TROJAN Systems Dry-out Example

Generation transformer – Example 1
13.333 mva, 11/220 kv - yellow phase, 40 years old
15,230 litres of oil, oil forced -water cooled - free breathing.

A Trojan 500 was used for the online Analysis and water removal. The 500 model has a filter of only 1/3 of the Trojan 1000 capacity. Therefore it fills faster and requires more Re-Dry's to remove the same volume of water. This model has been replaced by the 1000, unless specifically required.

The transformer had been on almost constant load leading up to and during Analysis. The key values from Analysis for calculating the water in cellulose are, (Sensor used)

- Top oil temperature 49°C
- Bottom oil temperature 35°C
- Water in oil 24.1 ppm
- Water in cellulose calculated at 3.12%

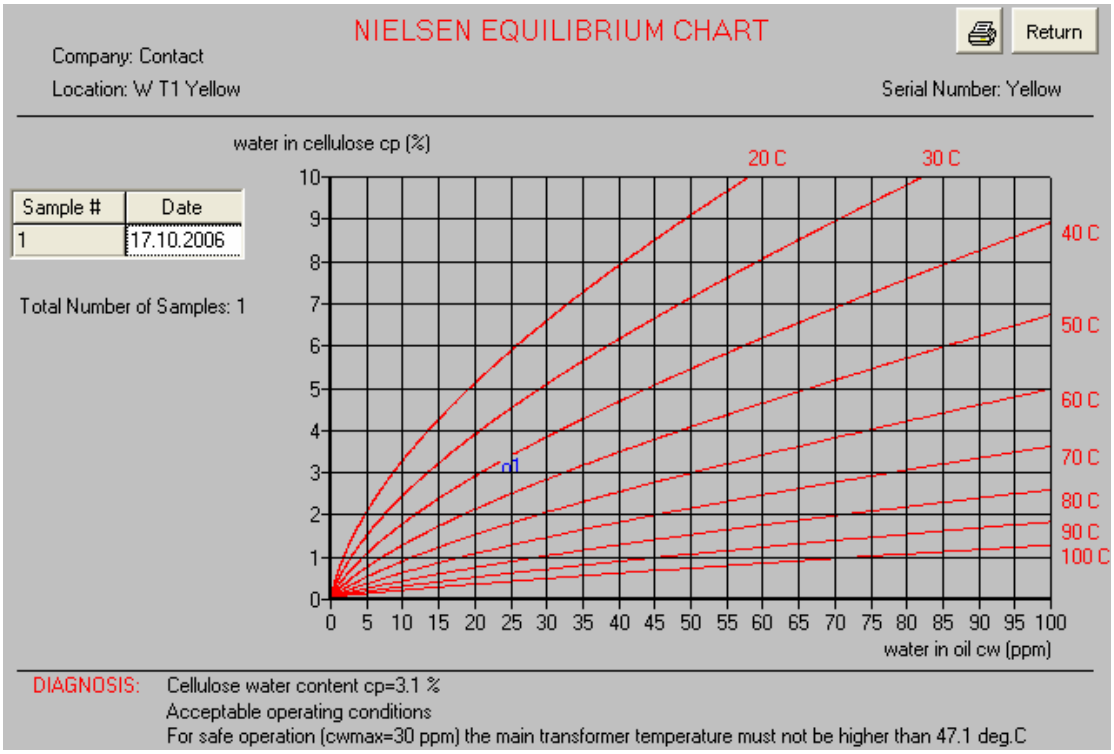

Fig. 1 - water in cellulose of yellow phase is 3.12 %.

The blue and red phase transformers had identical levels of water in cellulose.

The Trojan 500 Filtered for 25 days (first 7 days of data missing), then stood idle for 22 days during the transformer de-energised routine maintenance, then Filtered for another 39 days at mostly lower load temperatures.

Trojan Filtering was set at 12 hours before auto Re-Dry, with the filter Re-Dried 105 times in the 64 day period. A total of 4.15 litres of water was removed from the transformer.

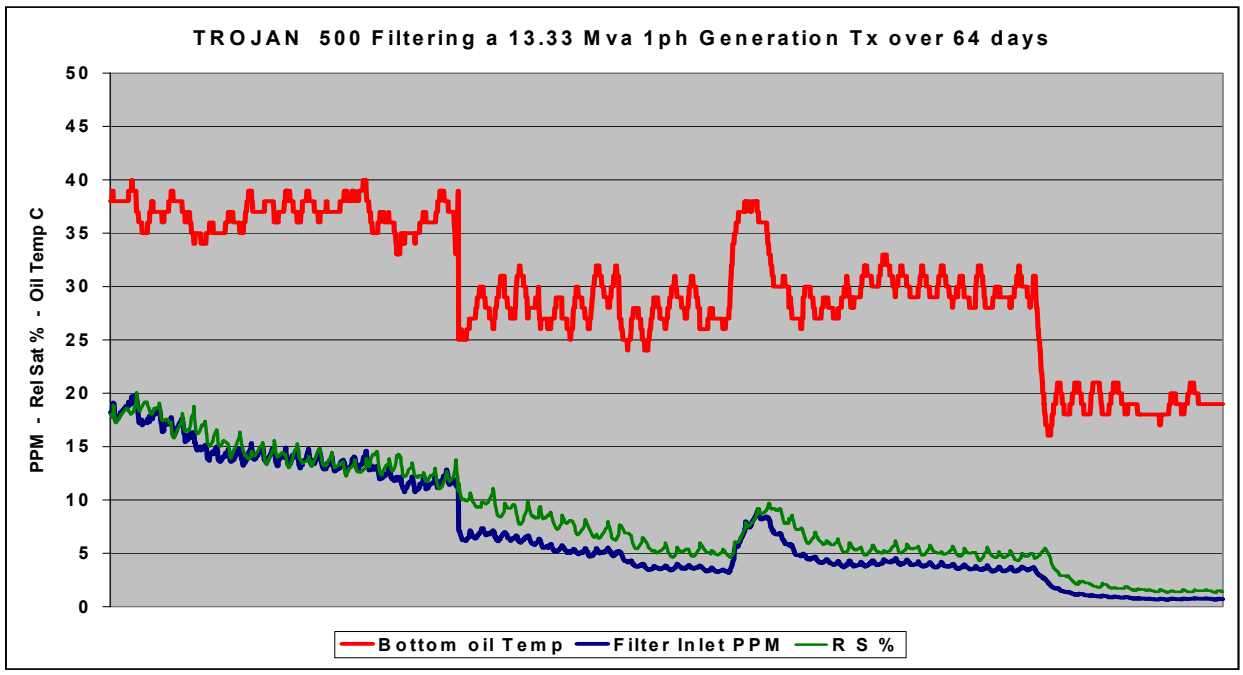

Fig. 2 – Filtering over 64 days
Data for the first 7 days is missing, and the water in oil has been reduced to about 18 ppm when the first data was recorded by the Trojan. The first temperature drop indicates the end of the 25 day period. When the transformer was re-energised, the Trojan filtered for a further 39 days. The load/temperature was at a reduced level most of the time over this latter period. The effect that the temperature has on available water is evident.

During Analysis the bottom oil temp was 35°C and water in oil of 24.1 ppm. The bottom oil temperature increased to 38°C at about the 40th day of filtering, the water in oil peaked at only 9 ppm. The Trojan at that point had created and maintained a 15 ppm (63%) disequilibrium at a similar temperature. Using the data in the equilibrium software it calculates to 1.41% water in cellulose (data point 2).

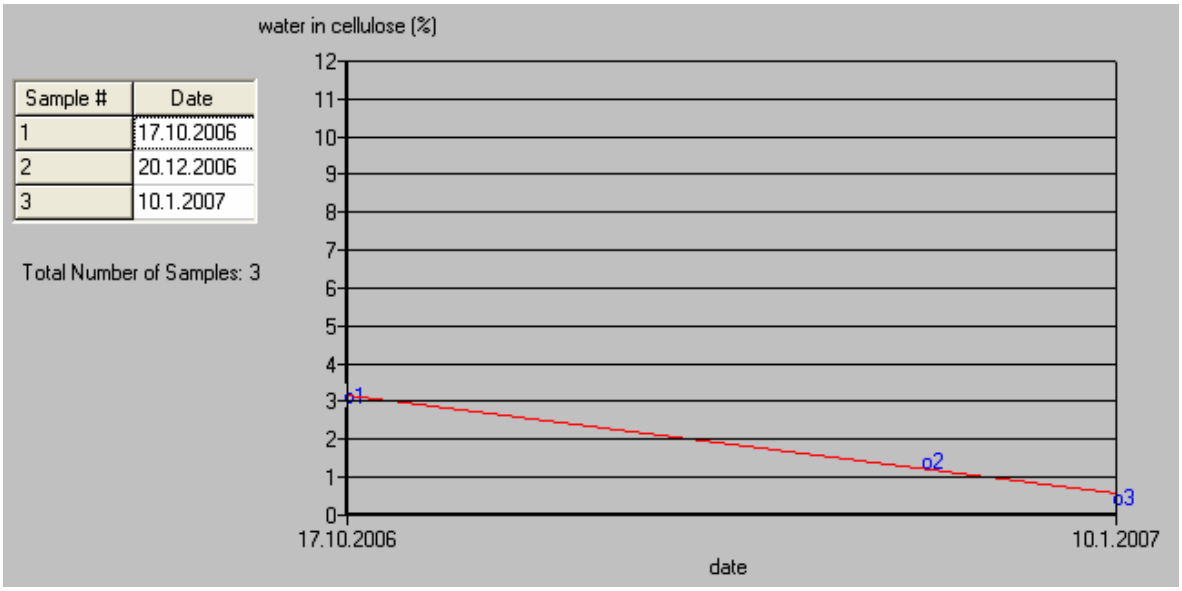

Fig.3 – Disequilibrium created by Trojan at days 40 and 61 during Filtering.

Fig. 3 details the oil / cellulose disequilibrium that was created over the filtering period as the 4.15 litres of water has been removed. Six days before the end of filtering the top oil was 30°C, the bottom oil 21°C, and the water in oil from the main tank was consistently under 1ppm, giving a water in cellulose calculation of 0.5%, or a disequilibrium of 2.5% from the starting point.

The entire cellulose is not dried to 0.5%. Once it recovers over a period of months, the average water in cellulose will most likely have reduced to 2.0% to 2.5%. The Trojan has dried the surface – inner layers of the cellulose to this level. The water in the cellulose available for interaction with the oil has been reduced to this level at this temperature. The strong disequilibrium created by the Trojan promotes faster water migration even at low temperatures

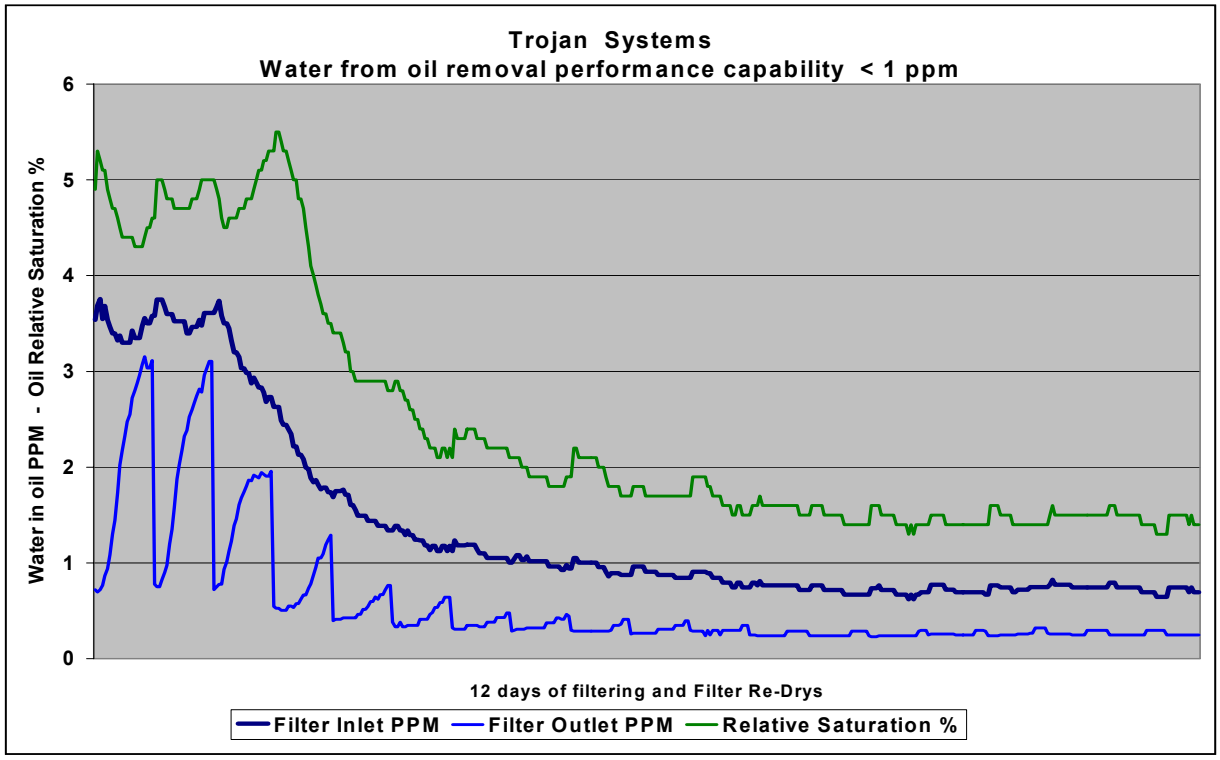

Fig. 4 - Last 12 days of Filtering holding a 2.5% oil / cellulose disequilibrium.

At the start of graph 4 the filter outlet ppm line increases as the filter fills with water. The filter is then Re-Dried and the removal efficiency is fully restored. During the last 6 days even though the water in oil is entering from the main tank at only 0.7ppm the filters are still removing 0.4ppm and returning the oil to the transformer at <0.3ppm removing 57%. The unique feature of the Trojan is that the dryer the transformer oil / cellulose becomes, the filters are dried to even lower levels automatically. Even near new transformers can have water removed.

This transformer will now be left to recover equilibrium, and at various times during that recovery Analysis will be undertaken regularly to measure the ongoing impact. This document will be updated accordingly.

Martin Cropp
Contact at
Trojan Dry-Out Systems
martin@dryoutsystems.com