REPORT

Condition Assessment and Health Index of Company A Transformers

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Summary

Company A commissioned EA Technology to assess the condition of the oil filled transformers located at their Site A and derive and populate a health index (HI). To facilitate this EA Technology undertook a sampling and test programme.

The condition of each transformer has been assessed using oil analysis techniques and is detailed in this report. On the basis of the health index, recommendations for future management of the assets in this population have been made.

Conclusions

C1. None of the transformers were found to be at their end of life, transformers Tx18, Tx21, Tx23 and Tx25 were found to be approaching their EOL in approximately 6, 6, 6 and 9 years respectively.

C2. Transformers Tx08, Tx17 and Tx25 which were found to have elevated moisture contents and Tx17 and Tx25 were also found to have reduced breakdown voltage strengths. In addition transformer Tx21 was found to have a slightly elevated acidity content. The remaining transformer population was found to have acceptable oil quality with low moisture and acidity contents and high breakdown voltage strength.

C3. The DGA indicated the transformers are performing satisfactorily, with no evidence of electrical degradation.

C4. The condition of the paper in Tx19 was found to indicate the onset of paper degradation. The paper condition for the remaining transformer population was acceptable with no evidence of significant degradation.

C5. The current condition of thirty-one transformers was found to be good with HI <4. Transformers Tx18, Tx21, Tx23 and Tx25 were found to be in a moderate condition.

Recommendations

R1. On-going oil analysis and the application of EA Technology's health index are recommended for the transformer population in order to monitor the rate of degradation and identify active management strategies.

R2. Transformers Tx08, Tx17. Tx21 and Tx25 should be re-sampled to confirm their oil quality condition. Transformers Tx17 and Tx25 could then be considered for remedial treatment in order to improve the oil quality.

R3. The transformers should be re-sampled and the health index recalculated in one year (September 2017) to assist in asset management strategies.

Contents

Appendices

1. Background & Introduction

EA Technology has extensive experience of working with owners and operators of high voltage equipment to understand degradation and failure processes. One aspect of this work has been the development of health indices for high voltage equipment which combine the available relevant asset information to derive a single number intended to provide an indication of overall degradation and proximity to end of life.

Company A commissioned EA Technology to assess the condition of their oil filled transformers located at their Site A and derive and populate a health index (HI). To facilitate this EA Technology undertook a sampling and test programme.

The condition of each transformer has been assessed using oil analysis techniques and is detailed in this report. On the basis of the health index, recommendations for future management of the assets in this population have been made.

This report details the findings for the ten transformer oil samples which were submitted for analysis.

2. EA Technology's Heath Index

Working with many owners and operators of high voltage equipment, EA Technology has developed a process for deriving and populating health indices for a wide range of HV assets. The intention is to combine relevant information in order to provide a means of ranking equipment by proximity to end of life. The final number for each piece of equipment is normalised onto a scale of 0 to 10; 0 representing the best condition and 10 the worst condition. The detailed formulation of a health index for each population of equipment is specific to that population, based on the available condition information and the background history of the units in the population. The formulation is designed such that increasing values represent increasing levels of degradation and probability of failure (POF). However, this is not a linear scale. By design the relationship between the health index and the probability of failure is a cubic relationship. Individual items of equipment with a health index of <4 are in 'good' condition with a very low probability of failure, that would not be expected to deteriorate significantly in the short or medium term. Values in the 4-7 range indicate 'moderate condition' with a low current probability of failure, but at risk of significant deterioration in the medium term. Values >7 indicate 'poor' condition with a significantly increased probability of failure that will continue to increase relatively quickly in the short term.

In general terms assets in 'good' condition (HI <4) would be expected to continue to operate satisfactorily for the foreseeable future (to have a long remnant life) and do not require any significant change to existing operation and maintenance.

Assets in 'moderate' condition (HI 4-7) are not at immediate risk but may become increasingly unreliable in the medium term (5-10years). Assets in this condition are potentially candidates for life extension measures, enhanced maintenance, refurbishment etc.

Assets in 'poor' condition (HI >7) are at risk in the short term, this risk will increase relatively quickly. Significant investment (replacement) is required to prevent unacceptable probability of failure. For electricity network assets this is often effectively End of Life (EOL).

Having derived the initial health index, the HI in future years can also be estimated based on the understanding of the degradation processes and the rates at which these proceed. Definition of end of life for assets will vary depending on the application and operational considerations. However, the approach is based on identifying units where the probability of failure is significantly raised, i.e. those with a health index of greater than 7. The actual end of life, and therefore the remnant life, of

an existing unit will depend on the level of risk acceptable to the owner. In the present case any transformer with a health index of greater than 7 would be deemed to be approaching end of life.

3. Transformer Degradation

3.1 Internal Degradation

Internal insulation degradation results from oxidation of the oil and paper components. The rate of degradation is very dependent upon the operating condition, in particular the temperature, and therefore the load. The rate of the oxidation processes increases exponentially with temperature and therefore a transformer that is heavily loaded for long periods of time will have a shorter life than a transformer that is subject to moderate loads. Occasional overload situations in which the temperature of the transformer may be raised above the normal maximum temperature cause particularly rapid degradation and therefore significantly shorten the transformer life.

The effects of internal oxidation can be sensitively and accurately monitored by oil tests. Oil test results provide information both on the degradation of the oil and the paper insulation. Measurement of moisture, acidity and breakdown strength of the oil directly indicate the condition of the oil, and also give an indication of the overall internal condition of the transformer. Moisture, acidity and solid contamination are products of the oxidation of the oil and the paper. Furthermore, moisture and acidity accelerate the ageing of both the oil and the paper. Therefore the indication of poor oil quality is an early warning of overall degradation of the oil and paper insulation system. In addition ensuring a satisfactory oil condition will assist in maintaining a safe and reliable transformer performance and prevent premature ageing of the paper insulation and therefore extend the life of the transformer.

The level of water in transformers is particularly significant. As indicated above, water is a product of the oxidation processes occurring internally but moisture could also originate outside the transformer and ingress via seals. The great majority of water in a transformer will be held in the paper not the oil as the solubility of water is approximately a thousand times greater in paper than oil. The relationship between water levels in oil and paper will vary significantly with temperature. It is therefore very important to measure the oil temperature at the time of sampling so that the water level can be properly interpreted.

A water level is therefore very significant as an indication of overall health of a transformer. Also because >99% of the water in a transformer is in the paper removing water from the oil will have very little effect on the level of water in the transformer. For this reason short term filtration processes are of limited value.

The condition of the paper can be assessed by measuring the level of furfuraldehyde in the oil. Furfuraldehyde is a by-product of the oxidation process of the cellulose chains that make up paper. As this oxidation process proceeds, the average length of the cellulose chains decreases and the mechanical capability of the paper will also decrease. The level of furfuraldehyde in the oil approximately follows the decreasing cellulose chain length (degree of polymerisation DP). The DP of paper in a new transformer is approximately 1000. As the paper ages this DP reduces and the ultimate end of life for the transformer is when the paper has virtually no mechanical strength left and starts to break up and dissolve into the oil, DP approximately 250.

Dissolved gas analysis provides indication of abnormal electrical or thermal activity within a transformer. The energy available from overheating or electrical discharge breaks the oil down into the hydrocarbon gases which can be detected by analysis. The level and ratios of the different gases are a well-established means for detecting and identifying a developing internal fault.

By combining the information available from these different analyses a very good understanding of the internal condition of the transformer can be obtained.

3.2 Interpretation of Dissolved Gas Analysis

3.2.1 Decomposition of oil

Mineral insulating oils are made of a blend of different hydrocarbon molecules containing CH_3, CH_2 and CH chemical groups linked together by carbon-carbon molecular bonds. Scission of some of the C-H and C-C bonds may occur as a result of electrical and thermal faults, with the formation of small unstable fragments which recombine rapidly, through complex reactions, into gas molecules such as hydrogen (H-H), methane (CH_3-H), ethane (CH_3-CH_3), ethylene (CH_2 = CH_2) or acetylene (CH N CH). The gases formed dissolve in oil, or accumulate as free gases if produced rapidly in large quantities, and may be analyzed by DGA according to IEC 60567.

Low-energy faults, such as partial discharges favour the scission of the weakest C-H bonds. More energy and/or higher temperatures are needed for the scission of the C-C bonds and their recombination following processes bearing some similarities with those observed in the petroleum oil-cracking industry. Ethylene is thus favoured over ethane and methane above temperatures of approximately 500 ˚C (although still present in lower quantities below). Acetylene requires temperatures of at least 800 ˚C to 1200 ˚C and is thus formed in significant quantities mainly in arcs. Acetylene may still be formed at lower temperatures (< 800 ˚C), but in very minor quantities. Carbon particles form at 500 ˚C to 800 ˚C and are observed after arcing in oil or around very hot spots. Oil may oxidize with the formation of small quantities of CO and CO2, which can accumulate over long periods of time into more substantial amounts.

3.2.2 Typical gas levels

Any gas formation in service results from a stress of some kind, even if it is a very mild one like normal temperature ageing. However, as long as gas formation is below typical values, it should not be considered as an indication of a “fault”, but rather as “typical gas formation”.

Typical concentration values are the acceptable gas quantities below which field experience shows no detectable or possible incipient fault, and which are over passed by only an arbitrarily low percentage of higher gas contents, for example 10 % (BS 60599). Typical concentration values will be referred to in such an example as the 90 % typical values. However, typical concentration values are preferably to be considered as initial guidelines for decision making, when no other experience is available. They shall not be used to ascertain whether or not a fault exists within a transformer but should be viewed as values above which the rate of gas formation may permit the detection of a probable fault. Typical concentration values are affected by a number of factors, chiefly the operating time since commissioning, the type of equipment and the nature of the fault (electrical or thermal). For power transformers, the type of oil protection, load factor and operation mode are other influencing factors. DGA limits from various sources are given below. IEC 60599 is typically used to assist in the interpretation of the oil results obtained as part of this project, although consideration of the individual results has been made by comparing to the remaining population and the background information relating to the transformers.

Table 1 Dissolved Key Gas Concentration Limits (ppm) IEC 60599: 1999 Standard

Asset	H2	CO	CO2	CH4	C2H6	C2H4	C2 H2
Power Tx	35 - 132	260-1060	1700-10000	10-120	5-90	10-120	0-4
Distribution Tx	100	200	500	50	50	50	5

Table 2 Dissolved Key Gas Concentration Limits (ppm) IEEE C57.104 - 1991 Standard

Status	H2	CH4	C2 H2	C2H4	C2H6	CO	CO2 1	TDCG
Condition 1	100	120	35	50	65	350	2,500	720
Condition 2	101-700	121-400	36-50	51-100	66-100	351-570	2,500-4,000	721-1,920

Status	H2	CH4	C2 H2	C2H4	C2H6	CO	CO2 1	TDCG
Condition 3	701-1,800	401-1,000	51-80	101-200	101-150	571-1,400	4,001-10,000	1,921-4,630
Condition 4	>1,800	>1,000	>80	>200	>150	>1,400	>10,000	>4,630

[1] CO2 is not included in adding the numbers for TDCG because it is not a combustible gas.

Table 3 Dissolved Key Gas Concentration Limits (ppm) CIGRE

H2	CH4	C2 H2	C2H4	C2H6	CO	CO2 1	TDCG
60 - 150	28.6	-	74.6	85.6	289	3771	520

3.2.3 Fault types

IEC 60599:1999 details the key gases and ratios associated with the various faults that can occur within a transformer. This information has been used to assist in the interpretation of the oil results obtained as part of this project.

The ratios are significant and should be calculated only if at least one of the gases is at a concentration and a rate of gas increase above typical values.

Table 4 Fault types IEC 60599: 1999 Standard

Type	Key Gases	Possible Faults	$\frac{C_2H_2}{C_2H_4}$	$\frac{CH_4}{H_2}$	$\frac{C_2H_4}{C_2H_6}$	Possible Findings
PD	H2, possible trace of CH4 and C2H6 Possible CO.	Partial discharges (corona).	NS	<0.1	<0.2	Weakened insulation from aging and electrical stress.
D1	H2, CH4, (some CO if discharges involve paper insulation). Possible trace amounts of C2H6.	Low energy discharges (sparking). (May be static discharges).	>1	0.1 - 0.5	>1	Pinhole punctures in paper insulation with carbon and carbon tracking. Possible carbon particles in oil. Possible loose shield, poor grounding of metal objects.
D2	H2, CH4, C2H6, C2H4, and the key gas for arcing C2H4 will be present perhaps in large amounts. If C2 H2 is being generated, arcing is still going on. CO will be present if paper is being heated.	High energy discharges (arcing).	0.6 – 2.5	0.1 - 1	>2	Metal fusion, (poor contacts in tap changer or lead connections). Weakened insulation, from aging and electrical stress. Carbonized oil. Paper destruction if it is in the arc path or overheated.
T1	H2, CO.	Thermal fault less than 300 ˚C in an area close to paper insulation (paper is being heated).	NS	NS	<1	Discoloration of paper insulation. Overloading and or cooling problem. Bad connection in leads or tap changer. Stray current path and/or stray magnetic flux.
T2	H2, CO, CH4, C2H6, C2H4.	Thermal fault between 300 ˚C and 700 ˚C.	<0.1	>1	1 -4	Paper insulation destroyed. Oil heavily carbonized.
T3	All the above gases and acetylene in large amounts.	High energy electrical arcing 700 ˚C and above.	<0.2*	>1	>4	Same as above with metal discoloration. Arcing may have caused a thermal fault.

NS = Non-significant whatever the value.

* An increasing amount of C2H4 may indicate that the hot spot temperature is higher than 1000ºC

3.3 External Degradation and Ancillary Components

Other than internal insulation condition, possible end of life conditions can occur as a result of external degradation (corrosion of tanks, pipe-work, cooling systems) or degradation and failure of

ancillary components (tap changers, bushings, cable boxes etc.). External corrosion can be prevented by appropriate maintenance and is readily assessed by inspection.

4. Oil Results & Health Index Assessment

Information on the history and background of the transformers and switchgear units was provided by Company A via a completed questionnaire. This information is intended to enable a good understanding of the maintenance history, environment, loading history and likely future requirements, nature of load and any specific concerns.

The oil samples submitted to EA Technology have been subjected to a comprehensive set of analytical procedures designed to obtain optimum condition information.

For the transformers three condition codes have been derived from the oil test results. These are derived from the measured values of moisture, acidity, breakdown strength, furfuraldehyde and DGA. The threshold levels for the different parameters have been established over many years of testing and assessing thousands of individual transformers.

The health index has been derived by combining the oil based information with codes relating to load/age, environment, maintenance and operational history, external condition and ancillary component obtained from the information submitted by Company A. Where no information was submitted assumptions have been made.

4.1 Summary of Oil Analysis Results

The most pertinent values (moisture, acidity, breakdown strength, hydrocarbon gases and furfuraldehyde) that are the basis of the three condition codes used in the transformer health index are summarised in Table 5. In addition recommendations for the future operation, testing interval and transformer management are given. The detailed transformer oil analysis results are given in Appendix I.

Table 5 Summary of Oil Results

TX ID	Serial No.	Sample Date	H2 ppm	CH4 ppm	C2H6 ppm	C2H4 ppm	C2H2 ppm	Moisture ppm	BD Strength kV	Acidity mgKOH/g	FFA ppm	Est. DP	Comments	Sampling Interval
Tx01	S12345	30/08/16	0	1	0	0	0	18.4	54.0	0.001	0.10	737	Transformer is operating satisfactorily. Acidity complies with IEC 60422. Moisture complies with IEC 60422. The breakdown voltage complies with IEC 60422. DGA is acceptable.	1 Year (Sept 17)
Tx02	S12346	30/08/16	0	1	0	0	0	16.4	52.9	0.012	0.04	847	Transformer is operating satisfactorily. Acidity complies with IEC 60422. Moisture complies with IEC 60422. The breakdown voltage complies with IEC 60422. DGA is acceptable.	1 Year (Sept 17)
Tx03	S12347	31/08/16	0	1	1	0	0	16.9	57.4	0.019	<0.01	1015	Transformer is operating satisfactorily. Acidity complies with IEC 60422. Moisture complies with IEC 60422. The breakdown voltage complies with IEC 60422. DGA is acceptable.	1 Year (Sept 17)
Tx04	S12348	01/09/16	0	2	1	3	0	19.8	60.7	0.006	0.08	764	Transformer is operating satisfactorily. Acidity complies with IEC 60422. Moisture complies with IEC 60422. The breakdown voltage complies with IEC 60422. DGA is acceptable.	1 Year (Sept 17)
Tx05	S12349	01/09/16	0	1	0	0	0	17.7	35.0	0.005	<0.01	1015	Transformer is operating satisfactorily. Acidity complies with IEC 60422. Moisture complies with IEC 60422. The breakdown voltage complies with IEC 60422. DGA is acceptable.	1 Year (Sept 17)
Tx06	S12350	01/09/16	0	1	0	1	0	15.6	32.6	0.004	<0.01	1015	Transformer is operating satisfactorily. Acidity complies with IEC 60422. Moisture complies with IEC 60422. The breakdown voltage complies with IEC 60422. DGA is acceptable.	1 Year (Sept 17)
Tx07	S12351	01/09/16	0	1	1	2	0	21.1	50.4	0.064	0.13	705	Transformer is operating satisfactorily. Acidity complies with IEC 60422. Moisture complies with IEC 60422. The breakdown voltage complies with IEC 60422. DGA is acceptable.	1 Year (Sept 17)

TX ID	Serial No.	Sample Date	H2 ppm	CH4 ppm	C2H6 ppm	C2H4 ppm	C2H2 ppm	Moisture ppm	BD Strength kV	Acidity mgKOH/g	FFA ppm	Est. DP	Comments	Sampling Interval
Tx08	S12352	01/09/16	34	3	3	5	0	**40.0**	33.3	0.116	<0.01	1015	Transformer is operating satisfactorily. Acidity complies with IEC 60422. The oil is wet, check for sources of moisture ingress and resample to confirm. The breakdown voltage complies with IEC 60422. DGA is acceptable.	**1 Year (Sept 17)**
Tx09	S12353	01/09/16	0	1	1	3	0	13.6	37.6	0.118	<0.01	1015	Transformer is operating satisfactorily. Acidity complies with IEC 60422. Moisture complies with IEC 60422. The breakdown voltage complies with IEC 60422. DGA is acceptable.	**1 Year (Sept 17)**
Tx10	S12354	01/08/16	0	1	1	1	0	14.9	72.6	0.013	0.05	820	Transformer is operating satisfactorily. Acidity complies with IEC 60422. Moisture complies with IEC 60422. The breakdown voltage complies with IEC 60422. DGA is acceptable.	**1 Year (Sept 17)**
Tx11	S12355	01/08/16	0	2	2	2	0	22.4	42.6	0.032	0.05	820	Transformer is operating satisfactorily. Acidity complies with IEC 60422. Moisture complies with IEC 60422. The breakdown voltage complies with IEC 60422. DGA is acceptable.	**1 Year (Sept 17)**
Tx12	S12356	01/08/16	0	2	1	3	0	18.5	63.0	0.079	0.25	626	Transformer is operating satisfactorily. Acidity complies with IEC 60422. Moisture complies with IEC 60422. The breakdown voltage complies with IEC 60422. DGA is acceptable.	**1 Year (Sept 17)**
Tx13	S12357	31/08/16	0	1	0	0	0	13.0	56.9	0.019	0.07	780	Transformer is operating satisfactorily. Acidity complies with IEC 60422. Moisture complies with IEC 60422. The breakdown voltage complies with IEC 60422. DGA is acceptable.	**1 Year (Sept 17)**
Tx14	S12358	31/08/16	0	2	1	3	0	13.8	49.2	0.054	0.20	653	Transformer is operating satisfactorily. Acidity complies with IEC 60422. Moisture complies with IEC 60422. The breakdown voltage complies with IEC 60422. DGA is acceptable.	**1 Year (Sept 17)**

TX ID	Serial No.	Sample Date	H2 ppm	CH4 ppm	C2H6 ppm	C2H4 ppm	C2H2 ppm	Moisture ppm	BD Strength kV	Acidity mgKOH/g	FFA ppm	Est. DP	Comments	Sampling Interval
Tx15	S12359	30/08/16	0	1	0	1	0	18.4	38.8	0.001	0.06	798	Transformer is operating satisfactorily. Acidity complies with IEC 60422. Moisture complies with IEC 60422. The breakdown voltage complies with IEC 60422. DGA is acceptable.	1 Year (Sept 17)
Tx16	S12360	30/08/16	0	1	1	1	0	16.0	56.1	0.011	0.14	696	Transformer is operating satisfactorily. Acidity complies with IEC 60422. Moisture complies with IEC 60422. The breakdown voltage complies with IEC 60422. DGA is acceptable.	1 Year (Sept 17)
Tx17	S12361	30/08/16	7	1	0	2	0	**35.0**	**21.0**	0.165	0.22	641	Transformer is operating satisfactorily. Acidity complies with IEC 60422. The oil is wet, check for sources of moisture ingress and resample to confirm. Breakdown voltage is low, resample to confirm or consider remedial treatment to remove contamination from the oil. DGA is acceptable.	1 Year (Sept 17)
Tx18	S12362	30/08/16	17	1	0	1	0	21.5	40.2	0.102	0.70	501	Transformer is operating satisfactorily. Acidity complies with IEC 60422. Moisture complies with IEC 60422. The breakdown voltage complies with IEC 60422. DGA is acceptable.	1 Year (Sept 17)
Tx19	S12363	30/08/16	0	1	0	1	0	20.1	63.8	0.031	**1.56**	**404**	Transformer is operating satisfactorily. Acidity complies with IEC 60422. Moisture complies with IEC 60422. The breakdown voltage complies with IEC 60422. DGA is acceptable. FFA indicates onset of paper degradation.	1 Year (Sept 17)
Tx20	S12364	31/08/16	0	1	0	0	0	18.2	61.5	0.010	0.03	882	Transformer is operating satisfactorily. Acidity complies with IEC 60422. Moisture complies with IEC 60422. The breakdown voltage complies with IEC 60422. DGA is acceptable.	1 Year (Sept 17)

TX ID	Serial No.	Sample Date	H2 ppm	CH4 ppm	C2H6 ppm	C2H4 ppm	C2H2 ppm	Moisture ppm	BD Strength kV	Acidity mgKOH/g	FFA ppm	Est. DP	Comments	Sampling Interval
Tx21	S12365	31/08/16	7	2	1	2	0	26.6	40.3	**0.222**	0.21	647	Transformer is operating satisfactorily. The oil is slightly acidic, resample to confirm or consider remedial treatment to remove oxidation products from the oil. Moisture complies with IEC 60422. The breakdown voltage complies with IEC 60422. DGA is acceptable.	**1 Year (Sept 17)**
Tx22	S12366	30/08/16	0	1	1	0	0	20.0	43.1	0.002	0.05	820	Transformer is operating satisfactorily. Acidity complies with IEC 60422. Moisture complies with IEC 60422. The breakdown voltage complies with IEC 60422. DGA is acceptable.	**1 Year (Sept 17)**
Tx23	S12367	01/09/16	11	1	0	1	0	25.6	38.7	0.001	0.08	764	Transformer is operating satisfactorily. Acidity complies with IEC 60422. Moisture complies with IEC 60422. The breakdown voltage complies with IEC 60422. DGA is acceptable.	**1 Year (Sept 17)**
Tx24	S12368	01/09/16	12	2	0	1	0	24.1	58.0	0.001	0.13	705	Transformer is operating satisfactorily. Acidity complies with IEC 60422. Moisture complies with IEC 60422. The breakdown voltage complies with IEC 60422. DGA is acceptable.	**1 Year (Sept 17)**
Tx25	S12369	30/08/16	14	3	9	3	0	**31.0**	**27.0**	0.012	0.20	653	Transformer is operating satisfactorily. Acidity complies with IEC 60422. The oil is wet, check for sources of moisture ingress and resample to confirm. Breakdown voltage is low, resample to confirm or consider remedial treatment to remove contamination from the oil. DGA is acceptable.	**1 Year (Sept 17)**
Tx26	S12370	31/08/16	0	1	1	1	0	18.1	43.7	0.009	0.06	798	Transformer is operating satisfactorily. Acidity complies with IEC 60422. Moisture complies with IEC 60422. The breakdown voltage complies with IEC 60422. DGA is acceptable.	**1 Year (Sept 17)**

TX ID	Serial No.	Sample Date	H2 ppm	CH4 ppm	C2H6 ppm	C2H4 ppm	C2H2 ppm	Moisture ppm	BD Strength kV	Acidity mgKOH/g	FFA ppm	Est. DP	Comments	Sampling Interval
Tx27	S12371	31/08/16	0	1	0	0	0	16.6	46.3	0.026	0.16	680	Transformer is operating satisfactorily. Acidity complies with IEC 60422. Moisture complies with IEC 60422. The breakdown voltage complies with IEC 60422. DGA is acceptable.	1 Year (Sept 17)
Tx28	S12372	30/08/16	0	1	0	0	0	20.8	30.8	0.006	0.06	798	Transformer is operating satisfactorily. Acidity complies with IEC 60422. Moisture complies with IEC 60422. The breakdown voltage complies with IEC 60422. DGA is acceptable.	1 Year (Sept 17)
Tx29	S12373	30/08/16	0	1	0	0	0	14.3	44.0	0.006	0.04	847	Transformer is operating satisfactorily. Acidity complies with IEC 60422. Moisture complies with IEC 60422. The breakdown voltage complies with IEC 60422. DGA is acceptable.	1 Year (Sept 17)
Tx30	S12374	30/08/16	0	1	0	0	0	18.1	35.1	0.052	0.01	1015	Transformer is operating satisfactorily. Acidity complies with IEC 60422. Moisture complies with IEC 60422. The breakdown voltage complies with IEC 60422. DGA is acceptable.	1 Year (Sept 17)
Tx31	S12375	30/08/16	18	1	1	1	0	16.8	58.7	0.045	0.35	585	Transformer is operating satisfactorily. Acidity complies with IEC 60422. Moisture complies with IEC 60422. The breakdown voltage complies with IEC 60422. DGA is acceptable.	1 Year (Sept 17)
Tx32	S12376	30/08/16	20	2	2	2	0	11.7	53.6	0.039	0.23	636	Transformer is operating satisfactorily. Acidity complies with IEC 60422. Moisture complies with IEC 60422. The breakdown voltage complies with IEC 60422. DGA is acceptable.	1 Year (Sept 17)
Tx33	S12377	31/08/16	0	1	1	0	0	10.9	60.0	0.025	0.03	882	Transformer is operating satisfactorily. Acidity complies with IEC 60422. Moisture complies with IEC 60422. The breakdown voltage complies with IEC 60422. DGA is acceptable.	1 Year (Sept 17)

TX ID	Serial No.	Sample Date	H2 ppm	CH4 ppm	C2H6 ppm	C2H4 ppm	C2H2 ppm	Moisture ppm	BD Strength kV	Acidity mgKOH/g	FFA ppm	Est. DP	Comments	Sampling Interval
Tx34	S12378	30/08/16	0	1	0	0	0	10.6	66.6	0.003	0.12	715	Transformer is operating satisfactorily. Acidity complies with IEC 60422. Moisture complies with IEC 60422. The breakdown voltage complies with IEC 60422. DGA is acceptable.	**1 Year (Sept 17)**
Tx35	S12379	30/08/16	0	1	0	0	0	10.8	30.9	0.001	0.07	780	Transformer is operating satisfactorily. Acidity complies with IEC 60422. Moisture complies with IEC 60422. The breakdown voltage complies with IEC 60422. DGA is acceptable.	**1 Year (Sept 17)**

H2 denotes Hydrogen, CH4 denotes Methane, C2H6 denotes Ethane, C2H4 denotes Ethylene, C2H2 denotes Acetylene, FFA denotes furfuraldehyde, DP denotes Degree of Polymerisation.

4.2 Transformer Health Index

Table 6 provides a summary of health index results for the transformers included in the work programme. The current and the ten year predicted health index and probability of failure (POF) was calculated. In addition the current estimated end of life was also calculated.

Table 6 Calculated Health Index and Probability of Failure for Transformer Population

Tx ID	Serial No	Current Health Index	Current POF	Health Index Year 10	POF Year 10	Estimated End of Life Years
Tx01	S12345	3.5	0.0048	4.9	0.0094	20
Tx02	S12346	3.5	0.0048	4.9	0.0094	20
Tx03	S12347	2.7	0.0031	3.9	0.0060	26
Tx04	S12348	2.5	0.0029	3.7	0.0054	27
Tx05	S12349	3.6	0.0052	5.4	0.0118	16
Tx06	S12350	3.6	0.0052	5.4	0.0118	16
Tx07	S12351	2.5	0.0029	3.7	0.0054	27
Tx08	S12352	3.6	0.0051	5.4	0.0118	16
Tx09	S12353	4.0	0.0062	6.0	0.0148	14
Tx10	S12354	2.0	0.0021	2.9	0.0036	34
Tx11	S12355	3.4	0.0045	4.9	0.0095	19
Tx12	S12356	2.4	0.0026	3.4	0.0045	31
Tx13	S12357	2.3	0.0025	3.4	0.0045	29
Tx14	S12358	2.9	0.0035	4.4	0.0076	21
Tx15	S12359	3.1	0.0040	4.8	0.0089	19
Tx16	S12360	2.9	0.0035	4.4	0.0076	21
Tx17	S12361	3.6	0.0051	5.6	0.0124	15
Tx18	S12362	5.7	0.0130	7.9	0.0278	6
Tx19	S12363	3.4	0.0046	5.3	0.0111	16
Tx20	S12364	2.1	0.0021	3.1	0.0038	31
Tx21	S12365	5.7	0.0130	7.9	0.0278	6
Tx22	S12366	3.8	0.0056	5.5	0.0123	16
Tx23	S12367	5.7	0.0130	7.9	0.0278	6
Tx24	S12368	3.5	0.0048	4.8	0.0089	22
Tx25	S12369	5.7	0.0130	7.9	0.0278	6
Tx26	S12370	3.5	0.0048	4.8	0.0090	22

Tx ID	Serial No	Current Health Index	Current POF	Health Index Year 10	POF Year 10	Estimated End of Life Years
Tx27	S12371	2.5	0.0029	3.7	0.0054	27
Tx28	S12372	1.8	0.0019	3.0	0.0037	28
Tx29	S12373	1.2	0.0012	1.7	0.0017	>50
Tx30	S12374	1.8	0.0017	2.8	0.0034	29
Tx31	S12375	1.8	0.0017	2.8	0.0034	29
Tx32	S12376	1.2	0.0012	1.7	0.0017	>50
Tx33	S12377	1.2	0.0012	1.6	0.0016	>50
Tx34	S12378	0.9	0.0009	1.1	0.0011	>50
Tx35	S12379	1.4	0.0014	2.5	0.0028	28

The health index values are determined by the contributions from the oil test results, transformer age, operational considerations, environment and previous history.

As explained in section 0 a health index >7 indicates an asset in relatively poor condition, with an increasing POF that will rise relatively quickly. End of life can be defined as when the POF becomes unacceptable, for critical assets a conservative view would be expected. On this basis a health index of 7 is a reasonable definition of reaching EOL. This is consistent with a DP value of 250 being one definition of EOL. The ageing process then enables an estimate of time to EOL. The current and ten year health index profiles for the transformer population are shown in Figure 1 and Figure 2.

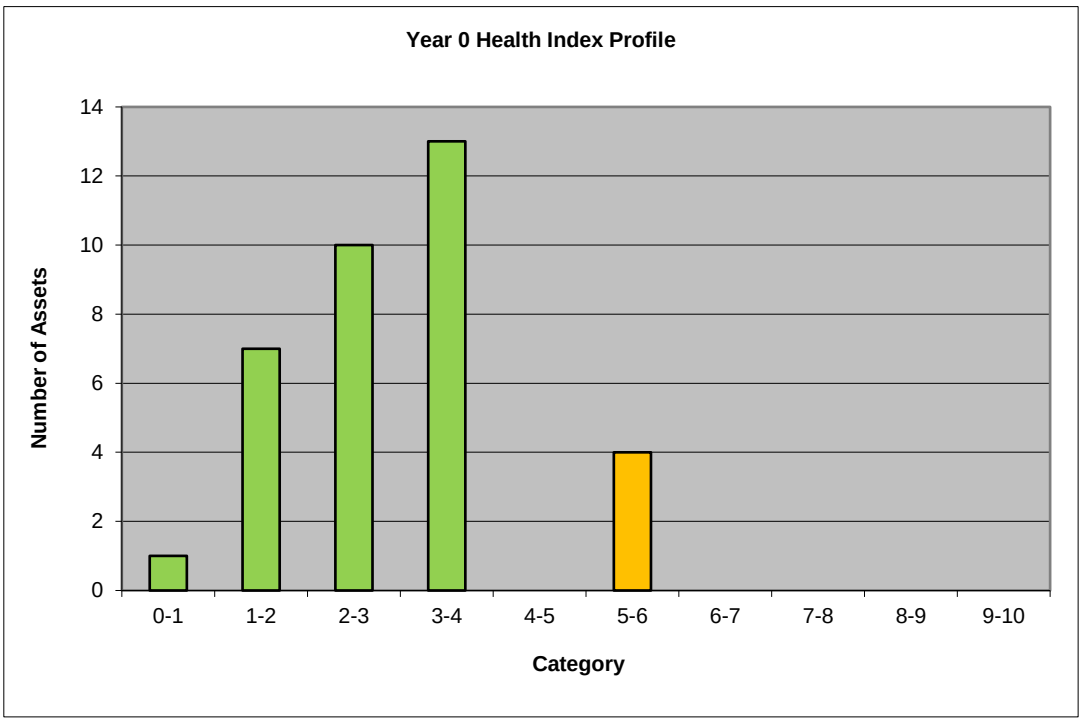

Figure 1 Current Health Index for Transformer Population

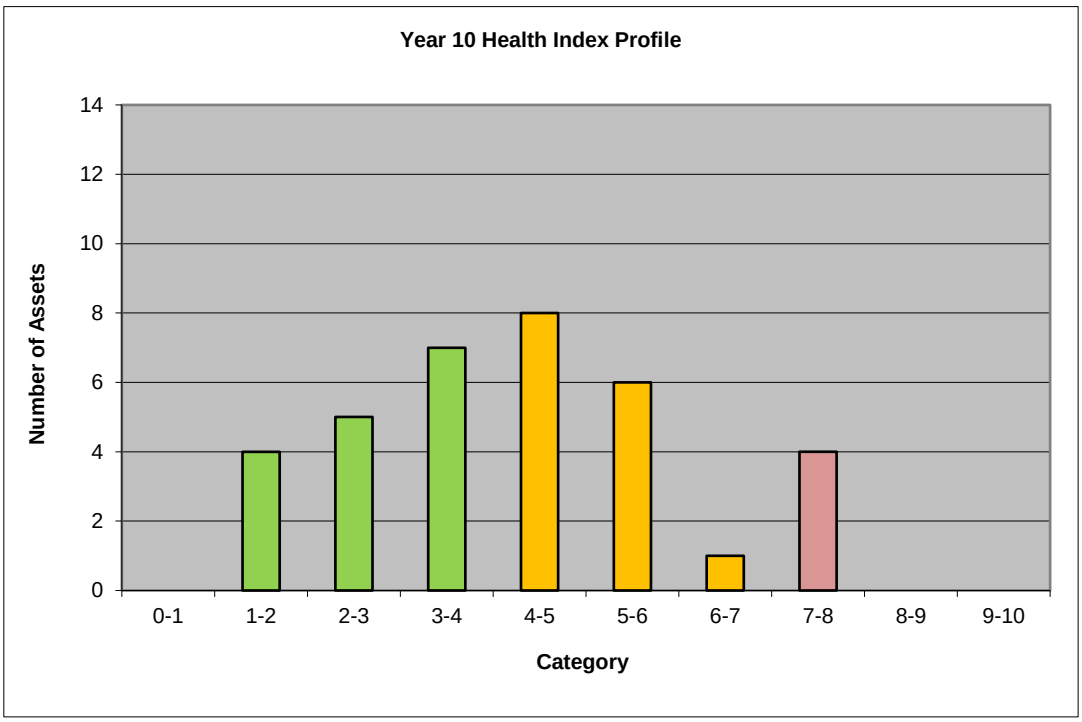

Figure 2 Ten Year Health Index for Transformer Population

5. Discussion

By applying the EA Technology methodology to the Health Index values it is possible to estimate future Health Index values and therefore to estimate the time to end-of-life (EOL) for each asset, where a Health Index of 7 is deemed to be end-of-life. For transformers the individual oil results with respect to the oil quality, DGA and FFA give a good indication of the overall condition of the transformer. Consequently these results are significant in the health index calculations.

All of the transformers were found to have good oil quality indicating low moisture and acidity contents and high breakdown voltage strengths with the exception of transformers Tx08, Tx17 and Tx25 which were found to have elevated moisture contents. These units should be checked for sources of moisture ingress. Transformers Tx17 and Tx25 were also found to have reduced breakdown voltage strengths and these units should be resampled to confirm their oil quality and could benefit from remedial treatment to improve the oil quality. In addition transformer Tx21 was found to have a slightly elevated acidity content. The unit should be resampled to confirm the oil quality. The temperature of the oils was not submitted so the moisture has not been corrected. The rate of oxidation of oil is dependent on several factors but the oil temperature is critical. As the temperature increases so does the rate of oxidation, which doubles for every 10˚C rise. Consequently the rate of oil oxidation is dependent on such parameters as loading, ambient temperature and transformer cooling in addition to the chemical properties of the oil itself. Maintaining an acceptable oil quality within the transformer is critical to assist in managing the performance of the transformer and protecting the paper insulation against premature ageing.

The DGA of all thirty-five transformers indicated they are performing satisfactorily, with no evidence of electrical degradation.

The FFA content for transformer Tx19 was found to be slightly elevated at 1.56ppm, correlation to a degree of polymerisation of 404DP and indicating the onset of paper degradation. The paper condition appears to be stable and the FFA has not increased since the previous analysis. The paper condition based on the FFA content for all of the remaining transformers was found to be good indicating no evidence of significant paper degradation.

The current condition of thirty-one of the transformers was found to be good (i.e. HI <4) and sixteen of these are expected to remain in good condition for the next ten years (assuming stable operational conditions). Fifteen of the transformers (Tx01, Tx02, Tx05, Tx06, Tx08, Tx09, Tx11, Tx14, Tx15, Tx16, Tx17, Tx19, Tx22, Tx24 and Tx26) are expected to slightly deteriorate to a moderate condition within the next ten years (assuming stable operational conditions). The remaining four transformers (Tx18, Tx21, Tx23 and Tx25) were found to be in a moderate condition and are expected to deteriorate to a poor condition within the next ten (assuming stable operational conditions).

None of the transformers were found to be at their end of life's, transformers Tx18, Tx21, Tx23 and Tx25 were found to be approaching their end of life in approximately 6, 6, 6 and 9 years respectively. EOL is generally accepted to be when the condition of the transformer results in an unacceptable probability of failure. In the case of transformers this occurs when the paper insulation has little mechanical strength left (DP ~250). Such transformers are at increased risk of failure, particularly if subjected to mechanical stress, including those generated during a through fault.

Regarding the transformer sampling interval, EA Technology normally recommends a maximum of 12 months for units showing no indication of performance issues (as in the case for all of the transformers). Shorter times of 6 months, 3 months or immediate retest are used when fault gases are detected and depend on the severity of indicated fault. A 12 month sampling interval is used as it enables the transformer's performance to be monitored and will ensure the vast majority of faults are identified before significant damage to the transformer or performance issues arise.

6. Conclusions

C1. None of the transformers were found to be at their end of life, transformers Tx18, Tx21, Tx23 and Tx25 were found to be approaching their EOL in approximately 6, 6, 6 and 9 years respectively.

C2. Transformers Tx08, Tx17 and Tx25 which were found to have elevated moisture contents and Tx17 and Tx25 were also found to have reduced breakdown voltage strengths. In addition transformer Tx21 was found to have a slightly elevated acidity content. The remaining transformer population was found to have acceptable oil quality with low moisture and acidity contents and high breakdown voltage strength.

C3. The DGA indicated the transformers are performing satisfactorily, with no evidence of electrical degradation.

C4. The condition of the paper in Tx19 was found to indicate the onset of paper degradation. The paper condition for the remaining transformer population was acceptable with no evidence of significant degradation.

C5. The current condition of thirty-one transformers was found to be good with HI <4. Transformers Tx18, Tx21, Tx23 and Tx25 were found to be in a moderate condition.

7. Recommendations

R1. On-going oil analysis and the application of EA Technology's health index are recommended for the transformer population in order to monitor the rate of degradation and identify active management strategies.

R2. Transformers Tx08, Tx17. Tx21 and Tx25 should be re-sampled to confirm their oil quality condition. Transformers Tx17 and Tx25 could then be considered for remedial treatment in order to improve the oil quality.

R3. The transformers should be re-sampled and the health index recalculated in one year (September 2017) to assist in asset management strategies.

Appendix I Transformer Oil Analysis Data Sheets

Transformer Oil Diagnostics

Oil Diagnostics by EA Technology

Company: Company A
Date: 30/08/2016
Location: Location A
Substation: Sub A
Transformer ID: Tx01
Manufacturer: Bonar Long 1970

Job Number: A0000
Sample Number: A00000101
Serial Number: S12345
Voltage (kV): 11
Rating (MVA): 1

RETEST 1 YEAR

Diagnostic Results

Test	Result
Hydrogen H2 (ppm) IEC 60567	0
Methane CH4 (ppm) IEC 60567	1
Ethane C2H6 (ppm) IEC 60567	0
Ethylene C2H4 (pm) IEC 60567	0
Acetylene C2H2 (ppm) IEC 60567	0
Carbon Monoxide Co (ppm) IEC 60567	10
Carbon Dioxide CO2 (ppm) IEC 60567	643
Nitrogen N2 (ppm) IEC 60567	72292
Oxygen O2 (ppm) IEC 60567	38792
Total (ppm)	111738
TDCG (ppm)	11
Viscosity (mm2/s)	N/A
Density (g/ml)	N/A
Particles 5 to 15 µm	N/A
Particles 15 to 25 µm	N/A
Particles 25 to 50 µm	N/A

Test	Result
Particles 50 to 100 µm	N/A
Particles >100 µm	N/A
Moisture (ppm) IEC 60814	18.4
Moisture @ 20C (ppm)	N/A
Diagnostic Breakdown Voltage (kV)	N/A
IEC Breakdown Voltage (kV) IEC 60156	54.0
Acid Number (mgKOH/g) IEC 62021	0.001
Interfacial tension (dynes /cm) ASTM D971	N/A
Power factor IEC 60247	N/A
Power factor IEC 60247	N/A
5 hydroxymethyl-2-furaldehyde (ppm) IEC 61198	N/A
2 furaldehyde (ppm) IEC 61198	0.10
2 acetylfuran (ppm) IEC 61198	N/A
5 methyl-2-furaldehyde (ppm) IEC 61198	N/A
2 furfurol (ppm) IEC 61198	N/A
Estimated Degree of Polymerisation DP	737

Retest: 1 Year

Operational Status:

Transformer is operating satisfactorily.

Paper Condition:

The mechanical strength of the paper is indicated by the estimated degree of polymerisation (DP). New paper starts with a DP of 1000 or more, as the paper starts to age or is damaged by poor fluid management or operational events, so the DP reduces. A DP of 250 indicates end of life. The paper inside this transformer is in normal condition. No specific actions are advised.

Fluid Condition:

Acidity complies with IEC 60422.
The temperature of the oil was not provided so the moisture as not been corrected. Moisture appears to comply with IEC 60422.
Breakdown voltage is acceptable and complies with IEC 60422.

Approved By:

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Transformer Oil Diagnostics

Oil Diagnostics by EA Technology

Company: Company A
Date: 30/08/2016
Location: Location A
Substation: Sub A
Transformer ID: Tx02
Manufacturer: Bonar Long 1970

Job Number: A0000
Sample Number: A00000102
Serial Number: S12346
Voltage (kV): 11
Rating (MVA): 1

RETEST 1 YEAR

Diagnostic Results

Test	Result
Hydrogen H2 (ppm) IEC 60567	0
Methane CH4 (ppm) IEC 60567	1
Ethane C2H6 (ppm) IEC 60567	0
Ethylene C2H4 (pm) IEC 60567	0
Acetylene C2H2 (ppm) IEC 60567	0
Carbon Monoxide Co (ppm) IEC 60567	8
Carbon Dioxide CO2 (ppm) IEC 60567	554
Nitrogen N2 (ppm) IEC 60567	70985
Oxygen O2 (ppm) IEC 60567	38816
Total (ppm)	110364
TDCG (ppm)	9
Viscosity (mm2/s)	N/A
Density (g/ml)	N/A
Particles 5 to 15 µm	N/A
Particles 15 to 25 µm	N/A
Particles 25 to 50 µm	N/A

Test	Result
Particles 50 to 100 µm	N/A
Particles >100 µm	N/A
Moisture (ppm) IEC 60814	16.4
Moisture @ 20C (ppm)	N/A
Diagnostic Breakdown Voltage (kV)	N/A
IEC Breakdown Voltage (kV) IEC 60156	52.9
Acid Number (mgKOH/g) IEC 62021	0.012
Interfacial tension (dynes /cm) ASTM D971	N/A
Power factor IEC 60247	N/A
Power factor IEC 60247	N/A
5 hydroxymethyl-2-furaldehyde (ppm) IEC 61198	N/A
2 furaldehyde (ppm) IEC 61198	0.04
2 acetylfuran (ppm) IEC 61198	N/A
5 methyl-2-furaldehyde (ppm) IEC 61198	N/A
2 furfurol (ppm) IEC 61198	N/A
Estimated Degree of Polymerisation DP	847

Retest: 1 Year

Operational Status:

Transformer is operating satisfactorily.

Paper Condition:

The mechanical strength of the paper is indicated by the estimated degree of polymerisation (DP). New paper starts with a DP of 1000 or more, as the paper starts to age or is damaged by poor fluid management or operational events, so the DP reduces. A DP of 250 indicates end of life. The paper inside this transformer is in normal condition. No specific actions are advised.

Fluid Condition:

Acidity complies with IEC 60422.
The temperature of the oil was not provided so the moisture as not been corrected. Moisture appears to comply with IEC 60422.
Breakdown voltage is acceptable and complies with IEC 60422.

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Transformer Oil Diagnostics

Oil Diagnostics by EA Technology

Company: Company A
Date: 31/08/2016
Location: Location A
Substation: Sub A
Transformer ID: Tx03
Manufacturer: Brush 1975

Job Number: A0000
Sample Number: A00000103
Serial Number: S12347
Voltage (kV): 11
Rating (MVA): 1

RETEST 1 YEAR

Diagnostic Results

Test	Result
Hydrogen H2 (ppm) IEC 60567	0
Methane CH4 (ppm) IEC 60567	1
Ethane C2H6 (ppm) IEC 60567	1
Ethylene C2H4 (pm) IEC 60567	0
Acetylene C2H2 (ppm) IEC 60567	0
Carbon Monoxide Co (ppm) IEC 60567	5
Carbon Dioxide CO2 (ppm) IEC 60567	507
Nitrogen N2 (ppm) IEC 60567	76599
Oxygen O2 (ppm) IEC 60567	40669
Total (ppm)	117783
TDCG (ppm)	8
Viscosity (mm2/s)	N/A
Density (g/ml)	N/A
Particles 5 to 15 µm	N/A
Particles 15 to 25 µm	N/A
Particles 25 to 50 µm	N/A

Test	Result
Particles 50 to 100 µm	N/A
Particles >100 µm	N/A
Moisture (ppm) IEC 60814	16.9
Moisture @ 20C (ppm)	N/A
Diagnostic Breakdown Voltage (kV)	N/A
IEC Breakdown Voltage (kV) IEC 60156	57.4
Acid Number (mgKOH/g) IEC 62021	0.019
Interfacial tension (dynes /cm) ASTM D971	N/A
Power factor IEC 60247	N/A
Power factor IEC 60247	N/A
5 hydroxymethyl-2-furaldehyde (ppm) IEC 61198	N/A
2 furaldehyde (ppm) IEC 61198	<0.01
2 acetylfuran (ppm) IEC 61198	N/A
5 methyl-2-furaldehyde (ppm) IEC 61198	N/A
2 furfurol (ppm) IEC 61198	N/A
Estimated Degree of Polymerisation DP	1015

Retest: 1 Year

Operational Status:

Transformer is operating satisfactorily.

Paper Condition:

The mechanical strength of the paper is indicated by the estimated degree of polymerisation (DP). New paper starts with a DP of 1000 or more, as the paper starts to age or is damaged by poor fluid management or operational events, so the DP reduces. A DP of 250 indicates end of life. The paper inside this transformer is in normal condition. No specific actions are advised.

Fluid Condition:

Acidity complies with IEC 60422.
The temperature of the oil was not provided so the moisture as not been corrected. Moisture appears to comply with IEC 60422.
Breakdown voltage is acceptable and complies with IEC 60422.

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ea technology

Transformer Oil Diagnostics

Oil Diagnostics by EA Technology

Company: Company A
Date: 01/09/2016
Location: Location A
Substation: Sub A
Transformer ID: Tx04
Manufacturer: Brush 1976

Job Number: A0000
Sample Number: A00000104
Serial Number: S12348
Voltage (kV): 11
Rating (MVA): 1

RETEST 1 YEAR

Diagnostic Results

Test	Result
Hydrogen H2 (ppm) IEC 60567	0
Methane CH4 (ppm) IEC 60567	2
Ethane C2H6 (ppm) IEC 60567	1
Ethylene C2H4 (pm) IEC 60567	3
Acetylene C2H2 (ppm) IEC 60567	0
Carbon Monoxide Co (ppm) IEC 60567	10
Carbon Dioxide CO2 (ppm) IEC 60567	781
Nitrogen N2 (ppm) IEC 60567	105648
Oxygen O2 (ppm) IEC 60567	53316
Total (ppm)	159761
TDCG (ppm)	15
Viscosity (mm2/s)	N/A
Density (g/ml)	N/A
Particles 5 to 15 µm	N/A
Particles 15 to 25 µm	N/A
Particles 25 to 50 µm	N/A

Test	Result
Particles 50 to 100 µm	N/A
Particles >100 µm	N/A
Moisture (ppm) IEC 60814	19.8
Moisture @ 20C (ppm)	N/A
Diagnostic Breakdown Voltage (kV)	N/A
IEC Breakdown Voltage (kV) IEC 60156	60.7
Acid Number (mgKOH/g) IEC 62021	0.006
Interfacial tension (dynes /cm) ASTM D971	N/A
Power factor IEC 60247	N/A
Power factor IEC 60247	N/A
5 hydroxymethyl-2-furaldehyde (ppm) IEC 61198	N/A
2 furaldehyde (ppm) IEC 61198	0.08
2 acetylfuran (ppm) IEC 61198	N/A
5 methyl-2-furaldehyde (ppm) IEC 61198	N/A
2 furfurol (ppm) IEC 61198	N/A
Estimated Degree of Polymerisation DP	764

Retest: 1 Year

Operational Status:

Transformer is operating satisfactorily.

Paper Condition:

The mechanical strength of the paper is indicated by the estimated degree of polymerisation (DP). New paper starts with a DP of 1000 or more, as the paper starts to age or is damaged by poor fluid management or operational events, so the DP reduces. A DP of 250 indicates end of life. The paper inside this transformer is in normal condition. No specific actions are advised.

Fluid Condition:

Acidity complies with IEC 60422.
The temperature of the oil was not provided so the moisture as not been corrected. Moisture appears to comply with IEC 60422.
Breakdown voltage is acceptable and complies with IEC 60422.

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Transformer Oil Diagnostics

Oil Diagnostics by EA Technology

Company: Company A
Date: 01/09/2016
Location: Location A
Substation: Sub A
Transformer ID: Tx05
Manufacturer: Brush 1976

Job Number: A0000
Sample Number: A00000105
Serial Number: S12349
Voltage (kV): 11
Rating (MVA): 1

RETEST 1 YEAR

Diagnostic Results

Test	Result
Hydrogen H2 (ppm) IEC 60567	0
Methane CH4 (ppm) IEC 60567	1
Ethane C2H6 (ppm) IEC 60567	0
Ethylene C2H4 (pm) IEC 60567	0
Acetylene C2H2 (ppm) IEC 60567	0
Carbon Monoxide Co (ppm) IEC 60567	8
Carbon Dioxide CO2 (ppm) IEC 60567	614
Nitrogen N2 (ppm) IEC 60567	89489
Oxygen O2 (ppm) IEC 60567	44762
Total (ppm)	134875
TDCG (ppm)	9
Viscosity (mm2/s)	N/A
Density (g/ml)	N/A
Particles 5 to 15 µm	N/A
Particles 15 to 25 µm	N/A
Particles 25 to 50 µm	N/A

Test	Result
Particles 50 to 100 µm	N/A
Particles >100 µm	N/A
Moisture (ppm) IEC 60814	17.7
Moisture @ 20C (ppm)	N/A
Diagnostic Breakdown Voltage (kV)	N/A
IEC Breakdown Voltage (kV) IEC 60156	35.0
Acid Number (mgKOH/g) IEC 62021	0.005
Interfacial tension (dynes /cm) ASTM D971	N/A
Power factor IEC 60247	N/A
Power factor IEC 60247	N/A
5 hydroxymethyl-2-furaldehyde (ppm) IEC 61198	N/A
2 furaldehyde (ppm) IEC 61198	<0.01
2 acetylfuran (ppm) IEC 61198	N/A
5 methyl-2-furaldehyde (ppm) IEC 61198	N/A
2 furfurol (ppm) IEC 61198	N/A
Estimated Degree of Polymerisation DP	1015

Retest: 1 Year

Operational Status:

Transformer is operating satisfactorily.

Paper Condition:

The mechanical strength of the paper is indicated by the estimated degree of polymerisation (DP). New paper starts with a DP of 1000 or more, as the paper starts to age or is damaged by poor fluid management or operational events, so the DP reduces. A DP of 250 indicates end of life. The paper inside this transformer is in normal condition. No specific actions are advised.

Fluid Condition:

Acidity complies with IEC 60422.
The temperature of the oil was not provided so the moisture as not been corrected. Moisture appears to comply with IEC 60422.
Breakdown voltage is acceptable and complies with IEC 60422.

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Transformer Oil Diagnostics

Oil Diagnostics by EA Technology

Company: Company A
Date: 01/09/2016
Location: Location A
Substation: Sub A
Transformer ID: Tx06
Manufacturer: Brush 1976

Job Number: A0000
Sample Number: A00000106
Serial Number: S12350
Voltage (kV): 11
Rating (MVA): 1

RETEST 1 YEAR

Diagnostic Results

Test	Result
Hydrogen H2 (ppm) IEC 60567	0
Methane CH4 (ppm) IEC 60567	1
Ethane C2H6 (ppm) IEC 60567	0
Ethylene C2H4 (pm) IEC 60567	1
Acetylene C2H2 (ppm) IEC 60567	0
Carbon Monoxide Co (ppm) IEC 60567	9
Carbon Dioxide CO2 (ppm) IEC 60567	537
Nitrogen N2 (ppm) IEC 60567	95781
Oxygen O2 (ppm) IEC 60567	49285
Total (ppm)	145614
TDCG (ppm)	11
Viscosity (mm2/s)	N/A
Density (g/ml)	N/A
Particles 5 to 15 µm	N/A
Particles 15 to 25 µm	N/A
Particles 25 to 50 µm	N/A

Test	Result
Particles 50 to 100 µm	N/A
Particles >100 µm	N/A
Moisture (ppm) IEC 60814	15.6
Moisture @ 20C (ppm)	N/A
Diagnostic Breakdown Voltage (kV)	N/A
IEC Breakdown Voltage (kV) IEC 60156	32.6
Acid Number (mgKOH/g) IEC 62021	0.004
Interfacial tension (dynes /cm) ASTM D971	N/A
Power factor IEC 60247	N/A
Power factor IEC 60247	N/A
5 hydroxymethyl-2-furaldehyde (ppm) IEC 61198	N/A
2 furaldehyde (ppm) IEC 61198	<0.01
2 acetylfuran (ppm) IEC 61198	N/A
5 methyl-2-furaldehyde (ppm) IEC 61198	N/A
2 furfurol (ppm) IEC 61198	N/A
Estimated Degree of Polymerisation DP	1015

Retest: 1 Year

Operational Status:

Transformer is operating satisfactorily.

Paper Condition:

The mechanical strength of the paper is indicated by the estimated degree of polymerisation (DP). New paper starts with a DP of 1000 or more, as the paper starts to age or is damaged by poor fluid management or operational events, so the DP reduces. A DP of 250 indicates end of life. The paper inside this transformer is in normal condition. No specific actions are advised.

Fluid Condition:

Acidity complies with IEC 60422.
The temperature of the oil was not provided so the moisture as not been corrected. Moisture appears to comply with IEC 60422.
Breakdown voltage is acceptable and complies with IEC 60422.

Approved By:

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Transformer Oil Diagnostics

Oil Diagnostics by EA Technology

Company: Company A
Date: 01/09/2016
Location: Location A
Substation: Sub A
Transformer ID: Tx07
Manufacturer: Brush 1978

Job Number: A0000
Sample Number: A00000107
Serial Number: S12351
Voltage (kV): 11
Rating (MVA): 1

RETEST 1 YEAR

Diagnostic Results

Test	Result
Hydrogen H2 (ppm) IEC 60567	0
Methane CH4 (ppm) IEC 60567	1
Ethane C2H6 (ppm) IEC 60567	1
Ethylene C2H4 (pm) IEC 60567	2
Acetylene C2H2 (ppm) IEC 60567	0
Carbon Monoxide Co (ppm) IEC 60567	55
Carbon Dioxide CO2 (ppm) IEC 60567	1024
Nitrogen N2 (ppm) IEC 60567	78774
Oxygen O2 (ppm) IEC 60567	37905
Total (ppm)	117763
TDCG (ppm)	59
Viscosity (mm2/s)	N/A
Density (g/ml)	N/A
Particles 5 to 15 µm	N/A
Particles 15 to 25 µm	N/A
Particles 25 to 50 µm	N/A

Test	Result
Particles 50 to 100 µm	N/A
Particles >100 µm	N/A
Moisture (ppm) IEC 60814	21.1
Moisture @ 20C (ppm)	N/A
Diagnostic Breakdown Voltage (kV)	N/A
IEC Breakdown Voltage (kV) IEC 60156	50.4
Acid Number (mgKOH/g) IEC 62021	0.064
Interfacial tension (dynes /cm) ASTM D971	N/A
Power factor IEC 60247	N/A
Power factor IEC 60247	N/A
5 hydroxymethyl-2-furaldehyde (ppm) IEC 61198	N/A
2 furaldehyde (ppm) IEC 61198	0.13
2 acetylfuran (ppm) IEC 61198	N/A
5 methyl-2-furaldehyde (ppm) IEC 61198	N/A
2 furfurol (ppm) IEC 61198	N/A
Estimated Degree of Polymerisation DP	705

Retest: 1 Year

Operational Status:

Transformer is operating satisfactorily.

Paper Condition:

The mechanical strength of the paper is indicated by the estimated degree of polymerisation (DP). New paper starts with a DP of 1000 or more, as the paper starts to age or is damaged by poor fluid management or operational events, so the DP reduces. A DP of 250 indicates end of life. The paper inside this transformer is in normal condition. No specific actions are advised.

Fluid Condition:

Acidity complies with IEC 60422.
The temperature of the oil was not provided so the moisture as not been corrected. Moisture appears to comply with IEC 60422.
Breakdown voltage is acceptable and complies with IEC 60422.

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Transformer Oil Diagnostics

Oil Diagnostics by EA Technology

Company: Company A
Date: 01/09/2016
Location: Location A
Substation: Sub A
Transformer ID: Tx08
Manufacturer: Bonar Long 1977

Job Number: A0000
Sample Number: A00000108
Serial Number: S12352
Voltage (kV): 11
Rating (MVA): 1

RETEST 1 YEAR

Diagnostic Results

Test	Result
Hydrogen H2 (ppm) IEC 60567	34
Methane CH4 (ppm) IEC 60567	3
Ethane C2H6 (ppm) IEC 60567	3
Ethylene C2H4 (pm) IEC 60567	5
Acetylene C2H2 (ppm) IEC 60567	0
Carbon Monoxide Co (ppm) IEC 60567	87
Carbon Dioxide CO2 (ppm) IEC 60567	3832
Nitrogen N2 (ppm) IEC 60567	77031
Oxygen O2 (ppm) IEC 60567	24581
Total (ppm)	105576
TDCG (ppm)	132
Viscosity (mm2/s)	N/A
Density (g/ml)	N/A
Particles 5 to 15 µm	N/A
Particles 15 to 25 µm	N/A
Particles 25 to 50 µm	N/A

Test	Result
Particles 50 to 100 µm	N/A
Particles >100 µm	N/A
Moisture (ppm) IEC 60814	40.0
Moisture @ 20C (ppm)	N/A
Diagnostic Breakdown Voltage (kV)	N/A
IEC Breakdown Voltage (kV) IEC 60156	33.3
Acid Number (mgKOH/g) IEC 62021	0.116
Interfacial tension (dynes /cm) ASTM D971	N/A
Power factor IEC 60247	N/A
Power factor IEC 60247	N/A
5 hydroxymethyl-2-furaldehyde (ppm) IEC 61198	N/A
2 furaldehyde (ppm) IEC 61198	<0.01
2 acetylfuran (ppm) IEC 61198	N/A
5 methyl-2-furaldehyde (ppm) IEC 61198	N/A
2 furfurol (ppm) IEC 61198	N/A
Estimated Degree of Polymerisation DP	1015

Retest: 1 Year

Operational Status:

Transformer is operating satisfactorily.

Paper Condition:

The mechanical strength of the paper is indicated by the estimated degree of polymerisation (DP). New paper starts with a DP of 1000 or more, as the paper starts to age or is damaged by poor fluid management or operational events, so the DP reduces. A DP of 250 indicates end of life. The paper inside this transformer is in normal condition. No specific actions are advised.

Fluid Condition:

Acidity complies with IEC 60422.
The temperature of the oil was not provided so the moisture as not been corrected. The oil is wet,
Check for sources of moisture ingress and resample to confirm.
Breakdown voltage is acceptable and complies with IEC 60422.

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Transformer Oil Diagnostics

Oil Diagnostics by EA Technology

Company: Company A
Date: 01/09/2016
Location: Location A
Substation: Sub A
Transformer ID: Tx09
Manufacturer: Bonar Long 1977

Job Number: A0000
Sample Number: A00000109
Serial Number: S12353
Voltage (kV): 11
Rating (MVA): 1

RETEST 1 YEAR

Diagnostic Results

Test	Result
Hydrogen H2 (ppm) IEC 60567	0
Methane CH4 (ppm) IEC 60567	1
Ethane C2H6 (ppm) IEC 60567	1
Ethylene C2H4 (pm) IEC 60567	3
Acetylene C2H2 (ppm) IEC 60567	0
Carbon Monoxide Co (ppm) IEC 60567	62
Carbon Dioxide CO2 (ppm) IEC 60567	924
Nitrogen N2 (ppm) IEC 60567	74805
Oxygen O2 (ppm) IEC 60567	28725
Total (ppm)	104521
TDCG (ppm)	67
Viscosity (mm2/s)	N/A
Density (g/ml)	N/A
Particles 5 to 15 µm	N/A
Particles 15 to 25 µm	N/A
Particles 25 to 50 µm	N/A

Test	Result
Particles 50 to 100 µm	N/A
Particles >100 µm	N/A
Moisture (ppm) IEC 60814	13.6
Moisture @ 20C (ppm)	N/A
Diagnostic Breakdown Voltage (kV)	N/A
IEC Breakdown Voltage (kV) IEC 60156	37.6
Acid Number (mgKOH/g) IEC 62021	0.118
Interfacial tension (dynes /cm) ASTM D971	N/A
Power factor IEC 60247	N/A
Power factor IEC 60247	N/A
5 hydroxymethyl-2-furaldehyde (ppm) IEC 61198	N/A
2 furaldehyde (ppm) IEC 61198	<0.01
2 acetylfuran (ppm) IEC 61198	N/A
5 methyl-2-furaldehyde (ppm) IEC 61198	N/A
2 furfurol (ppm) IEC 61198	N/A
Estimated Degree of Polymerisation DP	1015

Retest: 1 Year

Operational Status:

Transformer is operating satisfactorily.

Paper Condition:

The mechanical strength of the paper is indicated by the estimated degree of polymerisation (DP). New paper starts with a DP of 1000 or more, as the paper starts to age or is damaged by poor fluid management or operational events, so the DP reduces. A DP of 250 indicates end of life. The paper inside this transformer is in normal condition. No specific actions are advised.

Fluid Condition:

Acidity complies with IEC 60422.
The temperature of the oil was not provided so the moisture as not been corrected. Moisture appears to comply with IEC 60422.
Breakdown voltage is acceptable and complies with IEC 60422.

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Transformer Oil Diagnostics

Oil Diagnostics by EA Technology

Company: Company A
Date: 01/08/2016
Location: Location A
Substation: Sub A
Transformer ID: Tx10
Manufacturer: Bonar Long 1977

Job Number: A0000
Sample Number: A00000110
Serial Number: S12354
Voltage (kV): 11
Rating (MVA): 1

RETEST 1 YEAR

Diagnostic Results

Test	Result
Hydrogen H2 (ppm) IEC 60567	0
Methane CH4 (ppm) IEC 60567	1
Ethane C2H6 (ppm) IEC 60567	1
Ethylene C2H4 (pm) IEC 60567	1
Acetylene C2H2 (ppm) IEC 60567	0
Carbon Monoxide Co (ppm) IEC 60567	11
Carbon Dioxide CO2 (ppm) IEC 60567	947
Nitrogen N2 (ppm) IEC 60567	58259
Oxygen O2 (ppm) IEC 60567	29383
Total (ppm)	88602
TDCG (ppm)	14
Viscosity (mm2/s)	N/A
Density (g/ml)	N/A
Particles 5 to 15 µm	N/A
Particles 15 to 25 µm	N/A
Particles 25 to 50 µm	N/A

Test	Result
Particles 50 to 100 µm	N/A
Particles >100 µm	N/A
Moisture (ppm) IEC 60814	14.9
Moisture @ 20C (ppm)	N/A
Diagnostic Breakdown Voltage (kV)	N/A
IEC Breakdown Voltage (kV) IEC 60156	72.6
Acid Number (mgKOH/g) IEC 62021	0.013
Interfacial tension (dynes /cm) ASTM D971	N/A
Power factor IEC 60247	N/A
Power factor IEC 60247	N/A
5 hydroxymethyl-2-furaldehyde (ppm) IEC 61198	N/A
2 furaldehyde (ppm) IEC 61198	0.05
2 acetylfuran (ppm) IEC 61198	N/A
5 methyl-2-furaldehyde (ppm) IEC 61198	N/A
2 furfurol (ppm) IEC 61198	N/A
Estimated Degree of Polymerisation DP	820

Retest: 1 Year

Operational Status:

Transformer is operating satisfactorily.

Paper Condition:

The mechanical strength of the paper is indicated by the estimated degree of polymerisation (DP). New paper starts with a DP of 1000 or more, as the paper starts to age or is damaged by poor fluid management or operational events, so the DP reduces. A DP of 250 indicates end of life. The paper inside this transformer is in normal condition. No specific actions are advised.

Fluid Condition:

Acidity complies with IEC 60422.
The temperature of the oil was not provided so the moisture as not been corrected. Moisture appears to comply with IEC 60422.
Breakdown voltage is acceptable and complies with IEC 60422.

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Transformer Oil Diagnostics

Oil Diagnostics by EA Technology

Company: Company A
Date: 01/08/2016
Location: Location A
Substation: Sub A
Transformer ID: Tx11
Manufacturer: Bonar Long 1974

Job Number: A0000
Sample Number: A00000111
Serial Number: S12355
Voltage (kV): 11
Rating (MVA): 4

RETEST 1 YEAR

Diagnostic Results

Test	Result
Hydrogen H2 (ppm) IEC 60567	0
Methane CH4 (ppm) IEC 60567	2
Ethane C2H6 (ppm) IEC 60567	2
Ethylene C2H4 (pm) IEC 60567	2
Acetylene C2H2 (ppm) IEC 60567	0
Carbon Monoxide Co (ppm) IEC 60567	64
Carbon Dioxide CO2 (ppm) IEC 60567	1740
Nitrogen N2 (ppm) IEC 60567	64564
Oxygen O2 (ppm) IEC 60567	28141
Total (ppm)	94517
TDCG (ppm)	71
Viscosity (mm2/s)	N/A
Density (g/ml)	N/A
Particles 5 to 15 µm	N/A
Particles 15 to 25 µm	N/A
Particles 25 to 50 µm	N/A

Test	Result
Particles 50 to 100 µm	N/A
Particles >100 µm	N/A
Moisture (ppm) IEC 60814	22.4
Moisture @ 20C (ppm)	N/A
Diagnostic Breakdown Voltage (kV)	N/A
IEC Breakdown Voltage (kV) IEC 60156	42.6
Acid Number (mgKOH/g) IEC 62021	0.032
Interfacial tension (dynes /cm) ASTM D971	N/A
Power factor IEC 60247	N/A
Power factor IEC 60247	N/A
5 hydroxymethyl-2-furaldehyde (ppm) IEC 61198	N/A
2 furaldehyde (ppm) IEC 61198	0.05
2 acetylfuran (ppm) IEC 61198	N/A
5 methyl-2-furaldehyde (ppm) IEC 61198	N/A
2 furfurol (ppm) IEC 61198	N/A
Estimated Degree of Polymerisation DP	820

Retest: 1 Year

Operational Status:

Transformer is operating satisfactorily.

Paper Condition:

The mechanical strength of the paper is indicated by the estimated degree of polymerisation (DP). New paper starts with a DP of 1000 or more, as the paper starts to age or is damaged by poor fluid management or operational events, so the DP reduces. A DP of 250 indicates end of life. The paper inside this transformer is in normal condition. No specific actions are advised.

Fluid Condition:

Acidity complies with IEC 60422.
The temperature of the oil was not provided so the moisture as not been corrected. Moisture appears to comply with IEC 60422.
Breakdown voltage is acceptable and complies with IEC 60422.

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Transformer Oil Diagnostics

Oil Diagnostics by EA Technology

Company: Company A
Date: 01/08/2016
Location: Location A
Substation: Sub A
Transformer ID: Tx12
Manufacturer: Bonar Long 1974

Job Number: A0000
Sample Number: A00000112
Serial Number: S12356
Voltage (kV): 11
Rating (MVA): 4

RETEST 1 YEAR

Diagnostic Results

Test	Result
Hydrogen H2 (ppm) IEC 60567	0
Methane CH4 (ppm) IEC 60567	2
Ethane C2H6 (ppm) IEC 60567	1
Ethylene C2H4 (pm) IEC 60567	3
Acetylene C2H2 (ppm) IEC 60567	0
Carbon Monoxide Co (ppm) IEC 60567	85
Carbon Dioxide CO2 (ppm) IEC 60567	2123
Nitrogen N2 (ppm) IEC 60567	60588
Oxygen O2 (ppm) IEC 60567	24312
Total (ppm)	87114
TDCG (ppm)	91
Viscosity (mm2/s)	N/A
Density (g/ml)	N/A
Particles 5 to 15 µm	N/A
Particles 15 to 25 µm	N/A
Particles 25 to 50 µm	N/A

Test	Result
Particles 50 to 100 µm	N/A
Particles >100 µm	N/A
Moisture (ppm) IEC 60814	18.5
Moisture @ 20C (ppm)	N/A
Diagnostic Breakdown Voltage (kV)	N/A
IEC Breakdown Voltage (kV) IEC 60156	63.0
Acid Number (mgKOH/g) IEC 62021	0.079
Interfacial tension (dynes /cm) ASTM D971	N/A
Power factor IEC 60247	N/A
Power factor IEC 60247	N/A
5 hydroxymethyl-2-furaldehyde (ppm) IEC 61198	N/A
2 furaldehyde (ppm) IEC 61198	0.25
2 acetylfuran (ppm) IEC 61198	N/A
5 methyl-2-furaldehyde (ppm) IEC 61198	N/A
2 furfurol (ppm) IEC 61198	N/A
Estimated Degree of Polymerisation DP	626

Retest: 1 Year

Operational Status:

Transformer is operating satisfactorily.

Paper Condition:

The mechanical strength of the paper is indicated by the estimated degree of polymerisation (DP). New paper starts with a DP of 1000 or more, as the paper starts to age or is damaged by poor fluid management or operational events, so the DP reduces. A DP of 250 indicates end of life. The paper inside this transformer is in normal condition. No specific actions are advised.

Fluid Condition:

Acidity complies with IEC 60422.
The temperature of the oil was not provided so the moisture as not been corrected. Moisture appears to comply with IEC 60422.
Breakdown voltage is acceptable and complies with IEC 60422.

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Transformer Oil Diagnostics

Oil Diagnostics by EA Technology

Company: Company A
Date: 31/08/2016
Location: Location A
Substation: Sub A
Transformer ID: Tx13
Manufacturer: Brush 1978

Job Number: A0000
Sample Number: A00000113
Serial Number: S12357
Voltage (kV): 11
Rating (MVA): 1

RETEST 1 YEAR

Diagnostic Results

Test	Result
Hydrogen H2 (ppm) IEC 60567	0
Methane CH4 (ppm) IEC 60567	1
Ethane C2H6 (ppm) IEC 60567	0
Ethylene C2H4 (pm) IEC 60567	0
Acetylene C2H2 (ppm) IEC 60567	0
Carbon Monoxide Co (ppm) IEC 60567	8
Carbon Dioxide CO2 (ppm) IEC 60567	449
Nitrogen N2 (ppm) IEC 60567	72925
Oxygen O2 (ppm) IEC 60567	37206
Total (ppm)	110589
TDCG (ppm)	9
Viscosity (mm2/s)	N/A
Density (g/ml)	N/A
Particles 5 to 15 µm	N/A
Particles 15 to 25 µm	N/A
Particles 25 to 50 µm	N/A

Test	Result
Particles 50 to 100 µm	N/A
Particles >100 µm	N/A
Moisture (ppm) IEC 60814	13.0
Moisture @ 20C (ppm)	N/A
Diagnostic Breakdown Voltage (kV)	N/A
IEC Breakdown Voltage (kV) IEC 60156	56.9
Acid Number (mgKOH/g) IEC 62021	0.019
Interfacial tension (dynes /cm) ASTM D971	N/A
Power factor IEC 60247	N/A
Power factor IEC 60247	N/A
5 hydroxymethyl-2-furaldehyde (ppm) IEC 61198	N/A
2 furaldehyde (ppm) IEC 61198	0.07
2 acetylfuran (ppm) IEC 61198	N/A
5 methyl-2-furaldehyde (ppm) IEC 61198	N/A
2 furfurol (ppm) IEC 61198	N/A
Estimated Degree of Polymerisation DP	780

Retest: 1 Year

Operational Status:

Transformer is operating satisfactorily.

Paper Condition:

The mechanical strength of the paper is indicated by the estimated degree of polymerisation (DP). New paper starts with a DP of 1000 or more, as the paper starts to age or is damaged by poor fluid management or operational events, so the DP reduces. A DP of 250 indicates end of life. The paper inside this transformer is in normal condition. No specific actions are advised.

Fluid Condition:

Acidity complies with IEC 60422.
The temperature of the oil was not provided so the moisture as not been corrected. Moisture appears to comply with IEC 60422.
Breakdown voltage is acceptable and complies with IEC 60422.

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Transformer Oil Diagnostics

Oil Diagnostics by EA Technology

Company: Company A
Date: 31/08/2016
Location: Location A
Substation: Sub A
Transformer ID: Tx14
Manufacturer: Bonar Long 1979

Job Number: A0000
Sample Number: A00000114
Serial Number: S12358
Voltage (kV): 11
Rating (MVA): 0.63

RETEST 1 YEAR

Diagnostic Results

Test	Result
Hydrogen H2 (ppm) IEC 60567	0
Methane CH4 (ppm) IEC 60567	2
Ethane C2H6 (ppm) IEC 60567	1
Ethylene C2H4 (pm) IEC 60567	3
Acetylene C2H2 (ppm) IEC 60567	0
Carbon Monoxide Co (ppm) IEC 60567	48
Carbon Dioxide CO2 (ppm) IEC 60567	809
Nitrogen N2 (ppm) IEC 60567	92890
Oxygen O2 (ppm) IEC 60567	37875
Total (ppm)	131629
TDCG (ppm)	54
Viscosity (mm2/s)	N/A
Density (g/ml)	N/A
Particles 5 to 15 µm	N/A
Particles 15 to 25 µm	N/A
Particles 25 to 50 µm	N/A

Test	Result
Particles 50 to 100 µm	N/A
Particles >100 µm	N/A
Moisture (ppm) IEC 60814	13.8
Moisture @ 20C (ppm)	N/A
Diagnostic Breakdown Voltage (kV)	N/A
IEC Breakdown Voltage (kV) IEC 60156	49.2
Acid Number (mgKOH/g) IEC 62021	0.054
Interfacial tension (dynes /cm) ASTM D971	N/A
Power factor IEC 60247	N/A
Power factor IEC 60247	N/A
5 hydroxymethyl-2-furaldehyde (ppm) IEC 61198	N/A
2 furaldehyde (ppm) IEC 61198	0.20
2 acetylfuran (ppm) IEC 61198	N/A
5 methyl-2-furaldehyde (ppm) IEC 61198	N/A
2 furfurol (ppm) IEC 61198	N/A
Estimated Degree of Polymerisation DP	653

Retest: 1 Year

Operational Status:

Transformer is operating satisfactorily.

Paper Condition:

The mechanical strength of the paper is indicated by the estimated degree of polymerisation (DP). New paper starts with a DP of 1000 or more, as the paper starts to age or is damaged by poor fluid management or operational events, so the DP reduces. A DP of 250 indicates end of life. The paper inside this transformer is in normal condition. No specific actions are advised.

Fluid Condition:

Acidity complies with IEC 60422.
The temperature of the oil was not provided so the moisture as not been corrected. Moisture appears to comply with IEC 60422.
Breakdown voltage is acceptable and complies with IEC 60422.

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Transformer Oil Diagnostics

Oil Diagnostics by EA Technology

Company: Company A
Date: 30/08/2016
Location: Location A
Substation: Sub A
Transformer ID: Tx15
Manufacturer: Bonar Long 1979

Job Number: A0000
Sample Number: A00000115
Serial Number: S12359
Voltage (kV): 11
Rating (MVA): 1

RETEST 1 YEAR

Diagnostic Results

Test	Result
Hydrogen H2 (ppm) IEC 60567	0
Methane CH4 (ppm) IEC 60567	1
Ethane C2H6 (ppm) IEC 60567	0
Ethylene C2H4 (pm) IEC 60567	1
Acetylene C2H2 (ppm) IEC 60567	0
Carbon Monoxide Co (ppm) IEC 60567	10
Carbon Dioxide CO2 (ppm) IEC 60567	599
Nitrogen N2 (ppm) IEC 60567	92708
Oxygen O2 (ppm) IEC 60567	46917
Total (ppm)	140236
TDCG (ppm)	12
Viscosity (mm2/s)	N/A
Density (g/ml)	N/A
Particles 5 to 15 µm	N/A
Particles 15 to 25 µm	N/A
Particles 25 to 50 µm	N/A

Test	Result
Particles 50 to 100 µm	N/A
Particles >100 µm	N/A
Moisture (ppm) IEC 60814	18.4
Moisture @ 20C (ppm)	N/A
Diagnostic Breakdown Voltage (kV)	N/A
IEC Breakdown Voltage (kV) IEC 60156	38.8
Acid Number (mgKOH/g) IEC 62021	0.001
Interfacial tension (dynes /cm) ASTM D971	N/A
Power factor IEC 60247	N/A
Power factor IEC 60247	N/A
5 hydroxymethyl-2-furaldehyde (ppm) IEC 61198	N/A
2 furaldehyde (ppm) IEC 61198	0.06
2 acetylfuran (ppm) IEC 61198	N/A
5 methyl-2-furaldehyde (ppm) IEC 61198	N/A
2 furfurol (ppm) IEC 61198	N/A
Estimated Degree of Polymerisation DP	798

Retest: 1 Year

Operational Status:

Transformer is operating satisfactorily.

Paper Condition:

The mechanical strength of the paper is indicated by the estimated degree of polymerisation (DP). New paper starts with a DP of 1000 or more, as the paper starts to age or is damaged by poor fluid management or operational events, so the DP reduces. A DP of 250 indicates end of life. The paper inside this transformer is in normal condition. No specific actions are advised.

Fluid Condition:

Acidity complies with IEC 60422.
The temperature of the oil was not provided so the moisture as not been corrected. Moisture appears to comply with IEC 60422.
Breakdown voltage is acceptable and complies with IEC 60422.

Approved By:

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Transformer Oil Diagnostics

Oil Diagnostics by EA Technology

Company: Company A
Date: 30/08/2016
Location: Location A
Substation: Sub A
Transformer ID: Tx16
Manufacturer: Bonar Long 1979

Job Number: A0000
Sample Number: A00000116
Serial Number: S12360
Voltage (kV): 11
Rating (MVA): 1

RETEST 1 YEAR

Diagnostic Results

Test	Result
Hydrogen H2 (ppm) IEC 60567	0
Methane CH4 (ppm) IEC 60567	1
Ethane C2H6 (ppm) IEC 60567	1
Ethylene C2H4 (pm) IEC 60567	1
Acetylene C2H2 (ppm) IEC 60567	0
Carbon Monoxide Co (ppm) IEC 60567	8
Carbon Dioxide CO2 (ppm) IEC 60567	540
Nitrogen N2 (ppm) IEC 60567	86553
Oxygen O2 (ppm) IEC 60567	44387
Total (ppm)	131491
TDCG (ppm)	11
Viscosity (mm2/s)	N/A
Density (g/ml)	N/A
Particles 5 to 15 µm	N/A
Particles 15 to 25 µm	N/A
Particles 25 to 50 µm	N/A

Test	Result
Particles 50 to 100 µm	N/A
Particles >100 µm	N/A
Moisture (ppm) IEC 60814	16.0
Moisture @ 20C (ppm)	N/A
Diagnostic Breakdown Voltage (kV)	N/A
IEC Breakdown Voltage (kV) IEC 60156	56.1
Acid Number (mgKOH/g) IEC 62021	0.011
Interfacial tension (dynes /cm) ASTM D971	N/A
Power factor IEC 60247	N/A
Power factor IEC 60247	N/A
5 hydroxymethyl-2-furaldehyde (ppm) IEC 61198	N/A
2 furaldehyde (ppm) IEC 61198	0.14
2 acetylfuran (ppm) IEC 61198	N/A
5 methyl-2-furaldehyde (ppm) IEC 61198	N/A
2 furfurol (ppm) IEC 61198	N/A
Estimated Degree of Polymerisation DP	696

Retest: 1 Year

Operational Status:

Transformer is operating satisfactorily.

Paper Condition:

The mechanical strength of the paper is indicated by the estimated degree of polymerisation (DP). New paper starts with a DP of 1000 or more, as the paper starts to age or is damaged by poor fluid management or operational events, so the DP reduces. A DP of 250 indicates end of life. The paper inside this transformer is in normal condition. No specific actions are advised.

Fluid Condition:

Acidity complies with IEC 60422.
The temperature of the oil was not provided so the moisture as not been corrected. Moisture appears to comply with IEC 60422.
Breakdown voltage is acceptable and complies with IEC 60422.

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Transformer Oil Diagnostics

Oil Diagnostics by EA Technology

Company: Company A
Date: 30/08/2016
Location: Location A
Substation: Sub A
Transformer ID: Tx17
Manufacturer: Bonar Long 1979

Job Number: A0000
Sample Number: A00000117
Serial Number: S12361
Voltage (kV): 11
Rating (MVA): 1

RETEST 1 YEAR

Diagnostic Results

Test	Result
Hydrogen H2 (ppm) IEC 60567	7
Methane CH4 (ppm) IEC 60567	1
Ethane C2H6 (ppm) IEC 60567	0
Ethylene C2H4 (pm) IEC 60567	2
Acetylene C2H2 (ppm) IEC 60567	0
Carbon Monoxide Co (ppm) IEC 60567	82
Carbon Dioxide CO2 (ppm) IEC 60567	1122
Nitrogen N2 (ppm) IEC 60567	78255
Oxygen O2 (ppm) IEC 60567	34990
Total (ppm)	114460
TDCG (ppm)	93
Viscosity (mm2/s)	N/A
Density (g/ml)	N/A
Particles 5 to 15 µm	N/A
Particles 15 to 25 µm	N/A
Particles 25 to 50 µm	N/A

Test	Result
Particles 50 to 100 µm	N/A
Particles >100 µm	N/A
Moisture (ppm) IEC 60814	35.0
Moisture @ 20C (ppm)	N/A
Diagnostic Breakdown Voltage (kV)	N/A
IEC Breakdown Voltage (kV) IEC 60156	21.0
Acid Number (mgKOH/g) IEC 62021	0.165
Interfacial tension (dynes /cm) ASTM D971	N/A
Power factor IEC 60247	N/A
Power factor IEC 60247	N/A
5 hydroxymethyl-2-furaldehyde (ppm) IEC 61198	N/A
2 furaldehyde (ppm) IEC 61198	0.22
2 acetylfuran (ppm) IEC 61198	N/A
5 methyl-2-furaldehyde (ppm) IEC 61198	N/A
2 furfurol (ppm) IEC 61198	N/A
Estimated Degree of Polymerisation DP	641

Retest: 1 Year

Operational Status:

Transformer is operating satisfactorily.

Paper Condition:

The mechanical strength of the paper is indicated by the estimated degree of polymerisation (DP). New paper starts with a DP of 1000 or more, as the paper starts to age or is damaged by poor fluid management or operational events, so the DP reduces. A DP of 250 indicates end of life. The paper inside this transformer is in normal condition. No specific actions are advised.

Fluid Condition:

Acidity complies with IEC 60422.
The temperature of the oil was not provided so the moisture as not been corrected. The temperature of the oil was not provided so the moisture as not been corrected. The oil is wet, Check for sources of moisture ingress and resample to confirm.
Breakdown voltage is low, resample to confirm or consider remedial treatment to remove contamination from the oil.

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Transformer Oil Diagnostics

Oil Diagnostics by EA Technology

Company: Company A
Date: 30/08/2016
Location: Location A
Substation: Sub A
Transformer ID: Tx18
Manufacturer: Brush 1966

Job Number: A0000
Sample Number: A00000118
Serial Number: S12362
Voltage (kV): 11
Rating (MVA): 1

RETEST 1 YEAR

Diagnostic Results

Test	Result
Hydrogen H2 (ppm) IEC 60567	17
Methane CH4 (ppm) IEC 60567	1
Ethane C2H6 (ppm) IEC 60567	0
Ethylene C2H4 (pm) IEC 60567	1
Acetylene C2H2 (ppm) IEC 60567	0
Carbon Monoxide Co (ppm) IEC 60567	21
Carbon Dioxide CO2 (ppm) IEC 60567	941
Nitrogen N2 (ppm) IEC 60567	86869
Oxygen O2 (ppm) IEC 60567	45141
Total (ppm)	132992
TDCG (ppm)	40
Viscosity (mm2/s)	N/A
Density (g/ml)	N/A
Particles 5 to 15 µm	N/A
Particles 15 to 25 µm	N/A
Particles 25 to 50 µm	N/A

Test	Result
Particles 50 to 100 µm	N/A
Particles >100 µm	N/A
Moisture (ppm) IEC 60814	21.5
Moisture @ 20C (ppm)	N/A
Diagnostic Breakdown Voltage (kV)	N/A
IEC Breakdown Voltage (kV) IEC 60156	40.2
Acid Number (mgKOH/g) IEC 62021	0.102
Interfacial tension (dynes /cm) ASTM D971	N/A
Power factor IEC 60247	N/A
Power factor IEC 60247	N/A
5 hydroxymethyl-2-furaldehyde (ppm) IEC 61198	N/A
2 furaldehyde (ppm) IEC 61198	0.70
2 acetylfuran (ppm) IEC 61198	N/A
5 methyl-2-furaldehyde (ppm) IEC 61198	N/A
2 furfurol (ppm) IEC 61198	N/A
Estimated Degree of Polymerisation DP	501

Retest: 1 Year

Operational Status:

Transformer is operating satisfactorily.

Paper Condition:

The mechanical strength of the paper is indicated by the estimated degree of polymerisation (DP). New paper starts with a DP of 1000 or more, as the paper starts to age or is damaged by poor fluid management or operational events, so the DP reduces. A DP of 250 indicates end of life. The paper inside this transformer is in normal condition. No specific actions are advised.

Fluid Condition:

Acidity complies with IEC 60422.
The temperature of the oil was not provided so the moisture as not been corrected. Moisture appears to comply with IEC 60422.
Breakdown voltage is acceptable and complies with IEC 60422.

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Transformer Oil Diagnostics

Oil Diagnostics by EA Technology

Company: Company A
Date: 30/08/2016
Location: Location A
Substation: Sub A
Transformer ID: Tx19
Manufacturer: Brush 1980

Job Number: A0000
Sample Number: A00000119
Serial Number: S12363
Voltage (kV): 11
Rating (MVA): 1

RETEST 1 YEAR

Diagnostic Results

Test	Result
Hydrogen H2 (ppm) IEC 60567	0
Methane CH4 (ppm) IEC 60567	1
Ethane C2H6 (ppm) IEC 60567	0
Ethylene C2H4 (pm) IEC 60567	1
Acetylene C2H2 (ppm) IEC 60567	0
Carbon Monoxide Co (ppm) IEC 60567	19
Carbon Dioxide CO2 (ppm) IEC 60567	587
Nitrogen N2 (ppm) IEC 60567	71245
Oxygen O2 (ppm) IEC 60567	33432
Total (ppm)	105285
TDCG (ppm)	21
Viscosity (mm2/s)	N/A
Density (g/ml)	N/A
Particles 5 to 15 µm	N/A
Particles 15 to 25 µm	N/A
Particles 25 to 50 µm	N/A

Test	Result
Particles 50 to 100 µm	N/A
Particles >100 µm	N/A
Moisture (ppm) IEC 60814	20.1
Moisture @ 20C (ppm)	N/A
Diagnostic Breakdown Voltage (kV)	N/A
IEC Breakdown Voltage (kV) IEC 60156	63.8
Acid Number (mgKOH/g) IEC 62021	0.031
Interfacial tension (dynes /cm) ASTM D971	N/A
Power factor IEC 60247	N/A
Power factor IEC 60247	N/A
5 hydroxymethyl-2-furaldehyde (ppm) IEC 61198	N/A
2 furaldehyde (ppm) IEC 61198	1.56
2 acetylfuran (ppm) IEC 61198	N/A
5 methyl-2-furaldehyde (ppm) IEC 61198	N/A
2 furfurol (ppm) IEC 61198	N/A
Estimated Degree of Polymerisation DP	404

Retest: 1 Year

Operational Status:

Transformer is operating satisfactorily.

Paper Condition:

The mechanical strength of the paper is indicated by the estimated degree of polymerisation (DP). New paper starts with a DP of 1000 or more, as the paper starts to age or is damaged by poor fluid management or operational events, so the DP reduces. A DP of 250 indicates end of life. The paper inside this transformer is reduced to approximately 40% mechanical strength. No specific actions are advised.

Fluid Condition:

Acidity complies with IEC 60422.
The temperature of the oil was not provided so the moisture as not been corrected. Moisture appears to comply with IEC 60422.
Breakdown voltage is acceptable and complies with IEC 60422.
FFA indicates the onset of paper degradation.

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Transformer Oil Diagnostics

Oil Diagnostics by EA Technology

Company: Company A
Date: 31/08/2016
Location: Location A
Substation: Sub A
Transformer ID: Tx20
Manufacturer: Brush 1980

Job Number: A0000
Sample Number: A00000120
Serial Number: S12364
Voltage (kV): 11
Rating (MVA): 1

RETEST 1 YEAR

Diagnostic Results

Test	Result
Hydrogen H2 (ppm) IEC 60567	0
Methane CH4 (ppm) IEC 60567	1
Ethane C2H6 (ppm) IEC 60567	0
Ethylene C2H4 (pm) IEC 60567	0
Acetylene C2H2 (ppm) IEC 60567	0
Carbon Monoxide Co (ppm) IEC 60567	5
Carbon Dioxide CO2 (ppm) IEC 60567	454
Nitrogen N2 (ppm) IEC 60567	83888
Oxygen O2 (ppm) IEC 60567	42548
Total (ppm)	126896
TDCG (ppm)	6
Viscosity (mm2/s)	N/A
Density (g/ml)	N/A
Particles 5 to 15 µm	N/A
Particles 15 to 25 µm	N/A
Particles 25 to 50 µm	N/A

Test	Result
Particles 50 to 100 µm	N/A
Particles >100 µm	N/A
Moisture (ppm) IEC 60814	18.2
Moisture @ 20C (ppm)	N/A
Diagnostic Breakdown Voltage (kV)	N/A
IEC Breakdown Voltage (kV) IEC 60156	61.5
Acid Number (mgKOH/g) IEC 62021	0.010
Interfacial tension (dynes /cm) ASTM D971	N/A
Power factor IEC 60247	N/A
Power factor IEC 60247	N/A
5 hydroxymethyl-2-furaldehyde (ppm) IEC 61198	N/A
2 furaldehyde (ppm) IEC 61198	0.03
2 acetylfuran (ppm) IEC 61198	N/A
5 methyl-2-furaldehyde (ppm) IEC 61198	N/A
2 furfurol (ppm) IEC 61198	N/A
Estimated Degree of Polymerisation DP	882

Retest: 1 Year

Operational Status:

Transformer is operating satisfactorily.

Paper Condition:

The mechanical strength of the paper is indicated by the estimated degree of polymerisation (DP). New paper starts with a DP of 1000 or more, as the paper starts to age or is damaged by poor fluid management or operational events, so the DP reduces. A DP of 250 indicates end of life. The paper inside this transformer is in normal condition. No specific actions are advised.

Fluid Condition:

Acidity complies with IEC 60422.
The temperature of the oil was not provided so the moisture as not been corrected. Moisture appears to comply with IEC 60422.
Breakdown voltage is acceptable and complies with IEC 60422.

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Transformer Oil Diagnostics

Oil Diagnostics by EA Technology

Company: Company A
Date: 31/08/2016
Location: Location A
Substation: Sub A
Transformer ID: Tx21
Manufacturer: South Wales 1966

Job Number: A0000
Sample Number: A00000121
Serial Number: S12365
Voltage (kV): 11
Rating (MVA): 1

RETEST 1 YEAR

Diagnostic Results

Test	Result
Hydrogen H2 (ppm) IEC 60567	7
Methane CH4 (ppm) IEC 60567	2
Ethane C2H6 (ppm) IEC 60567	1
Ethylene C2H4 (pm) IEC 60567	2
Acetylene C2H2 (ppm) IEC 60567	0
Carbon Monoxide Co (ppm) IEC 60567	120
Carbon Dioxide CO2 (ppm) IEC 60567	1671
Nitrogen N2 (ppm) IEC 60567	72239
Oxygen O2 (ppm) IEC 60567	27684
Total (ppm)	101726
TDCG (ppm)	132
Viscosity (mm2/s)	N/A
Density (g/ml)	N/A
Particles 5 to 15 µm	N/A
Particles 15 to 25 µm	N/A
Particles 25 to 50 µm	N/A

Test	Result
Particles 50 to 100 µm	N/A
Particles >100 µm	N/A
Moisture (ppm) IEC 60814	26.6
Moisture @ 20C (ppm)	N/A
Diagnostic Breakdown Voltage (kV)	N/A
IEC Breakdown Voltage (kV) IEC 60156	40.3
Acid Number (mgKOH/g) IEC 62021	0.222
Interfacial tension (dynes /cm) ASTM D971	N/A
Power factor IEC 60247	N/A
Power factor IEC 60247	N/A
5 hydroxymethyl-2-furaldehyde (ppm) IEC 61198	N/A
2 furaldehyde (ppm) IEC 61198	0.21
2 acetylfuran (ppm) IEC 61198	N/A
5 methyl-2-furaldehyde (ppm) IEC 61198	N/A
2 furfurol (ppm) IEC 61198	N/A
Estimated Degree of Polymerisation DP	647

Retest: 1 Year

Operational Status:

Transformer is operating satisfactorily.

Paper Condition:

The mechanical strength of the paper is indicated by the estimated degree of polymerisation (DP). New paper starts with a DP of 1000 or more, as the paper starts to age or is damaged by poor fluid management or operational events, so the DP reduces. A DP of 250 indicates end of life. The paper inside this transformer is in normal condition. No specific actions are advised.

Fluid Condition:

The oil is slightly acidic, resample to confirm or consider remedial treatment to remove oxidation products from the oil.
The temperature of the oil was not provided so the moisture as not been corrected. Moisture appears to comply with IEC 60422.
Breakdown voltage is acceptable and complies with IEC 60422.

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Transformer Oil Diagnostics

Oil Diagnostics by EA Technology

Company: Company A
Date: 30/08/2016
Location: Location A
Substation: Sub A
Transformer ID: Tx22
Manufacturer: Brush 1974

Job Number: A0000
Sample Number: A00000122
Serial Number: S12366
Voltage (kV): 11
Rating (MVA): 2

RETEST 1 YEAR

Diagnostic Results

Test	Result
Hydrogen H2 (ppm) IEC 60567	0
Methane CH4 (ppm) IEC 60567	1
Ethane C2H6 (ppm) IEC 60567	1
Ethylene C2H4 (pm) IEC 60567	0
Acetylene C2H2 (ppm) IEC 60567	0
Carbon Monoxide Co (ppm) IEC 60567	8
Carbon Dioxide CO2 (ppm) IEC 60567	570
Nitrogen N2 (ppm) IEC 60567	77598
Oxygen O2 (ppm) IEC 60567	41213
Total (ppm)	119391
TDCG (ppm)	10
Viscosity (mm2/s)	N/A
Density (g/ml)	N/A
Particles 5 to 15 µm	N/A
Particles 15 to 25 µm	N/A
Particles 25 to 50 µm	N/A

Test	Result
Particles 50 to 100 µm	N/A
Particles >100 µm	N/A
Moisture (ppm) IEC 60814	20.0
Moisture @ 20C (ppm)	N/A
Diagnostic Breakdown Voltage (kV)	N/A
IEC Breakdown Voltage (kV) IEC 60156	43.1
Acid Number (mgKOH/g) IEC 62021	0.002
Interfacial tension (dynes /cm) ASTM D971	N/A
Power factor IEC 60247	N/A
Power factor IEC 60247	N/A
5 hydroxymethyl-2-furaldehyde (ppm) IEC 61198	N/A
2 furaldehyde (ppm) IEC 61198	0.05
2 acetylfuran (ppm) IEC 61198	N/A
5 methyl-2-furaldehyde (ppm) IEC 61198	N/A
2 furfurol (ppm) IEC 61198	N/A
Estimated Degree of Polymerisation DP	820

Retest: 1 Year

Operational Status:

Transformer is operating satisfactorily.

Paper Condition:

The mechanical strength of the paper is indicated by the estimated degree of polymerisation (DP). New paper starts with a DP of 1000 or more, as the paper starts to age or is damaged by poor fluid management or operational events, so the DP reduces. A DP of 250 indicates end of life. The paper inside this transformer is in normal condition. No specific actions are advised.

Fluid Condition:

Acidity complies with IEC 60422.
The temperature of the oil was not provided so the moisture as not been corrected. Moisture appears to comply with IEC 60422.
Breakdown voltage is acceptable and complies with IEC 60422.

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Transformer Oil Diagnostics

Oil Diagnostics by EA Technology

Company: Company A
Date: 01/09/2016
Location: Location A
Substation: Sub A
Transformer ID: Tx23
Manufacturer: GEC 1966

Job Number: A0000
Sample Number: A00000123
Serial Number: S12367
Voltage (kV): 11
Rating (MVA): 1

RETEST 1 YEAR

Diagnostic Results

Test	Result
Hydrogen H2 (ppm) IEC 60567	11
Methane CH4 (ppm) IEC 60567	1
Ethane C2H6 (ppm) IEC 60567	0
Ethylene C2H4 (pm) IEC 60567	1
Acetylene C2H2 (ppm) IEC 60567	0
Carbon Monoxide Co (ppm) IEC 60567	52
Carbon Dioxide CO2 (ppm) IEC 60567	1049
Nitrogen N2 (ppm) IEC 60567	71465
Oxygen O2 (ppm) IEC 60567	34620
Total (ppm)	107200
TDCG (ppm)	66
Viscosity (mm2/s)	N/A
Density (g/ml)	N/A
Particles 5 to 15 µm	N/A
Particles 15 to 25 µm	N/A
Particles 25 to 50 µm	N/A

Test	Result
Particles 50 to 100 µm	N/A
Particles >100 µm	N/A
Moisture (ppm) IEC 60814	25.6
Moisture @ 20C (ppm)	N/A
Diagnostic Breakdown Voltage (kV)	N/A
IEC Breakdown Voltage (kV) IEC 60156	38.7
Acid Number (mgKOH/g) IEC 62021	0.001
Interfacial tension (dynes /cm) ASTM D971	N/A
Power factor IEC 60247	N/A
Power factor IEC 60247	N/A
5 hydroxymethyl-2-furaldehyde (ppm) IEC 61198	N/A
2 furaldehyde (ppm) IEC 61198	0.08
2 acetylfuran (ppm) IEC 61198	N/A
5 methyl-2-furaldehyde (ppm) IEC 61198	N/A
2 furfurol (ppm) IEC 61198	N/A
Estimated Degree of Polymerisation DP	764

Retest: 1 Year

Operational Status:

Transformer is operating satisfactorily.

Paper Condition:

The mechanical strength of the paper is indicated by the estimated degree of polymerisation (DP). New paper starts with a DP of 1000 or more, as the paper starts to age or is damaged by poor fluid management or operational events, so the DP reduces. A DP of 250 indicates end of life. The paper inside this transformer is in normal condition. No specific actions are advised.

Fluid Condition:

Acidity complies with IEC 60422.
The temperature of the oil was not provided so the moisture as not been corrected. Moisture appears to comply with IEC 60422.
Breakdown voltage is acceptable and complies with IEC 60422.

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Transformer Oil Diagnostics

Oil Diagnostics by EA Technology

Company: Company A
Date: 01/09/2016
Location: Location A
Substation: Sub A
Transformer ID: Tx24
Manufacturer: GEC 1966

Job Number: A0000
Sample Number: A00000124
Serial Number: S12368
Voltage (kV): 11
Rating (MVA): 1

RETEST 1 YEAR

Diagnostic Results

Test	Result
Hydrogen H2 (ppm) IEC 60567	12
Methane CH4 (ppm) IEC 60567	2
Ethane C2H6 (ppm) IEC 60567	0
Ethylene C2H4 (pm) IEC 60567	1
Acetylene C2H2 (ppm) IEC 60567	0
Carbon Monoxide Co (ppm) IEC 60567	40
Carbon Dioxide CO2 (ppm) IEC 60567	974
Nitrogen N2 (ppm) IEC 60567	79598
Oxygen O2 (ppm) IEC 60567	40669
Total (ppm)	121294
TDCG (ppm)	54
Viscosity (mm2/s)	N/A
Density (g/ml)	N/A
Particles 5 to 15 µm	N/A
Particles 15 to 25 µm	N/A
Particles 25 to 50 µm	N/A

Test	Result
Particles 50 to 100 µm	N/A
Particles >100 µm	N/A
Moisture (ppm) IEC 60814	24.1
Moisture @ 20C (ppm)	N/A
Diagnostic Breakdown Voltage (kV)	N/A
IEC Breakdown Voltage (kV) IEC 60156	58.0
Acid Number (mgKOH/g) IEC 62021	0.001
Interfacial tension (dynes /cm) ASTM D971	N/A
Power factor IEC 60247	N/A
Power factor IEC 60247	N/A
5 hydroxymethyl-2-furaldehyde (ppm) IEC 61198	N/A
2 furaldehyde (ppm) IEC 61198	0.13
2 acetylfuran (ppm) IEC 61198	N/A
5 methyl-2-furaldehyde (ppm) IEC 61198	N/A
2 furfurol (ppm) IEC 61198	N/A
Estimated Degree of Polymerisation DP	705

Retest: 1 Year

Operational Status:

Transformer is operating satisfactorily.

Paper Condition:

The mechanical strength of the paper is indicated by the estimated degree of polymerisation (DP). New paper starts with a DP of 1000 or more, as the paper starts to age or is damaged by poor fluid management or operational events, so the DP reduces. A DP of 250 indicates end of life. The paper inside this transformer is in normal condition. No specific actions are advised.

Fluid Condition:

Acidity complies with IEC 60422.
The temperature of the oil was not provided so the moisture as not been corrected. Moisture appears to comply with IEC 60422.
Breakdown voltage is acceptable and complies with IEC 60422.

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Transformer Oil Diagnostics

Oil Diagnostics by EA Technology

Company: Company A
Date: 30/08/2016
Location: Location A
Substation: Sub A
Transformer ID: Tx25
Manufacturer: South Wales 1966

Job Number: A0000
Sample Number: A00000125
Serial Number: S12369
Voltage (kV): 11
Rating (MVA): 1

RETEST 1 YEAR

Diagnostic Results

Test	Result
Hydrogen H2 (ppm) IEC 60567	14
Methane CH4 (ppm) IEC 60567	3
Ethane C2H6 (ppm) IEC 60567	9
Ethylene C2H4 (pm) IEC 60567	3
Acetylene C2H2 (ppm) IEC 60567	0
Carbon Monoxide Co (ppm) IEC 60567	49
Carbon Dioxide CO2 (ppm) IEC 60567	2920
Nitrogen N2 (ppm) IEC 60567	88268
Oxygen O2 (ppm) IEC 60567	45611
Total (ppm)	136877
TDCG (ppm)	79
Viscosity (mm2/s)	N/A
Density (g/ml)	N/A
Particles 5 to 15 µm	N/A
Particles 15 to 25 µm	N/A
Particles 25 to 50 µm	N/A

Test	Result
Particles 50 to 100 µm	N/A
Particles >100 µm	N/A
Moisture (ppm) IEC 60814	31.0
Moisture @ 20C (ppm)	N/A
Diagnostic Breakdown Voltage (kV)	N/A
IEC Breakdown Voltage (kV) IEC 60156	27.0
Acid Number (mgKOH/g) IEC 62021	0.012
Interfacial tension (dynes /cm) ASTM D971	N/A
Power factor IEC 60247	N/A
Power factor IEC 60247	N/A
5 hydroxymethyl-2-furaldehyde (ppm) IEC 61198	N/A
2 furaldehyde (ppm) IEC 61198	0.20
2 acetylfuran (ppm) IEC 61198	N/A
5 methyl-2-furaldehyde (ppm) IEC 61198	N/A
2 furfurol (ppm) IEC 61198	N/A
Estimated Degree of Polymerisation DP	653

Retest: 1 Year

Operational Status:

Transformer is operating satisfactorily.

Paper Condition:

The mechanical strength of the paper is indicated by the estimated degree of polymerisation (DP). New paper starts with a DP of 1000 or more, as the paper starts to age or is damaged by poor fluid management or operational events, so the DP reduces. A DP of 250 indicates end of life. The paper inside this transformer is in normal condition. No specific actions are advised.

Fluid Condition:

Acidity complies with IEC 60422.
The temperature of the oil was not provided so the moisture as not been corrected. The temperature of the oil was not provided so the moisture as not been corrected. The oil is wet, Check for sources of moisture ingress and resample to confirm.
Breakdown voltage is low, resample to confirm or consider remedial treatment to remove contamination from the oil.

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Transformer Oil Diagnostics

Oil Diagnostics by EA Technology

Company: Company A
Date: 31/08/2016
Location: Location A
Substation: Sub A
Transformer ID: Tx26
Manufacturer: South Wales 1967

Job Number: A0000
Sample Number: A00000126
Serial Number: S12370
Voltage (kV): 11
Rating (MVA): 1

RETEST 1 YEAR

Diagnostic Results

Test	Result
Hydrogen H2 (ppm) IEC 60567	0
Methane CH4 (ppm) IEC 60567	1
Ethane C2H6 (ppm) IEC 60567	1
Ethylene C2H4 (pm) IEC 60567	1
Acetylene C2H2 (ppm) IEC 60567	0
Carbon Monoxide Co (ppm) IEC 60567	20
Carbon Dioxide CO2 (ppm) IEC 60567	801
Nitrogen N2 (ppm) IEC 60567	97926
Oxygen O2 (ppm) IEC 60567	51481
Total (ppm)	150231
TDCG (ppm)	22
Viscosity (mm2/s)	N/A
Density (g/ml)	N/A
Particles 5 to 15 µm	N/A
Particles 15 to 25 µm	N/A
Particles 25 to 50 µm	N/A

Test	Result
Particles 50 to 100 µm	N/A
Particles >100 µm	N/A
Moisture (ppm) IEC 60814	18.1
Moisture @ 20C (ppm)	N/A
Diagnostic Breakdown Voltage (kV)	N/A
IEC Breakdown Voltage (kV) IEC 60156	43.7
Acid Number (mgKOH/g) IEC 62021	0.009
Interfacial tension (dynes /cm) ASTM D971	N/A
Power factor IEC 60247	N/A
Power factor IEC 60247	N/A
5 hydroxymethyl-2-furaldehyde (ppm) IEC 61198	N/A
2 furaldehyde (ppm) IEC 61198	0.06
2 acetylfuran (ppm) IEC 61198	N/A
5 methyl-2-furaldehyde (ppm) IEC 61198	N/A
2 furfurol (ppm) IEC 61198	N/A
Estimated Degree of Polymerisation DP	798

Retest: 1 Year

Operational Status:

Transformer is operating satisfactorily.

Paper Condition:

The mechanical strength of the paper is indicated by the estimated degree of polymerisation (DP). New paper starts with a DP of 1000 or more, as the paper starts to age or is damaged by poor fluid management or operational events, so the DP reduces. A DP of 250 indicates end of life. The paper inside this transformer is in normal condition. No specific actions are advised.

Fluid Condition:

Acidity complies with IEC 60422.
The temperature of the oil was not provided so the moisture as not been corrected. Moisture appears to comply with IEC 60422.
Breakdown voltage is acceptable and complies with IEC 60422.

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Transformer Oil Diagnostics

Oil Diagnostics by EA Technology

Company: Company A
Date: 31/08/2016
Location: Location A
Substation: Sub A
Transformer ID: Tx27
Manufacturer: Brush 1976

Job Number: A0000
Sample Number: A00000127
Serial Number: S12371
Voltage (kV): 11
Rating (MVA): 1

RETEST 1 YEAR

Diagnostic Results

Test	Result
Hydrogen H2 (ppm) IEC 60567	0
Methane CH4 (ppm) IEC 60567	1
Ethane C2H6 (ppm) IEC 60567	0
Ethylene C2H4 (pm) IEC 60567	0
Acetylene C2H2 (ppm) IEC 60567	0
Carbon Monoxide Co (ppm) IEC 60567	11
Carbon Dioxide CO2 (ppm) IEC 60567	569
Nitrogen N2 (ppm) IEC 60567	77717
Oxygen O2 (ppm) IEC 60567	39012
Total (ppm)	117309
TDCG (ppm)	12
Viscosity (mm2/s)	N/A
Density (g/ml)	N/A
Particles 5 to 15 µm	N/A
Particles 15 to 25 µm	N/A
Particles 25 to 50 µm	N/A

Test	Result
Particles 50 to 100 µm	N/A
Particles >100 µm	N/A
Moisture (ppm) IEC 60814	16.6
Moisture @ 20C (ppm)	N/A
Diagnostic Breakdown Voltage (kV)	N/A
IEC Breakdown Voltage (kV) IEC 60156	46.3
Acid Number (mgKOH/g) IEC 62021	0.026
Interfacial tension (dynes /cm) ASTM D971	N/A
Power factor IEC 60247	N/A
Power factor IEC 60247	N/A
5 hydroxymethyl-2-furaldehyde (ppm) IEC 61198	N/A
2 furaldehyde (ppm) IEC 61198	0.16
2 acetylfuran (ppm) IEC 61198	N/A
5 methyl-2-furaldehyde (ppm) IEC 61198	N/A
2 furfurol (ppm) IEC 61198	N/A
Estimated Degree of Polymerisation DP	680

Retest: 1 Year

Operational Status:

Transformer is operating satisfactorily.

Paper Condition:

The mechanical strength of the paper is indicated by the estimated degree of polymerisation (DP). New paper starts with a DP of 1000 or more, as the paper starts to age or is damaged by poor fluid management or operational events, so the DP reduces. A DP of 250 indicates end of life. The paper inside this transformer is in normal condition. No specific actions are advised.

Fluid Condition:

Acidity complies with IEC 60422.
The temperature of the oil was not provided so the moisture as not been corrected. Moisture appears to comply with IEC 60422.
Breakdown voltage is acceptable and complies with IEC 60422.

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Transformer Oil Diagnostics

Oil Diagnostics by EA Technology

Company: Company A
Date: 30/08/2016
Location: Location A
Substation: Sub A
Transformer ID: Tx28
Manufacturer: Brush 1989

Job Number: A0000
Sample Number: A00000128
Serial Number: S12372
Voltage (kV): 11
Rating (MVA): 1

RETEST 1 YEAR

Diagnostic Results

Test	Result
Hydrogen H2 (ppm) IEC 60567	0
Methane CH4 (ppm) IEC 60567	1
Ethane C2H6 (ppm) IEC 60567	0
Ethylene C2H4 (pm) IEC 60567	0
Acetylene C2H2 (ppm) IEC 60567	0
Carbon Monoxide Co (ppm) IEC 60567	13
Carbon Dioxide CO2 (ppm) IEC 60567	567
Nitrogen N2 (ppm) IEC 60567	91032
Oxygen O2 (ppm) IEC 60567	42911
Total (ppm)	134525
TDCG (ppm)	15
Viscosity (mm2/s)	N/A
Density (g/ml)	N/A
Particles 5 to 15 µm	N/A
Particles 15 to 25 µm	N/A
Particles 25 to 50 µm	N/A

Test	Result
Particles 50 to 100 µm	N/A
Particles >100 µm	N/A
Moisture (ppm) IEC 60814	20.8
Moisture @ 20C (ppm)	N/A
Diagnostic Breakdown Voltage (kV)	N/A
IEC Breakdown Voltage (kV) IEC 60156	30.8
Acid Number (mgKOH/g) IEC 62021	0.006
Interfacial tension (dynes /cm) ASTM D971	N/A
Power factor IEC 60247	N/A
Power factor IEC 60247	N/A
5 hydroxymethyl-2-furaldehyde (ppm) IEC 61198	N/A
2 furaldehyde (ppm) IEC 61198	0.06
2 acetylfuran (ppm) IEC 61198	N/A
5 methyl-2-furaldehyde (ppm) IEC 61198	N/A
2 furfurol (ppm) IEC 61198	N/A
Estimated Degree of Polymerisation DP	798

Retest: 1 Year

Operational Status:

Transformer is operating satisfactorily.

Paper Condition:

The mechanical strength of the paper is indicated by the estimated degree of polymerisation (DP). New paper starts with a DP of 1000 or more, as the paper starts to age or is damaged by poor fluid management or operational events, so the DP reduces. A DP of 250 indicates end of life. The paper inside this transformer is in normal condition. No specific actions are advised.

Fluid Condition:

Acidity complies with IEC 60422.
The temperature of the oil was not provided so the moisture as not been corrected. Moisture appears to comply with IEC 60422.
Breakdown voltage is acceptable and complies with IEC 60422.

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Transformer Oil Diagnostics

Oil Diagnostics by EA Technology

Company: Company A
Date: 30/08/2016
Location: Location A
Substation: Sub A
Transformer ID: Tx29
Manufacturer: Brush 1990

Job Number: A0000
Sample Number: A00000129
Serial Number: S12373
Voltage (kV): 11
Rating (MVA): 1

RETEST 1 YEAR

Diagnostic Results

Test	Result
Hydrogen H2 (ppm) IEC 60567	0
Methane CH4 (ppm) IEC 60567	1
Ethane C2H6 (ppm) IEC 60567	0
Ethylene C2H4 (pm) IEC 60567	0
Acetylene C2H2 (ppm) IEC 60567	0
Carbon Monoxide Co (ppm) IEC 60567	4
Carbon Dioxide CO2 (ppm) IEC 60567	530
Nitrogen N2 (ppm) IEC 60567	64866
Oxygen O2 (ppm) IEC 60567	34958
Total (ppm)	100358
TDCG (ppm)	5
Viscosity (mm2/s)	N/A
Density (g/ml)	N/A
Particles 5 to 15 µm	N/A
Particles 15 to 25 µm	N/A
Particles 25 to 50 µm	N/A

Test	Result
Particles 50 to 100 µm	N/A
Particles >100 µm	N/A
Moisture (ppm) IEC 60814	14.3
Moisture @ 20C (ppm)	N/A
Diagnostic Breakdown Voltage (kV)	N/A
IEC Breakdown Voltage (kV) IEC 60156	44.0
Acid Number (mgKOH/g) IEC 62021	0.006
Interfacial tension (dynes /cm) ASTM D971	N/A
Power factor IEC 60247	N/A
Power factor IEC 60247	N/A
5 hydroxymethyl-2-furaldehyde (ppm) IEC 61198	N/A
2 furaldehyde (ppm) IEC 61198	0.04
2 acetylfuran (ppm) IEC 61198	N/A
5 methyl-2-furaldehyde (ppm) IEC 61198	N/A
2 furfurol (ppm) IEC 61198	N/A
Estimated Degree of Polymerisation DP	847

Retest: 1 Year

Operational Status:

Transformer is operating satisfactorily.

Paper Condition:

The mechanical strength of the paper is indicated by the estimated degree of polymerisation (DP). New paper starts with a DP of 1000 or more, as the paper starts to age or is damaged by poor fluid management or operational events, so the DP reduces. A DP of 250 indicates end of life. The paper inside this transformer is in normal condition. No specific actions are advised.

Fluid Condition:

Acidity complies with IEC 60422.
The temperature of the oil was not provided so the moisture as not been corrected. Moisture appears to comply with IEC 60422.
Breakdown voltage is acceptable and complies with IEC 60422.

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Transformer Oil Diagnostics

Oil Diagnostics by EA Technology

Company: Company A
Date: 30/08/2016
Location: Location A
Substation: Sub A
Transformer ID: Tx30
Manufacturer: EB Nitran 1990

Job Number: A0000
Sample Number: A00000130
Serial Number: S12374
Voltage (kV): 11
Rating (MVA): 1

RETEST 1 YEAR

Diagnostic Results

Test	Result
Hydrogen H2 (ppm) IEC 60567	0
Methane CH4 (ppm) IEC 60567	1
Ethane C2H6 (ppm) IEC 60567	0
Ethylene C2H4 (pm) IEC 60567	0
Acetylene C2H2 (ppm) IEC 60567	0
Carbon Monoxide Co (ppm) IEC 60567	35
Carbon Dioxide CO2 (ppm) IEC 60567	756
Nitrogen N2 (ppm) IEC 60567	82256
Oxygen O2 (ppm) IEC 60567	38260
Total (ppm)	121309
TDCG (ppm)	37
Viscosity (mm2/s)	N/A
Density (g/ml)	N/A
Particles 5 to 15 µm	N/A
Particles 15 to 25 µm	N/A
Particles 25 to 50 µm	N/A

Test	Result
Particles 50 to 100 µm	N/A
Particles >100 µm	N/A
Moisture (ppm) IEC 60814	18.1
Moisture @ 20C (ppm)	N/A
Diagnostic Breakdown Voltage (kV)	N/A
IEC Breakdown Voltage (kV) IEC 60156	35.1
Acid Number (mgKOH/g) IEC 62021	0.052
Interfacial tension (dynes /cm) ASTM D971	N/A
Power factor IEC 60247	N/A
Power factor IEC 60247	N/A
5 hydroxymethyl-2-furaldehyde (ppm) IEC 61198	N/A
2 furaldehyde (ppm) IEC 61198	0.01
2 acetylfuran (ppm) IEC 61198	N/A
5 methyl-2-furaldehyde (ppm) IEC 61198	N/A
2 furfurol (ppm) IEC 61198	N/A
Estimated Degree of Polymerisation DP	1015

Retest: 1 Year

Operational Status:

Transformer is operating satisfactorily.

Paper Condition:

The mechanical strength of the paper is indicated by the estimated degree of polymerisation (DP). New paper starts with a DP of 1000 or more, as the paper starts to age or is damaged by poor fluid management or operational events, so the DP reduces. A DP of 250 indicates end of life. The paper inside this transformer is in normal condition. No specific actions are advised.

Fluid Condition:

Acidity complies with IEC 60422.
The temperature of the oil was not provided so the moisture as not been corrected. Moisture appears to comply with IEC 60422.
Breakdown voltage is acceptable and complies with IEC 60422.

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Transformer Oil Diagnostics

Oil Diagnostics by EA Technology

Company: Company A
Date: 30/08/2016
Location: Location A
Substation: Sub A
Transformer ID: Tx31
Manufacturer: EB Nitran 1990

Job Number: A0000
Sample Number: A00000131
Serial Number: S12375
Voltage (kV): 11
Rating (MVA): 1.5

RETEST 1 YEAR

Diagnostic Results

Test	Result
Hydrogen H2 (ppm) IEC 60567	18
Methane CH4 (ppm) IEC 60567	1
Ethane C2H6 (ppm) IEC 60567	1
Ethylene C2H4 (pm) IEC 60567	1
Acetylene C2H2 (ppm) IEC 60567	0
Carbon Monoxide Co (ppm) IEC 60567	35
Carbon Dioxide CO2 (ppm) IEC 60567	926
Nitrogen N2 (ppm) IEC 60567	63225
Oxygen O2 (ppm) IEC 60567	33080
Total (ppm)	97288
TDCG (ppm)	57
Viscosity (mm2/s)	N/A
Density (g/ml)	N/A
Particles 5 to 15 µm	N/A
Particles 15 to 25 µm	N/A
Particles 25 to 50 µm	N/A

Test	Result
Particles 50 to 100 µm	N/A
Particles >100 µm	N/A
Moisture (ppm) IEC 60814	16.8
Moisture @ 20C (ppm)	N/A
Diagnostic Breakdown Voltage (kV)	N/A
IEC Breakdown Voltage (kV) IEC 60156	58.7
Acid Number (mgKOH/g) IEC 62021	0.045
Interfacial tension (dynes /cm) ASTM D971	N/A
Power factor IEC 60247	N/A
Power factor IEC 60247	N/A
5 hydroxymethyl-2-furaldehyde (ppm) IEC 61198	N/A
2 furaldehyde (ppm) IEC 61198	0.35
2 acetylfuran (ppm) IEC 61198	N/A
5 methyl-2-furaldehyde (ppm) IEC 61198	N/A
2 furfurol (ppm) IEC 61198	N/A
Estimated Degree of Polymerisation DP	585

Retest: 1 Year

Operational Status:

Transformer is operating satisfactorily.

Paper Condition:

The mechanical strength of the paper is indicated by the estimated degree of polymerisation (DP). New paper starts with a DP of 1000 or more, as the paper starts to age or is damaged by poor fluid management or operational events, so the DP reduces. A DP of 250 indicates end of life. The paper inside this transformer is in normal condition. No specific actions are advised.

Fluid Condition:

Acidity complies with IEC 60422.
The temperature of the oil was not provided so the moisture as not been corrected. Moisture appears to comply with IEC 60422.
Breakdown voltage is acceptable and complies with IEC 60422.

Approved By:

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Transformer Oil Diagnostics

Oil Diagnostics by EA Technology

Company: Company A
Date: 30/08/2016
Location: Location A
Substation: Sub A
Transformer ID: Tx32
Manufacturer: EB Nitran 1990

Job Number: A0000
Sample Number: A00000132
Serial Number: S12376
Voltage (kV): 11
Rating (MVA): 1.5

RETEST 1 YEAR

Diagnostic Results

Test	Result
Hydrogen H2 (ppm) IEC 60567	20
Methane CH4 (ppm) IEC 60567	2
Ethane C2H6 (ppm) IEC 60567	2
Ethylene C2H4 (pm) IEC 60567	2
Acetylene C2H2 (ppm) IEC 60567	0
Carbon Monoxide Co (ppm) IEC 60567	43
Carbon Dioxide CO2 (ppm) IEC 60567	1114
Nitrogen N2 (ppm) IEC 60567	100264
Oxygen O2 (ppm) IEC 60567	45736
Total (ppm)	147181
TDCG (ppm)	68
Viscosity (mm2/s)	N/A
Density (g/ml)	N/A
Particles 5 to 15 µm	N/A
Particles 15 to 25 µm	N/A
Particles 25 to 50 µm	N/A

Test	Result
Particles 50 to 100 µm	N/A
Particles >100 µm	N/A
Moisture (ppm) IEC 60814	11.7
Moisture @ 20C (ppm)	N/A
Diagnostic Breakdown Voltage (kV)	N/A
IEC Breakdown Voltage (kV) IEC 60156	53.6
Acid Number (mgKOH/g) IEC 62021	0.039
Interfacial tension (dynes /cm) ASTM D971	N/A
Power factor IEC 60247	N/A
Power factor IEC 60247	N/A
5 hydroxymethyl-2-furaldehyde (ppm) IEC 61198	N/A
2 furaldehyde (ppm) IEC 61198	0.23
2 acetylfuran (ppm) IEC 61198	N/A
5 methyl-2-furaldehyde (ppm) IEC 61198	N/A
2 furfurol (ppm) IEC 61198	N/A
Estimated Degree of Polymerisation DP	636

Retest: 1 Year

Operational Status:

Transformer is operating satisfactorily.

Paper Condition:

The mechanical strength of the paper is indicated by the estimated degree of polymerisation (DP). New paper starts with a DP of 1000 or more, as the paper starts to age or is damaged by poor fluid management or operational events, so the DP reduces. A DP of 250 indicates end of life. The paper inside this transformer is in normal condition. No specific actions are advised.

Fluid Condition:

Acidity complies with IEC 60422.
The temperature of the oil was not provided so the moisture as not been corrected. Moisture appears to comply with IEC 60422.
Breakdown voltage is acceptable and complies with IEC 60422.

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Transformer Oil Diagnostics

Oil Diagnostics by EA Technology

Company: Company A
Date: 31/08/2016
Location: Location A
Substation: Sub A
Transformer ID: Tx33
Manufacturer: EB Nitran 1991

Job Number: A0000
Sample Number: A00000133
Serial Number: S12377
Voltage (kV): 11
Rating (MVA): 1

RETEST 1 YEAR

Diagnostic Results

Test	Result
Hydrogen H2 (ppm) IEC 60567	0
Methane CH4 (ppm) IEC 60567	1
Ethane C2H6 (ppm) IEC 60567	1
Ethylene C2H4 (pm) IEC 60567	0
Acetylene C2H2 (ppm) IEC 60567	0
Carbon Monoxide Co (ppm) IEC 60567	18
Carbon Dioxide CO2 (ppm) IEC 60567	583
Nitrogen N2 (ppm) IEC 60567	82878
Oxygen O2 (ppm) IEC 60567	38089
Total (ppm)	121571
TDCG (ppm)	21
Viscosity (mm2/s)	N/A
Density (g/ml)	N/A
Particles 5 to 15 µm	N/A
Particles 15 to 25 µm	N/A
Particles 25 to 50 µm	N/A

Test	Result
Particles 50 to 100 µm	N/A
Particles >100 µm	N/A
Moisture (ppm) IEC 60814	10.9
Moisture @ 20C (ppm)	N/A
Diagnostic Breakdown Voltage (kV)	N/A
IEC Breakdown Voltage (kV) IEC 60156	60.0
Acid Number (mgKOH/g) IEC 62021	0.025
Interfacial tension (dynes /cm) ASTM D971	N/A
Power factor IEC 60247	N/A
Power factor IEC 60247	N/A
5 hydroxymethyl-2-furaldehyde (ppm) IEC 61198	N/A
2 furaldehyde (ppm) IEC 61198	0.03
2 acetylfuran (ppm) IEC 61198	N/A
5 methyl-2-furaldehyde (ppm) IEC 61198	N/A
2 furfurol (ppm) IEC 61198	N/A
Estimated Degree of Polymerisation DP	882

Retest: 1 Year

Operational Status:

Transformer is operating satisfactorily.

Paper Condition:

The mechanical strength of the paper is indicated by the estimated degree of polymerisation (DP). New paper starts with a DP of 1000 or more, as the paper starts to age or is damaged by poor fluid management or operational events, so the DP reduces. A DP of 250 indicates end of life. The paper inside this transformer is in normal condition. No specific actions are advised.

Fluid Condition:

Acidity complies with IEC 60422.
The temperature of the oil was not provided so the moisture as not been corrected. Moisture appears to comply with IEC 60422.
Breakdown voltage is acceptable and complies with IEC 60422.

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Transformer Oil Diagnostics

Oil Diagnostics by EA Technology

Company: Company A
Date: 30/08/2016
Location: Location A
Substation: Sub A
Transformer ID: Tx34
Manufacturer: Merlin Gerin 1997

Job Number: A0000
Sample Number: A00000134
Serial Number: S12378
Voltage (kV): 11
Rating (MVA): 1.5

RETEST 1 YEAR

Diagnostic Results

Test	Result
Hydrogen H2 (ppm) IEC 60567	0
Methane CH4 (ppm) IEC 60567	1
Ethane C2H6 (ppm) IEC 60567	0
Ethylene C2H4 (pm) IEC 60567	0
Acetylene C2H2 (ppm) IEC 60567	0
Carbon Monoxide Co (ppm) IEC 60567	13
Carbon Dioxide CO2 (ppm) IEC 60567	595
Nitrogen N2 (ppm) IEC 60567	82047
Oxygen O2 (ppm) IEC 60567	44167
Total (ppm)	126822
TDCG (ppm)	14
Viscosity (mm2/s)	N/A
Density (g/ml)	N/A
Particles 5 to 15 µm	N/A
Particles 15 to 25 µm	N/A
Particles 25 to 50 µm	N/A

Test	Result
Particles 50 to 100 µm	N/A
Particles >100 µm	N/A
Moisture (ppm) IEC 60814	10.6
Moisture @ 20C (ppm)	N/A
Diagnostic Breakdown Voltage (kV)	N/A
IEC Breakdown Voltage (kV) IEC 60156	66.6
Acid Number (mgKOH/g) IEC 62021	0.003
Interfacial tension (dynes /cm) ASTM D971	N/A
Power factor IEC 60247	N/A
Power factor IEC 60247	N/A
5 hydroxymethyl-2-furaldehyde (ppm) IEC 61198	N/A
2 furaldehyde (ppm) IEC 61198	0.12
2 acetylfuran (ppm) IEC 61198	N/A
5 methyl-2-furaldehyde (ppm) IEC 61198	N/A
2 furfurol (ppm) IEC 61198	N/A
Estimated Degree of Polymerisation DP	715

Retest: 1 Year

Operational Status:

Transformer is operating satisfactorily.

Paper Condition:

The mechanical strength of the paper is indicated by the estimated degree of polymerisation (DP). New paper starts with a DP of 1000 or more, as the paper starts to age or is damaged by poor fluid management or operational events, so the DP reduces. A DP of 250 indicates end of life. The paper inside this transformer is in normal condition. No specific actions are advised.

Fluid Condition:

Acidity complies with IEC 60422.
The temperature of the oil was not provided so the moisture as not been corrected. Moisture appears to comply with IEC 60422.
Breakdown voltage is acceptable and complies with IEC 60422.

Approved By:

EA Technology

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Capenhurst, Chester, CH1 6ES, United Kingdom

Transformer Oil Diagnostics

Oil Diagnostics by EA Technology

Company: Company A
Date: 30/08/2016
Location: Location A
Substation: Sub A
Transformer ID: Tx35
Manufacturer: Merlin Gerin 1997

Job Number: A0000
Sample Number: A00000135
Serial Number: S12379
Voltage (kV): 11
Rating (MVA): 1.5

RETEST 1 YEAR

Diagnostic Results

Test	Result
Hydrogen H2 (ppm) IEC 60567	0
Methane CH4 (ppm) IEC 60567	1
Ethane C2H6 (ppm) IEC 60567	0
Ethylene C2H4 (pm) IEC 60567	0
Acetylene C2H2 (ppm) IEC 60567	0
Carbon Monoxide Co (ppm) IEC 60567	9
Carbon Dioxide CO2 (ppm) IEC 60567	581
Nitrogen N2 (ppm) IEC 60567	73978
Oxygen O2 (ppm) IEC 60567	40263
Total (ppm)	114833
TDCG (ppm)	11
Viscosity (mm2/s)	N/A
Density (g/ml)	N/A
Particles 5 to 15 µm	N/A
Particles 15 to 25 µm	N/A
Particles 25 to 50 µm	N/A

Test	Result
Particles 50 to 100 µm	N/A
Particles >100 µm	N/A
Moisture (ppm) IEC 60814	10.8
Moisture @ 20C (ppm)	N/A
Diagnostic Breakdown Voltage (kV)	N/A
IEC Breakdown Voltage (kV) IEC 60156	30.9
Acid Number (mgKOH/g) IEC 62021	0.001
Interfacial tension (dynes /cm) ASTM D971	N/A
Power factor IEC 60247	N/A
Power factor IEC 60247	N/A
5 hydroxymethyl-2-furaldehyde (ppm) IEC 61198	N/A
2 furaldehyde (ppm) IEC 61198	0.07
2 acetylfuran (ppm) IEC 61198	N/A
5 methyl-2-furaldehyde (ppm) IEC 61198	N/A
2 furfurol (ppm) IEC 61198	N/A
Estimated Degree of Polymerisation DP	780

Retest: 1 Year

Operational Status:

Transformer is operating satisfactorily.

Paper Condition:

The mechanical strength of the paper is indicated by the estimated degree of polymerisation (DP). New paper starts with a DP of 1000 or more, as the paper starts to age or is damaged by poor fluid management or operational events, so the DP reduces. A DP of 250 indicates end of life. The paper inside this transformer is in normal condition. No specific actions are advised.

Fluid Condition:

Acidity complies with IEC 60422.
The temperature of the oil was not provided so the moisture as not been corrected. Moisture appears to comply with IEC 60422.
Breakdown voltage is acceptable and complies with IEC 60422.

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- Understand why assets fail
- Optimise network operations
- Make smarter investment decisions
- Build smarter grids
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- Develop their power skills

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