

Towards Operational Excellence: Introducing Transformer Oil Analysis and Regeneration in Kuwait Oil Company

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A Subsidiary of Kuwait Petroleum Corporation

Agenda

- Introduction
- Dissolved Gas Analysis
- Total Acid Number and Moisture Analysis
- Transformer Oil Regeneration Vs. Oil Replacement
- Conclusion

Introduction

- West Kuwait (WK) asset area has over **400** transformers in the field and facilities
- Survey was conducted on WK transformers to assess oil condition with below findings:
 - Volume > 500,000 L @ 0.840 KD/L of new oil required
 - Volume required over 3 year period
 - approximate cost **420,000 KD**
 - Disposal cost of approximately **125,000KD**
 - Total cost of activity > **500,000KD**

Introduction

- Transformers were operated on *run to failure* Maintenance approach
- Transformer Oil testing was limited to Break Down voltage (BDV) only
- No Predictive/Preventive/ Condition Monitoring Maintenance tests were performed
 - Decision to replace the oil was taken based on BDV only
 - Oil Replacement required minimum 6hr shutdown
 - Shutdown =
 - **Production losses**
 - **Risk of lower production rate after ESP start up**
 - **Risk of ESP failure after start up**

Dissolved Gas Analysis (DGA)

- DGA is an important Predictive/Condition monitoring tool for the transformer
- DGA can identify :
 - Deteriorating insulation and oil
 - Overheating
 - Hot Spots
 - Partial Discharges
 - Arcing

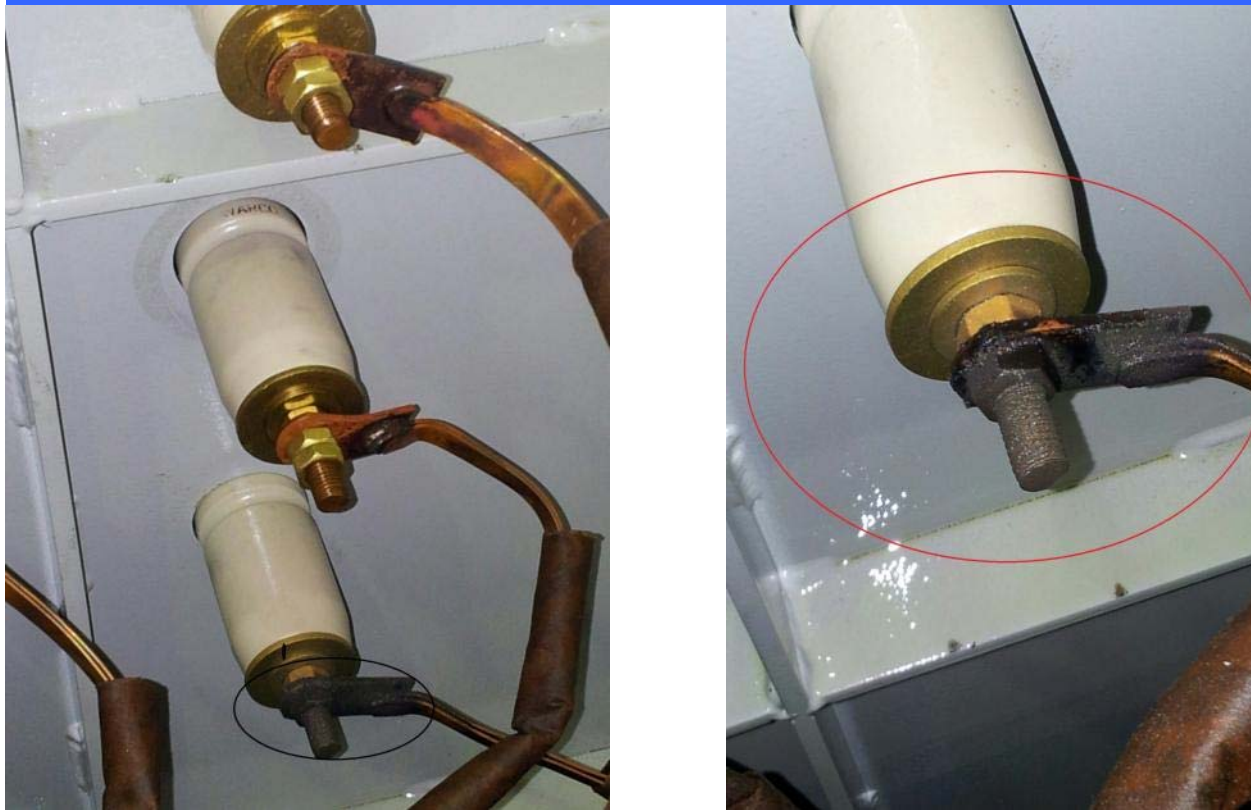
Dissolved Gas Analysis (DGA)

– UG 34

H₂(ppm)	CH₄	C₂H₂	C₂H₄	C₂H₆	CO	CO₂	TDCG	H₂O
L1 (100)	L1(120)	L1(35)	L1(280)	L1(90)	L1(350)	L1(2500)	L1(720)	
1263	5978	0	5201	1537	805	14411	14783	11

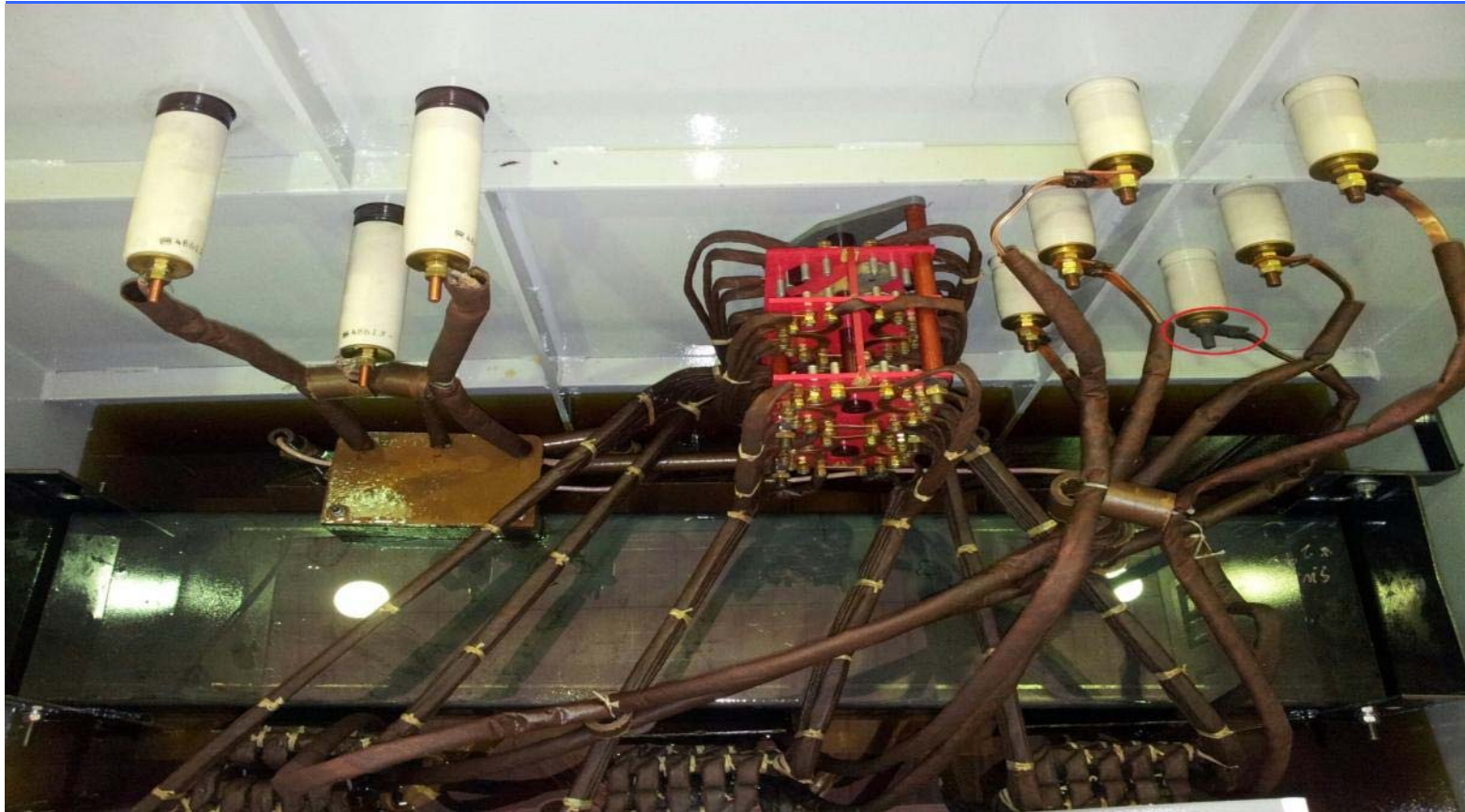
- Each of the above gases is formed at a different temperature
- Analysis derived from above results using IEC 60599 is :
 - Thermal fault of temperature between 300° C and 700° C
 - Over heated insulation and oil
- Maintenance Support & Reliability recommended an internal inspection of the Transformer

Dissolved Gas Analysis (DGA)



Loose connection and sparking evidence

Dissolved Gas Analysis (DGA)



Brownish paper evidence of over heating

Total Acid Number (TAN) and Moisture Analysis

- TAN and Moisture analysis are predictive/ condition monitoring tools
- TAN measures the total acid in the oil
 - Acid in oil
 - Attacks the tank and all metal parts in the transformer
 - Acid is indication of sludge accumulation in the tank which effects Transformer performance and cooling
 - TAN is measured through KOC Water Handling Team West Kuwait labs

Total Acid Number (TAN) and Moisture Analysis

- Moisture analysis is vital to transformer life
- Life of the transformer is the life of the insulation
- Failures due to moisture are the most common in the world
 - Transformer insulation is made of paper
 - Transformer core is constructed using wood
- Moisture limits are set by both IEC and IEEE standards
- MS&R WK measures the moisture through the use of DGA results and IEEE 62-1995
 - Myers Multiplier method

Transformer Oil Regeneration Vs. Oil Replacement

- Transformer oil regeneration consists of three functions :
 1. Degassing
 2. Moisture removal
 3. Solid contaminates and acid removal
- During regular oil replacement activity the following occurs :
 1. Dissolved gasses and moisture in the oil will migrate to insulation as TR cools down
 2. Sludge and particles cleaning will depend on flushing time and pressure
 3. New oil is required for flushing

Transformer Oil Regeneration Vs. Oil Replacement

- Below table shows a comparison between oil replacement and regeneration for UG 10 800KVA Transformer (1450 L)

Description	Oil Replacement	Oil Regeneration
Cost of New Oil	1462KD	0KD
Hazardous waste disposal Cost	1740 L (435KD)	40L(10KD)
Transformer down time	Min 6Hrs	0Hrs
Moisture removal	60-80%	90-100%
Sludge, Gas, Acid & particle removal	70-80%	90-100%

Transformer Oil Regeneration Vs. Oil Replacement

- Transformer Oil Regeneration started in September 2013
- Savings achieved from the use of Transformer oil regeneration as end of Q2 2014:
 - New oil cost & Disposal cost saving of 30,000 KD
 - Time savings of min of 6Hrs on each location (online operation)
 - Production loss of 40,000 BBLS saved by online operation

Transformer Oil Regeneration Vs. Oil Replacement

- Online Transformer oil regeneration has helped in :
 - Elimination of risk of ESP failure during re-start
 - Completely removed Moisture , gases, and sludge
 - Integrity of the transformer preserved
 - Reliability of the transformer increased

Transformer Oil Regeneration Vs. Oil Replacement

Test	UG 10 800KVA TR old Oil	UG10 800KVA TR Regenerated Oil	New Oil
BDV	35 KV	50KV	45KV
Moisture in insulation	1.92%	.657 %	-
Total Acid Number (mg KOH/g)	0.27	< 0.05	<0.05
Color	Brown	Clear	Clear

Transformer Oil Regeneration Vs. Oil Replacement



Transformer Oil Regeneration Vs. Oil Replacement



Operator Room

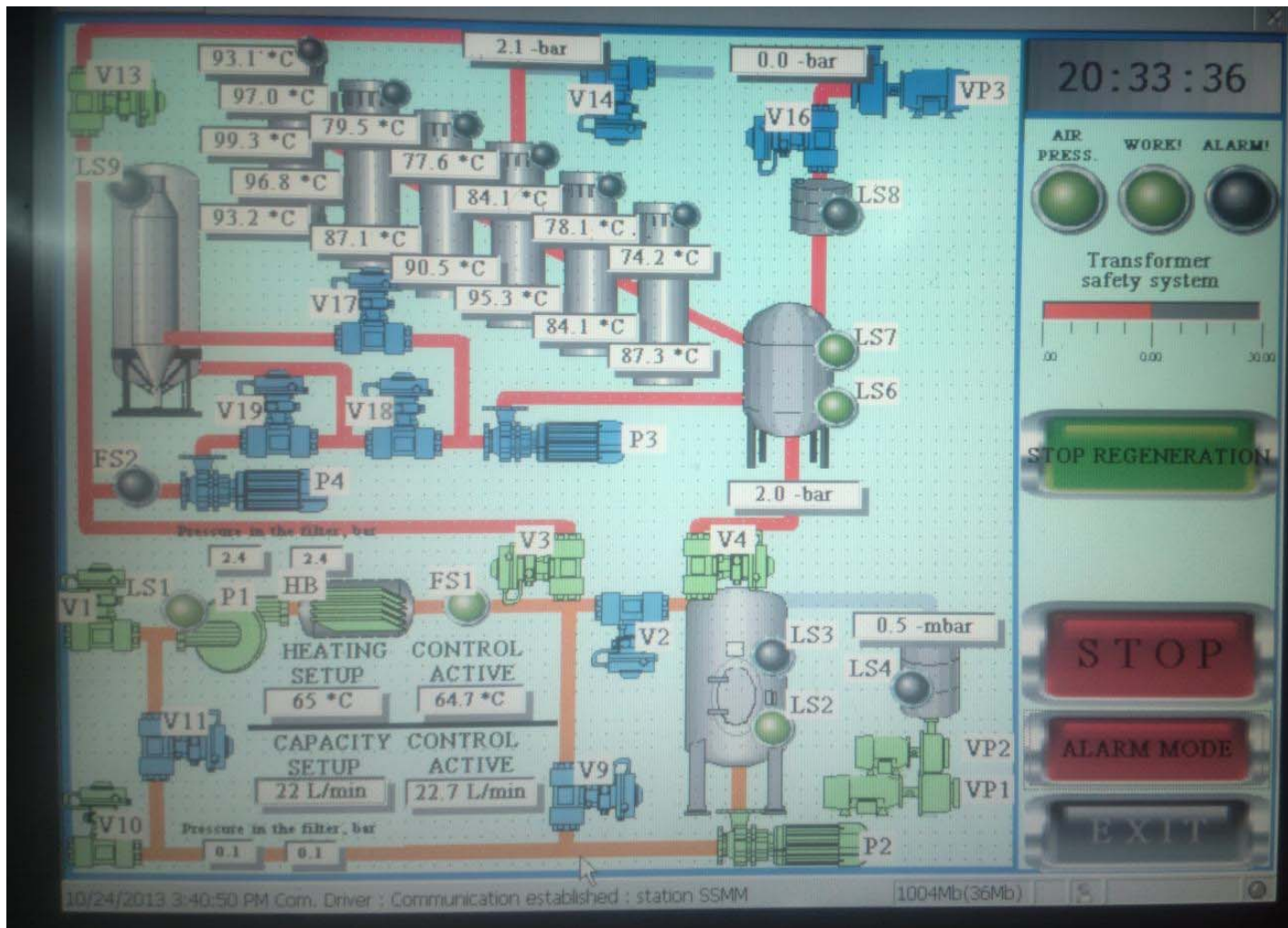
De-gassing Compartment

Buffer Tanks to maintain TR oil level

Trailer mounted for mobility

Regeneration columns (Fuller Earth)

Transformer Oil Regeneration Vs. Oil Replacement



Machine control panel

Transformer Oil Regeneration Vs. Oil Replacement



Conclusion

- Transformer oil analysis has proved its ability to predict failures
- Transformer oil analysis helps in predicting faults during online operation
 - Useful in non-redundant systems
- Online oil regeneration eliminates the cost for new oil
- Regeneration reduces maintenance costs in terms of
 - Production losses in non redundant systems
 - Hazardous waste disposal costs

Thank You

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