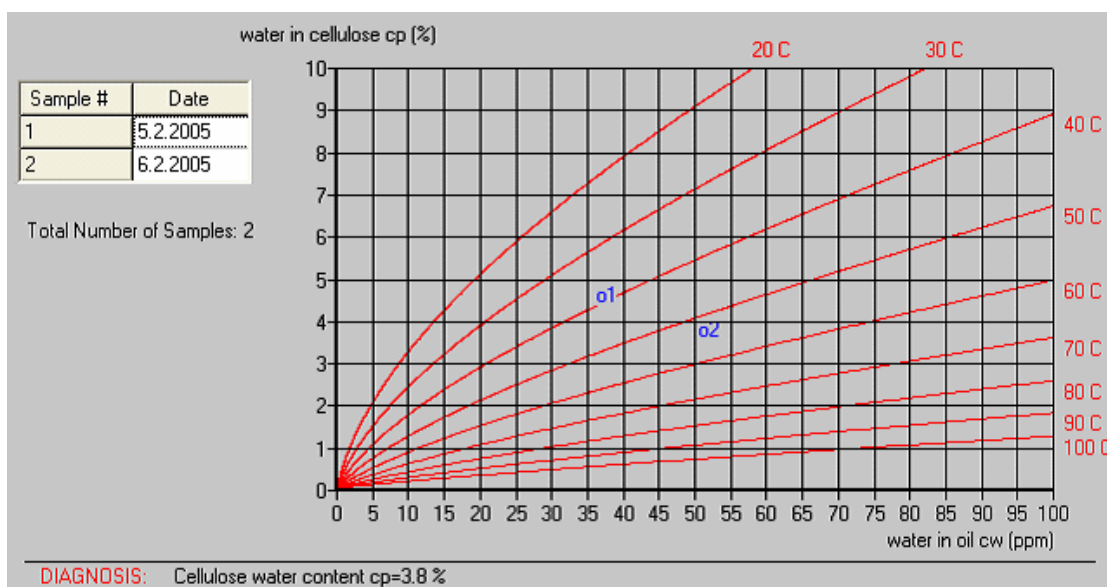


Fig. 3 – Water in cellulose calculations averaged and peak values

The average water in cellulose is between these two values and is about 4.25%.

Water in cellulose calculations are based on the Altmann / Buvkis 2003 equilibrium trials using water in oil sensors.

Calculating the oil dielectric

When the oil is free of particles the relative saturation value can be used to fairly accurately calculate the oil dielectric. During Analysis, an oil sample was sent to the laboratory for traditional dielectric testing, the result was 36Kv (2.5mm), which has a good correlation with the calculated value. The sample oil temperature was 33°C and was tested at 20C, so the increase in RS% as the oil cooled would have lowered the dielectric compared to the operating temperature. Particle contamination will reduce the dielectric further.

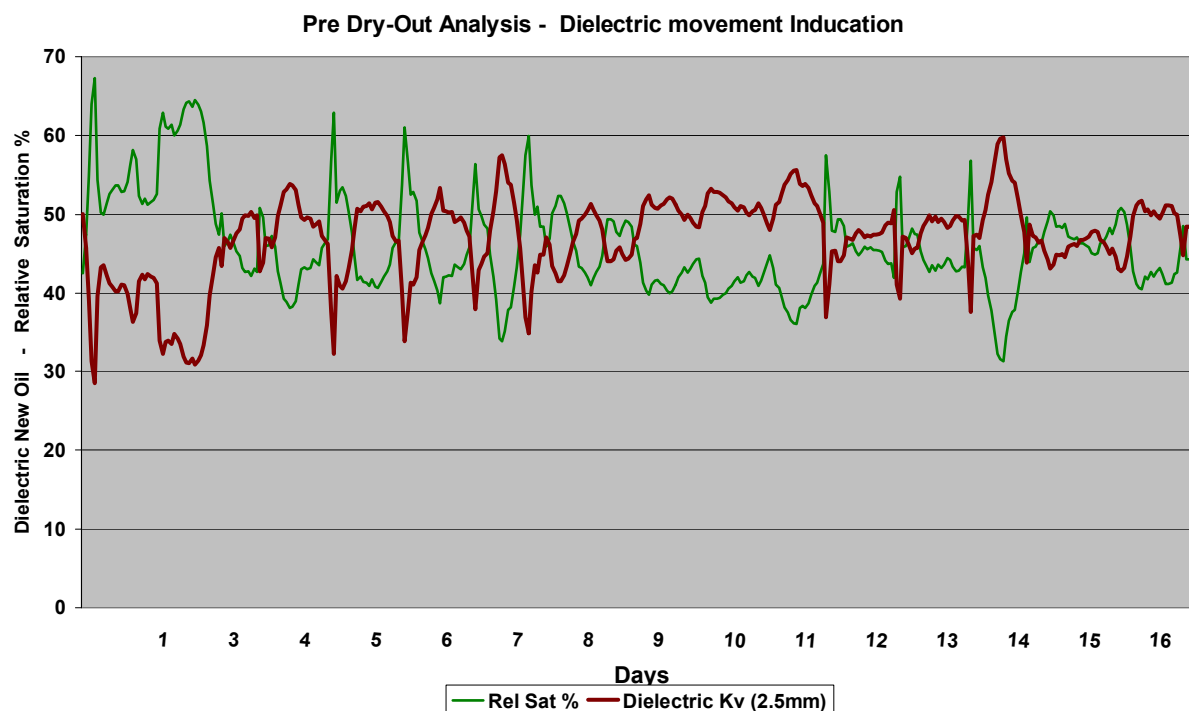


Fig. 4 – Dielectric calculated from relative saturation

This subject of calculating the dielectric will be covered in detail in the Technical Centre.

The analysis of this transformer confirms

1. That the oil is reaching unacceptable high relative saturation levels
2. Dielectric failure cannot be ruled out.
3. The water in cellulose has been accurately calculated
4. The water level in the cellulose must be reduced to between 2% to 2.5%

Actions

The water in cellulose was reduced online over a six week continuous period using a Trojan Compact. After some months of equilibrium recovery the transformer was analysed again to measure the impact. The improvement was significant and is detailed in a separate report is in the Dry-Out Examples.

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