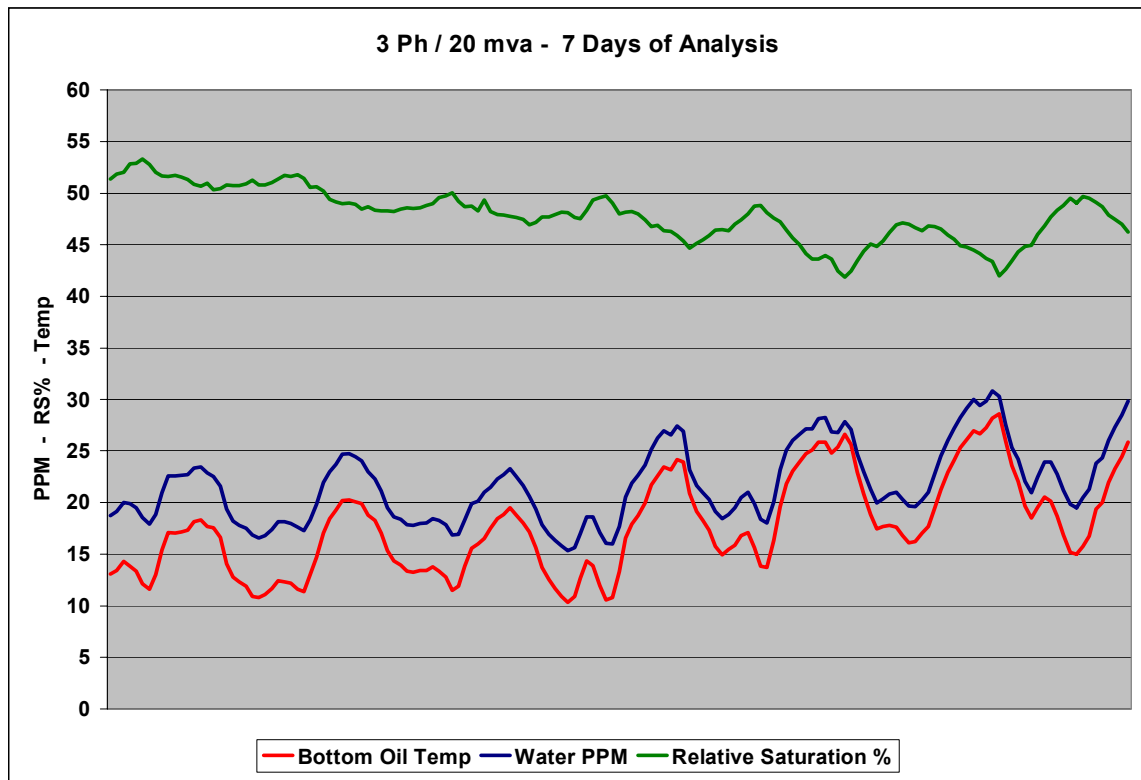


## TROJAN Analysis and water in cellulose diagnosis

**Analysis Example 2**  
**Transmission transformer**  
**20 Mva - 3 ph - 66 / 22Kv**  
**1964 – 17,000 litres of oil.**  
**Free breathing ONAF**



The transformer was suspected of being wet by traditional oil samples, however the historical oil sampling method was providing widely variable results. The Trojan was connected to the transformer, and set on Analysis for seven days.



**Fig. 1 – Water activity Analysis over 7 days.**

Over the 7 days the average operating temperature increased gradually and consistently. The water in oil activity responded immediately to the temperature movements. The oil relative saturation profile is within a 8% band despite the large quantity of water in the oil. The water is adsorbing and desorbing quickly and is within a narrow quasi equilibrium range. The gradual rise in temperature and regular peaking cycles gives us the opportunity to check the various methods of calculating the water in cellulose and showing the different outcomes.

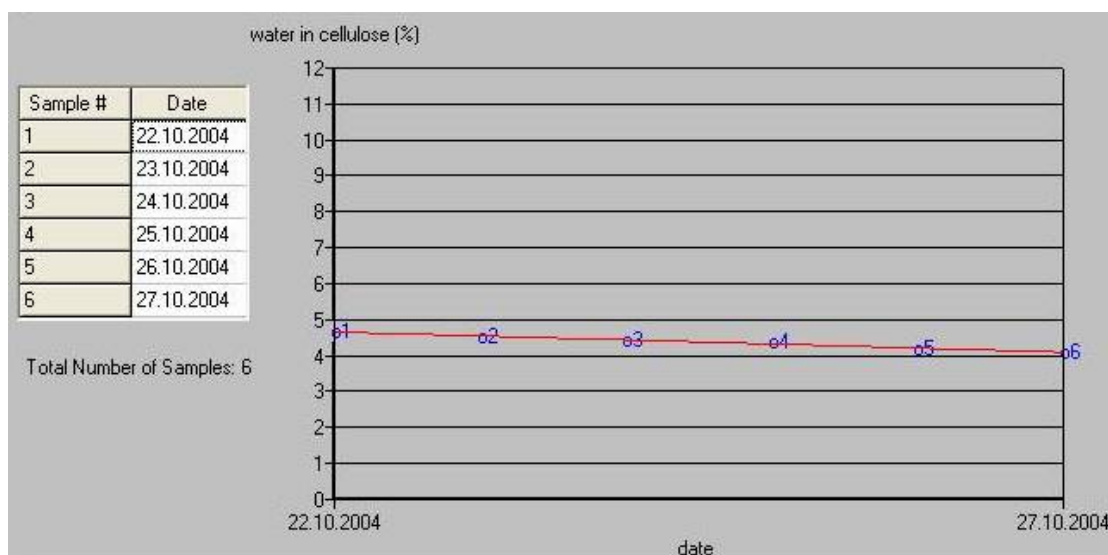
- The values at the peak temperatures points over the 7 days
- All 160 data values over the 7 days - averaged

### Peak values

	Top oil Temp	Bottom oil Temp	Water in oil ppm	Water in Cellulose
22.10.04	36 °C	19 °C	23.4	4.67 %
23.10.04	39 °C	21 °C	24.7	4.52 %
24.10.04	38 °C	20 °C	23.3	4.43 %
25.10.07	42 °C	24 °C	27.4	4.36 %
26.10.07	45 °C	26 °C	28.3	4.20 %
27.10.07	48 °C	29 °C	30.8	4.09 %

**Fig. 2 – Peak values over 7 days of Analysis**

## TROJAN Analysis and water in cellulose diagnosis



**Fig 3. Water in cellulose calculations of all Peak values.**

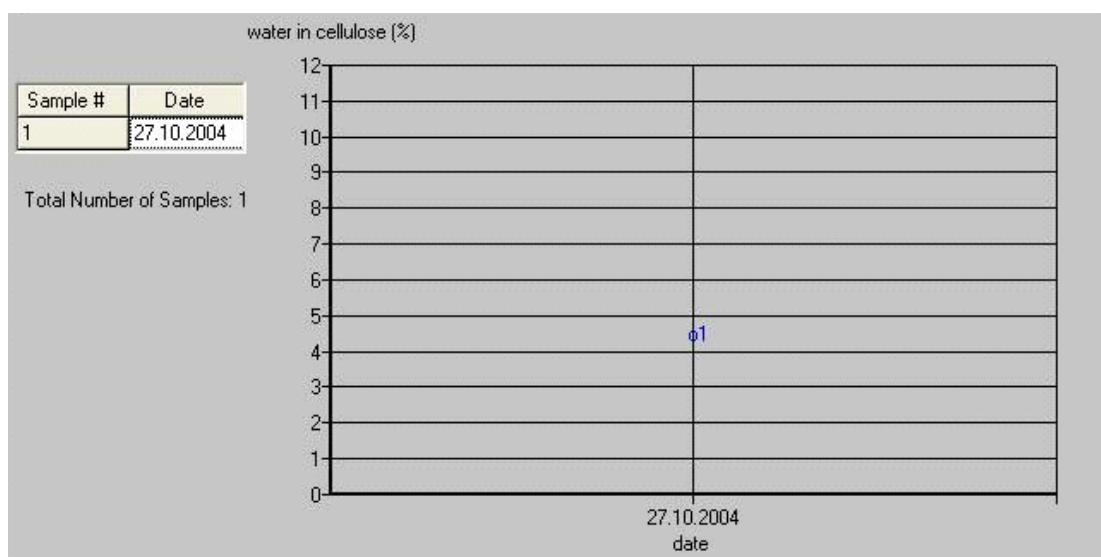
Note that the water in cellulose % calculation **decreases** over the temperature rise. Our experience confirms that the higher the winding temperature during analysis of a given transformer, the water in cellulose calculation reduces slightly when compared to the lower temperatures.

### Averaged values

Over the seven days the values were recorded hourly. The average of the 160 data points is shown in fig. 4.

	Top oil	Bottom oil	Water in oil	Water in Cellulose
	Temp	Temp	ppm	
27.10.2004	<b>35°C</b>	<b>18°C</b>	<b>21.6</b>	<b>4.47%</b>

**Fig 4. – the 160 data points Averaged of over the 7 days**



**Fig 5. – Water in cellulose calculation = 4.47%**

The comparison of diagnostic methods provides a very similar outcome and cross reference. Using the peak values, or just averaging all the 160 data values over the entire period, the water in cellulose range was between 4.09% to 4.67%, a 0.58% variance over the temperature profile. The variation between the peak and the averaged values shows that the transformer is operating

## **TROJAN Analysis and water in cellulose diagnosis**

at a more gradual load profile than the transformer in **Analysis Example #1**, and the transformer is maintaining a far closer natural equilibrium.

This degree of accuracy is all that is needed. A good indication of the water content of the cellulose, over the normal load cycle, and most importantly what is the relative saturation – dielectric profile of the oil with that volume of water in the cellulose.

### **What is the risk ?**

The transformer during this Analysis period was operating at a relatively low cyclical load and temperature profile. The relative saturation is reaching 50% even at these low load variances. If the transformer is subjected to higher / undulating temperatures the relative saturation and dielectric profiles will be very adversely effected with relative saturation going to >75%.

### **Actions required**

This transformer requires water to be removed by online filtering using the Trojan, about 5 litres to start, leave for 6 to 12months to recover, then undertake Analysis and compare the improvement to the pre-treatment data, and schedule the removal of a specific volume of water if required.

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