TTP 1
Transmission Transformer
15 Mva, 66/22Kv, 3ph, 40 Years old
17,000 litres of oil, ONAN.

Objective
The report will document the impact of removing 5.25 litres of water over 42 days of filtering from a 15 mva 3ph transmission transformer on medium load with a Trojan Compact. The graphs and data summary will show the analysis data (temperature / water activity relative saturation / dielectric profile) before the water removal, then at two occasions after the Trojan was removed. All analysis was conducted over seven or more days to obtain a good water activity trend over many load cycles. In summary a significant improvement in dielectric strength and cellulose life extension was achieved at very low cost, and in a relatively short time.

Schedule
- Analysis over 17 day period
- Water removal over 42 days of Filtering (Trojan Compact)
- Re-analyse #1 – 36 days after Filtering
- Re-analyse #2 – 66 days after Filtering

Analysis – on all three occasions the oil sensor was installed through a valve in the bottom of the radiator to reach the oil. The sensor recorded the oil temperature, relative saturation and water in oil ppm. Measuring the oil at the bottom of the radiator, the coolest point, shows the effects that a rapidly cooling ambient can have on sharply increasing the relative saturation, and reducing the dielectric of the oil. The summer ambient during the 17 days of Analysis varied between 10°C to 35°C. Once the particles are removed from the oil, the dielectric value is directly controlled by the level of water saturating the oil.

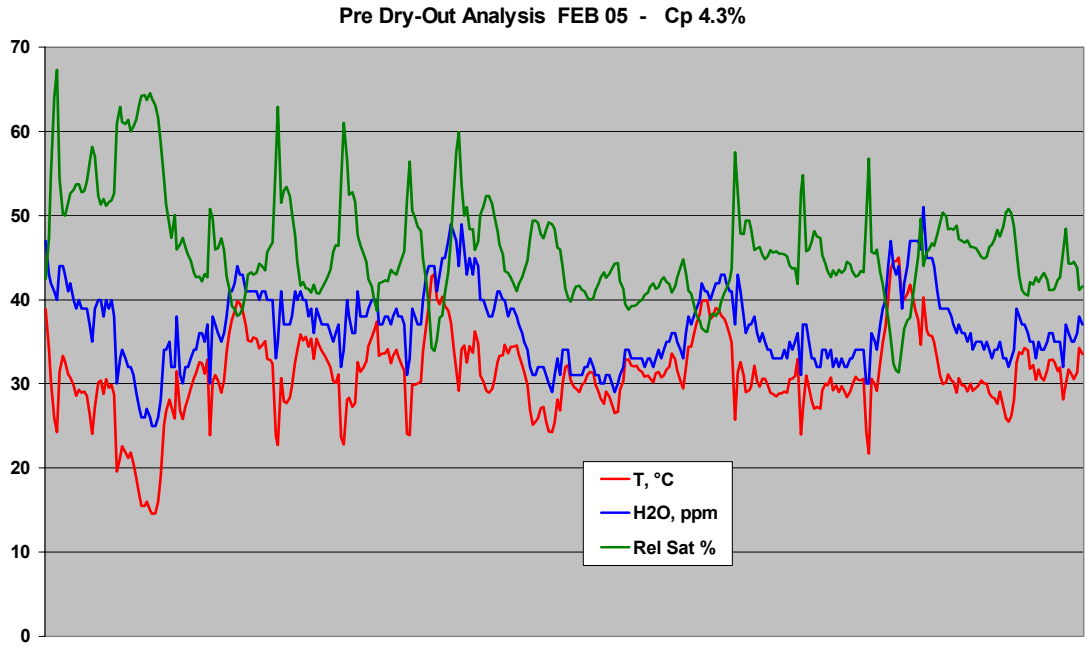

Fig. 1 – Pre-filtering Analysis over 17 days

The bottom oil temperature peaked at 45C and water in oil at 51 ppm which caused relative saturation to peak at 68% during cooling. Water in cellulose was calculated at 4.3% using the average of the entire data values over the period. At 35°C the water in oil was 41 ppm.

TROJAN Analysis and Dry-Out example

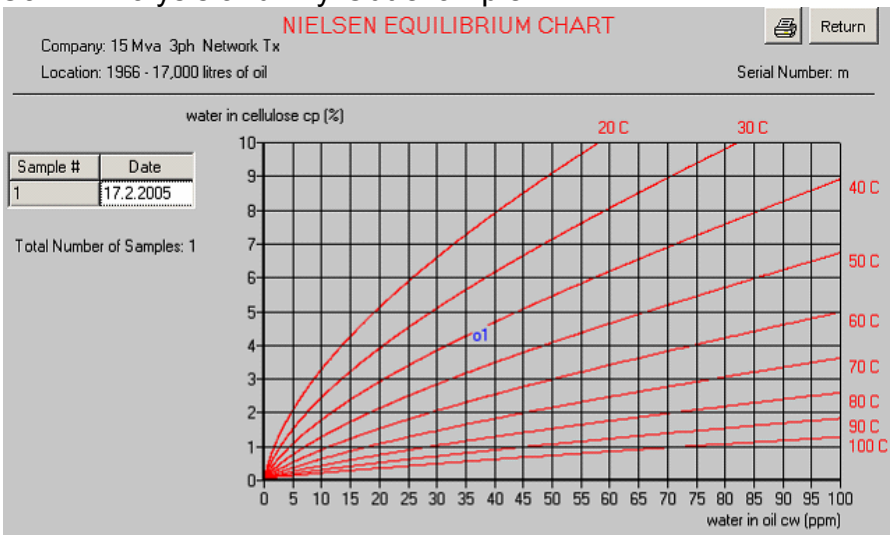

Fig. 2 – Water in cellulose calculation is 4.3%.

Online Filtering - using a Trojan Compact over 42 days removed **5.25 litres** of water, or 125 mils per day. All water was physically collected at the auto Filter Re-Dry. The oil dielectric was 36 Kv (2.5mm) before the start of filtering, after 7 days of filtering it had improved to 59 Kv, and at the point of Trojan removal it had increased to 80 Kv (2.5mm).

The transformer was then left to recover equilibrium. Re-Analysis of the transformer was conducted on two occasions, the first 36 days, and the second 66 days after the Trojan stopped filtering, to measure what impact removing the 5.25 litres had on water activity.

Re Analysis # 1 – after 36 days the same sensor was installed into the radiator and the data recorded over a 10 day period. It was now winter and the average oil temperature was 6°C lower. Water activity is still very restrained. The water in oil at 35°C is 17 ppm compared to the 41 ppm before filtering at the same temperature. The improvements in relative saturation / dielectric profile of the oil are significant. Water in cellulose was calculated at 2.8%.

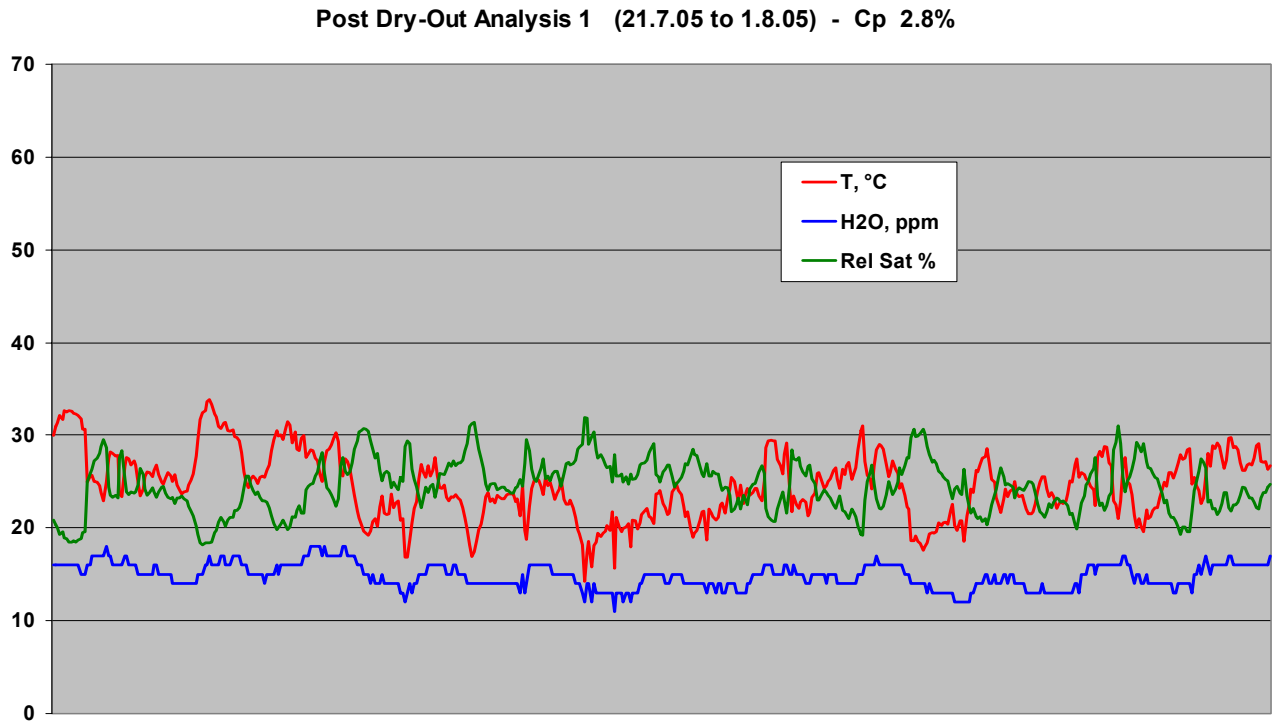

Fig. 3 – Re - Analysis # 1

Re-Analysis # 2 - 66 days after the Trojan filtering, the sensor recorded the water in oil activity over 7 days. The temperature profile was identical to the previous analysis and equilibrium recovery had continued and appeared stable over the last analysis period. The benefits of removing the 5.25 litres of water are evident. Water in oil at 35°C is now 20 ppm compared to the 41 ppm before Filtering. Water in cellulose was calculated at 3.12%.

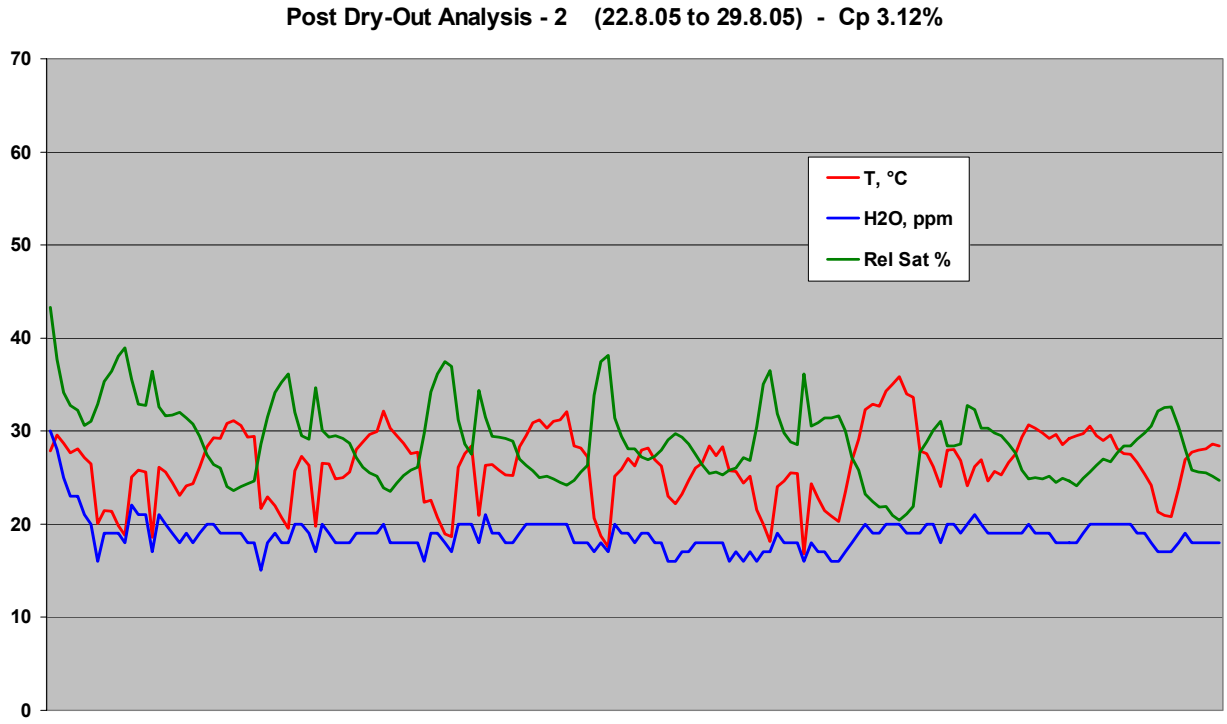

Fig. 4 – Re - Analysis # 2

The water in cellulose has been reduced from 4.3% down to about 3.1%, a reduction of about 1.2%.

The transformer was first analysed during summer, had the water removed at the start of winter, and the two follow up Analysis were conducted in winter. The average bottom oil temperature profile during the second and third analysis was lower than the first. The load on the transformer (amps) during analysis was recorded at hourly intervals and averaged, showing 262 amps for the pre-filtering analysis, 275 for the second and 268, all very similar, the only difference is the ambient temperature.

Key analysis data

Analysis Date	Average Bottom Oil temp	Average Water in oil	Oil Relative Sat. %	Water in Cellulose %	Water In oil At 35°C	Amps Loading On Tx
17.2.05	31°C	37 **ppm**	46%	**4.3 %**	41 ppm	262
1.8.05	25°C	15 **ppm**	24%	2.8 %	18 ppm	275
29.8.05	27°C	19 **ppm**	29%	**3.1 %**	20 ppm	268

The recovery in equilibrium after the Trojan stopped filtering is normal. The higher the load temperature profile the faster the water will re-distribute around the transformer. When the water is being removed from the transformer during filtering, it releases from the hottest cellulose faster. So the hotter cellulose will be proportionally dryer than the cooler cellulose.

TROJAN Analysis and Dry-Out example

When filtering stops the water redistributes from the colder more dense cellulose to the hottest in an effort to reach quasi – equilibrium based on the temperature of the cellulose.

Conclusions

Filtering the water and particles from the oil has an almost immediate impact on relative saturation and dielectric strength. Independent laboratory analysis of the dielectric, water content and particles suspended in the oil, before, during and after the Trojan Filtering are shown in Fig. 8.

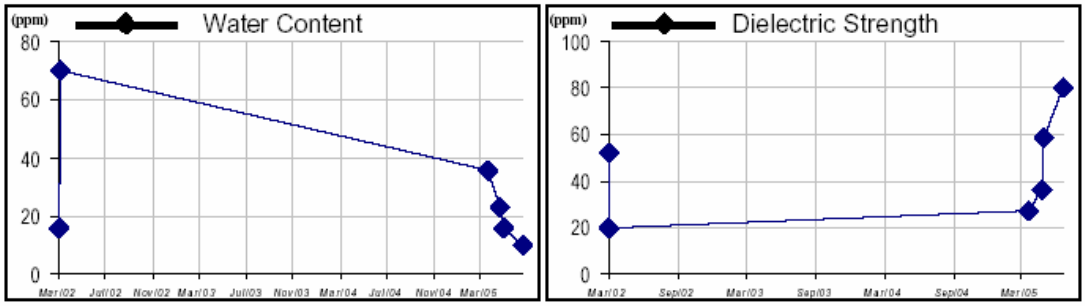

Fig. 8 – independent qualification.

Oil Screen Chemical

Sample Type	Date:	Water (mg/kg)	Temp's Deg C Sample	Top	Wind	Acid (mg KOH/g)	Colour	IFT (mN/m)	Inhibitor %(w/w)
Bottom	7/07/2005	10	24	36	60		L2.0		0.33
Bottom	19/05/2005	16	30	48	55				0.33
Bottom	10/05/2005	23	30	44	52		1.5		0.31

Oil Screen Electrical

Sample Type	Sampled:	Dielectric Strength	VR @ 90 Deg C	DDF @ 90 Deg C	VR @ 20 Deg C	DDF at 20 Deg 1KV/mm)	DDF at 20 Deg 2KV/mm)
Bottom	7/07/2005	80					
Bottom	19/05/2005	59					
Bottom	10/05/2005	36					

Particle Profile (Counts / 100ml)

Sample Type	Sampled:	5 - < 15 um	15 - < 25 um	25 - < 50 um	50 - < 100 um	100um
Bottom	7/07/2005	14853	1573	448	33	5
Bottom	19/05/2005	1836	248	125	8	0
Bottom	10/05/2005	100036	10695	4773	240	33

The oil dielectric has been improved from 36 Kv (2.5 mm) to over 80 Kv. Particles have been removed to a very satisfactory level. The water in cellulose has been reduced to the first step, and the transformer can now operate safely at normal load requirements.

Within the next eighteen months the Trojan will be returned to remove about 3 litres. This should take about 4 weeks of filtering and will reduce the water in cellulose down to about 2.5% and be all that is required. The volume of water remaining will not reduce the cellulose life of any consequence. Dielectric stability is restored.

Martin Cropp
Contact
Website - dryoutsystems.com
Email – martin@dryoutsystems.com