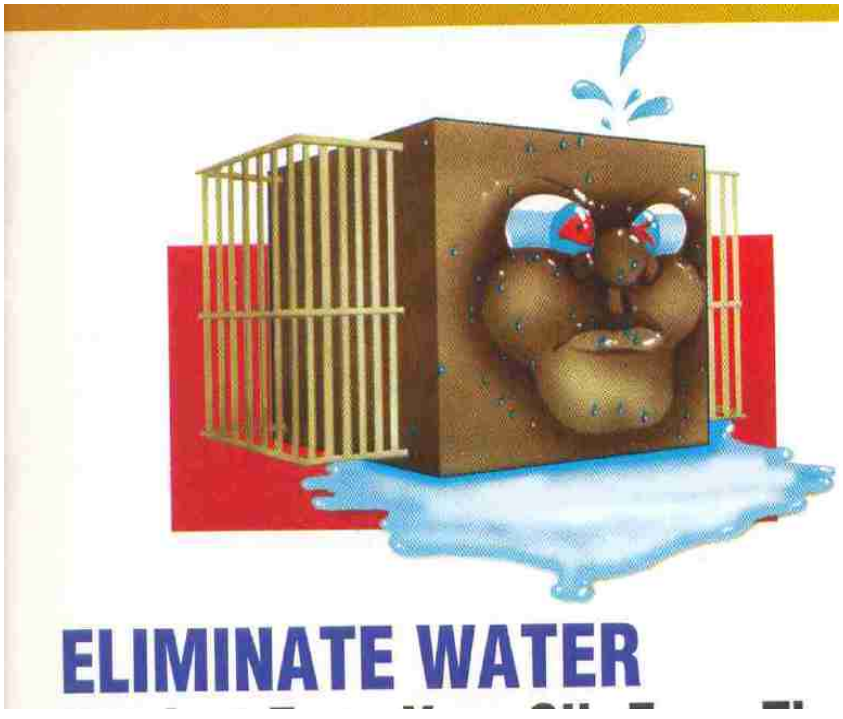
The Life of the Transformer is the life of its insulation system

The Process of Insulation Degradation



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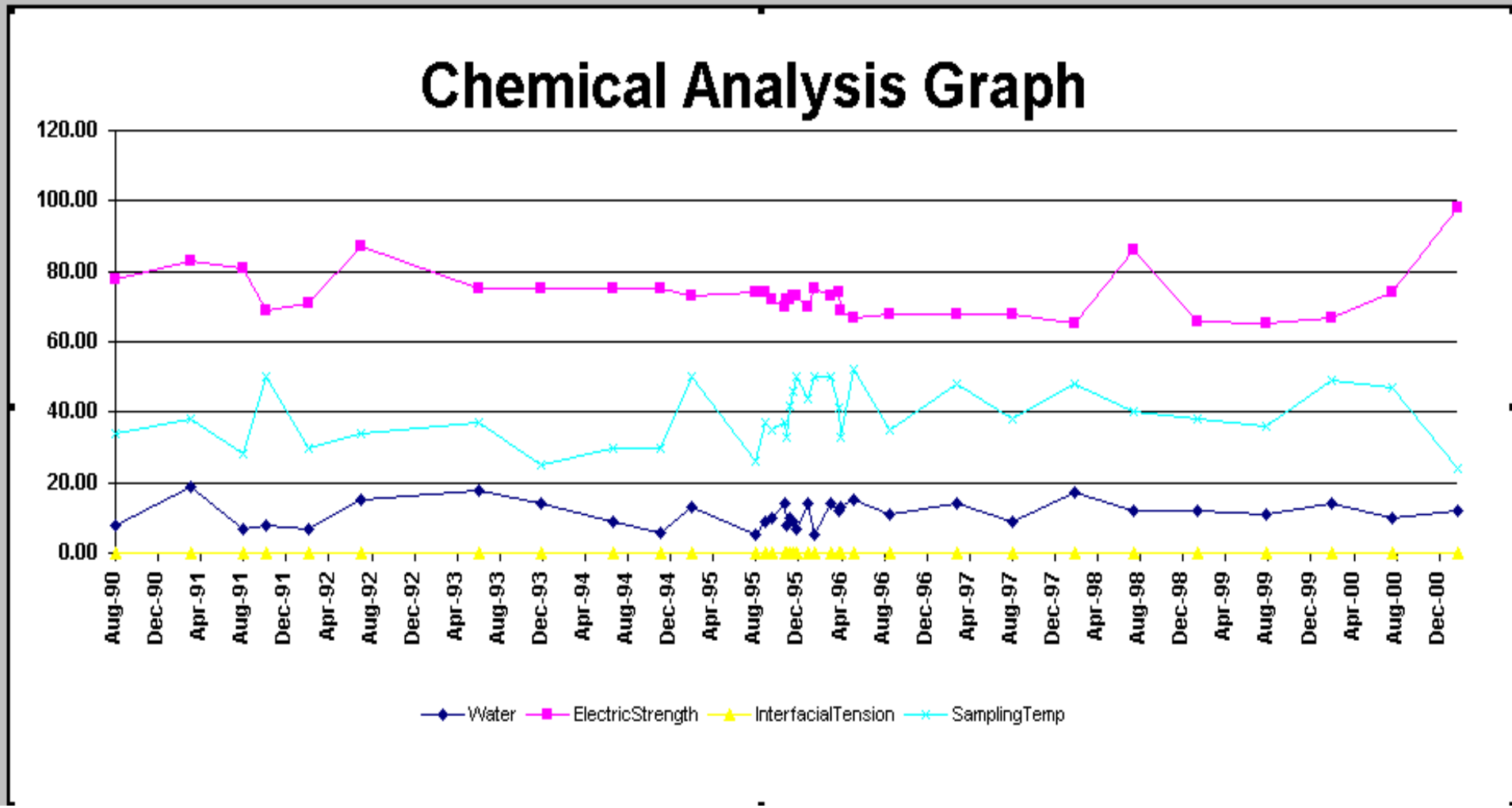
TRANSFORMER OIL/PAPER EQUILIBRUIM

Open Client | Transformer Listing | Report Manager | Transformer Details | Data Capture | Cost Benefit Analysis | Analysis Report | Oil Test Report

Client Name: DRAKENSBURG PEAKE/GE
Substation: POWER STATION
SerialNumber: 27497
Transformer: GENERATOR 2

Close Graph



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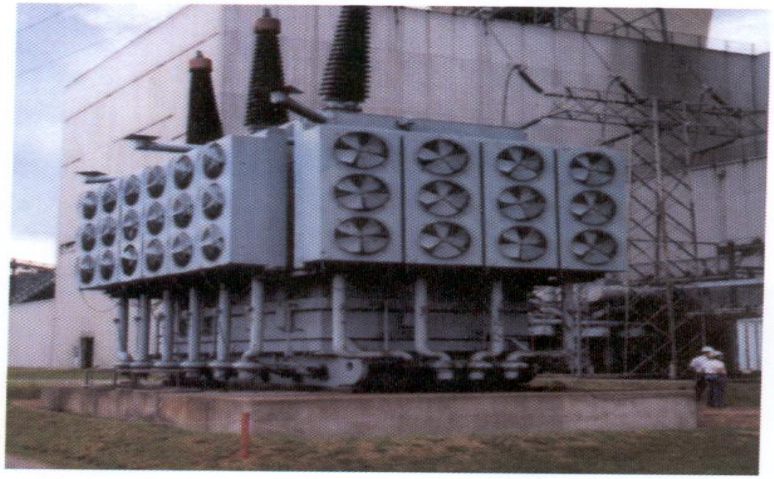
What Keeps Your Transformers Operating?

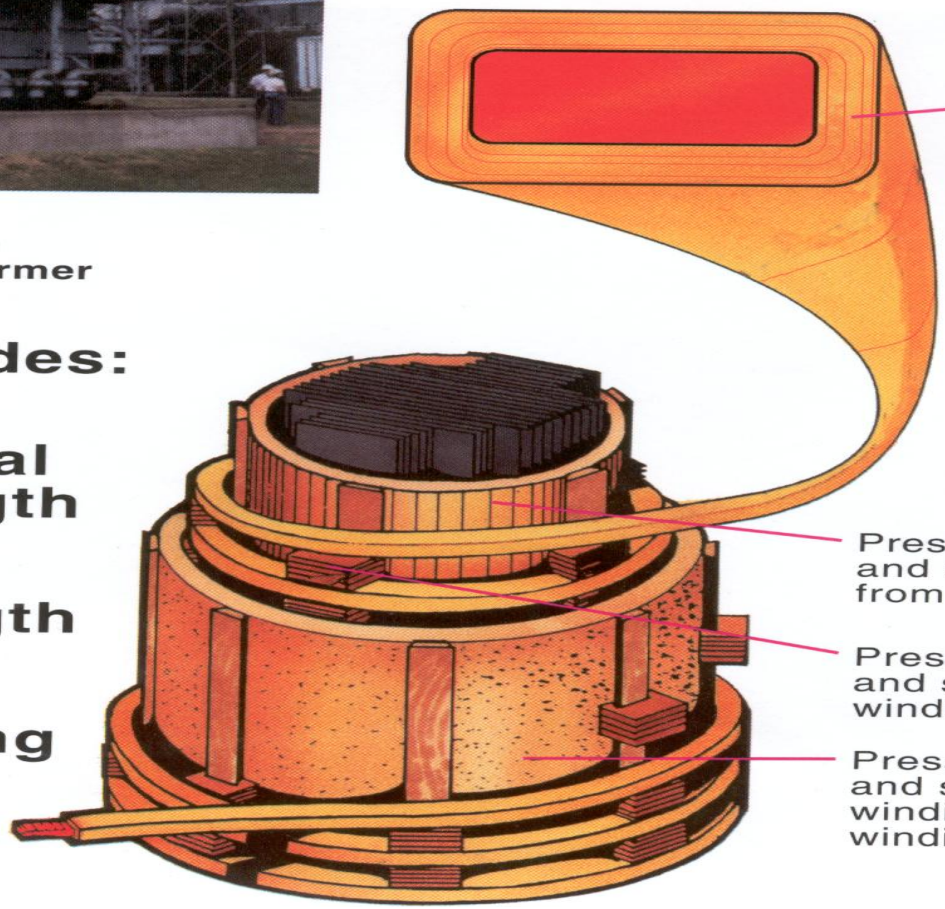
Paper!



Paper provides the mechanical strength holding this Transformer together!

Paper Provides:

- Mechanical Strength
- Dielectric Strength
- Dielectric Spacing



Conductors of a transformer are typically wrapped in Kraft paper.

Press board cylinders support and separate the windings from the core.

Press board spacers support and separate each turn in the winding.

Press board cylinders support and separate the high voltage winding from the low voltage winding.

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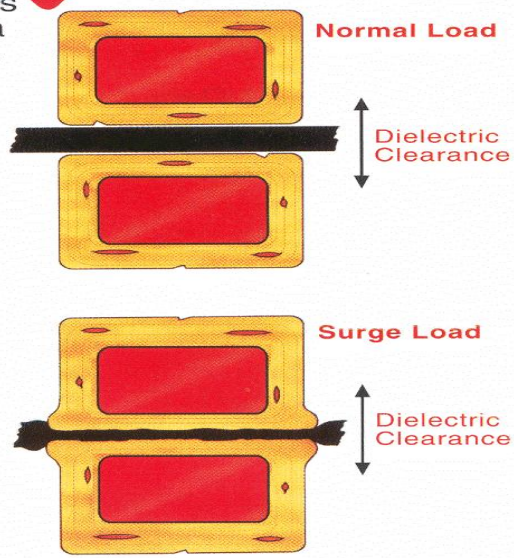
So what if my transformer is held together by paper? It can't be under any stress since a transformer has no moving parts, right?

Wrong !

Other than in load tap changers and regulating transformers, a transformer has no functional, mechanical moving parts...

...but it does move! How?

- **mechanical vibration**
- **switching surges**
- **line surges**
- **limited short circuts**



This is the type of stress your windings undergo.

The paper wrapping and spacers withstand this movement when your transformer is new.

As your transformer ages it loses this ability.

IEEE defines your transformer's end of life = 75% loss in paper tensile strength - beyond this point your transformer may not reliably withstand the next surge load or short circuit.

This transformer failed *(and so did its owner).*

But, how does your transformer's paper insulation lose tensile strength?

Good question! Read on...

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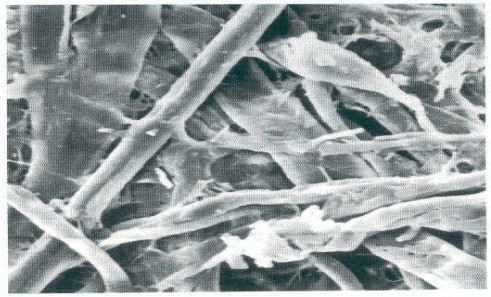
2 Your transformer's paper insulation acts just like the paper in your car's oil filter- it filters these decay products out of the oil and holds them, DESTROYING YOUR TRANSFORMER'S PAPER INSULATION!



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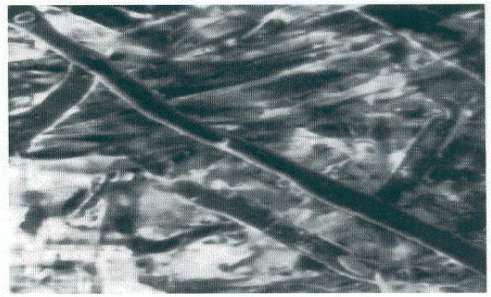

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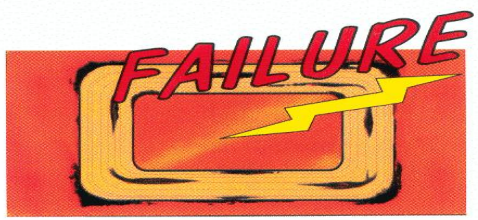
Electron Scanning Micrograph of Kraft Pressboard Spacer at 250x.

3 If allowed to continue unchecked, oil decay products will form sludge deposits in your transformer. This is really awful!



This sludge will:

Trap Heat inside your transformer by coating surfaces, clogging oil passageways between windings and paths for oil flow.

Accelerate Destruction of the paper insulation.

Eventually bridge the dielectric gap at some point and **cause flashover and failure.**

How do I prevent this catastrophe?

I'm glad you asked that question.

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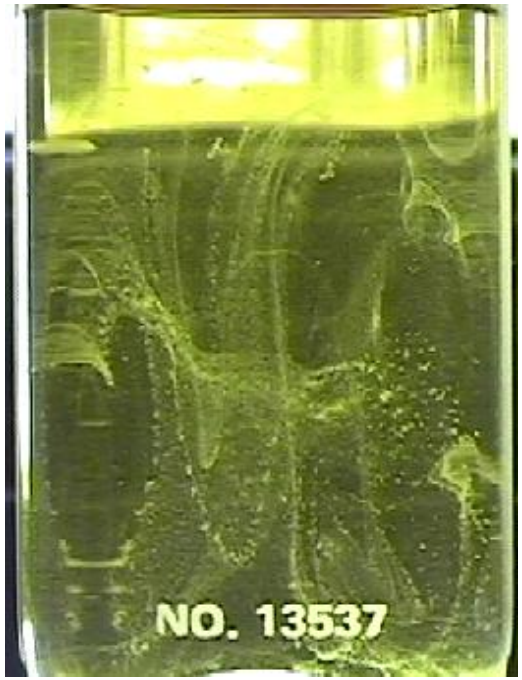
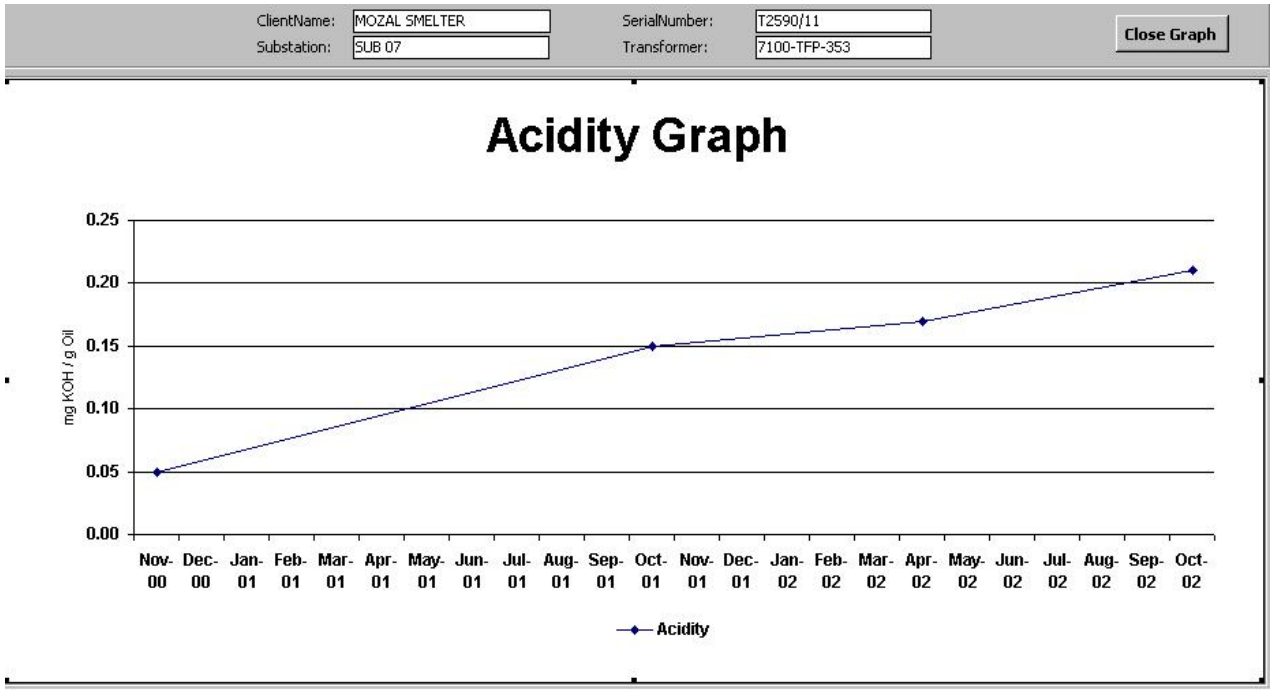
Mozal Smelter

Substation	Transformer	SerialNumber	SamplingDate	Water	kV	Acidity
SUB 07	7100-TFP-353	T2590/11	17-10-2002	21	48	**0.21**





The oxidation stability, also known as the life test of an oil, will give an indication of the oil's ability to withstand ageing in the form of oxidation and will give an indication of the life expectancy of an oil"

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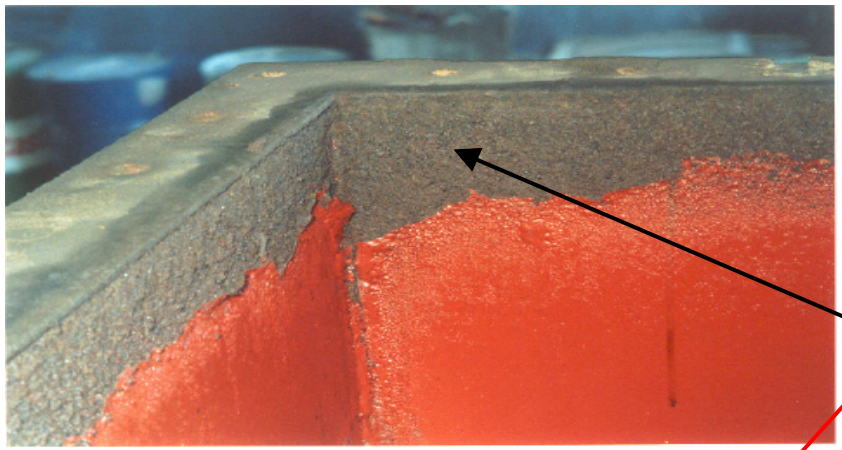
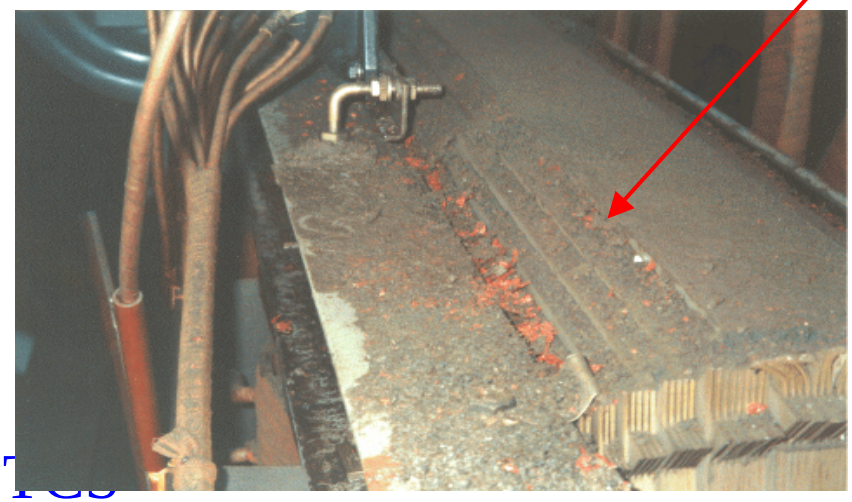
Sappi Fine: Paper Mill

Transformer Insulating Condition			
Water Content:	67	Density @ 20C:	0.000
Dielectric Strength:	16	Kinematic Viscosity @ 40C:	0.00
Acidity:	0.32	Flash Point:	0
Interfacial Tension:	0.0	Pour Point:	0
Oil Quality Index:	0	Resistivity @ 90C:	0
Oil Colour:		Corrisive Sulphur:	
Dissipation Factor @ 90C:	0.000	P.C.B at CL:	
Transformer Oil Temp:	50	Water in paper: % Dry	3.29
Total P.C.B:	0	Water in paper: Total	6.99





Rating: 1250 KVA: Voltage11kV/546v
Oil Volume: 1305 Liters: Non Conservator

Analysis/Diagnosis: Insulating oil failed tests indicating a sludging condition
Note: This level of acidity can induce corrosion

Recommended: Removal from service for oil replacement/purification with internal flushing
Note: This unit had in the past under gone Power-On purification to remove water

Findings: Internal corrosion/sludge caused by excess water and Acidity
Note: A common problem with Non Conservator Type Transformers

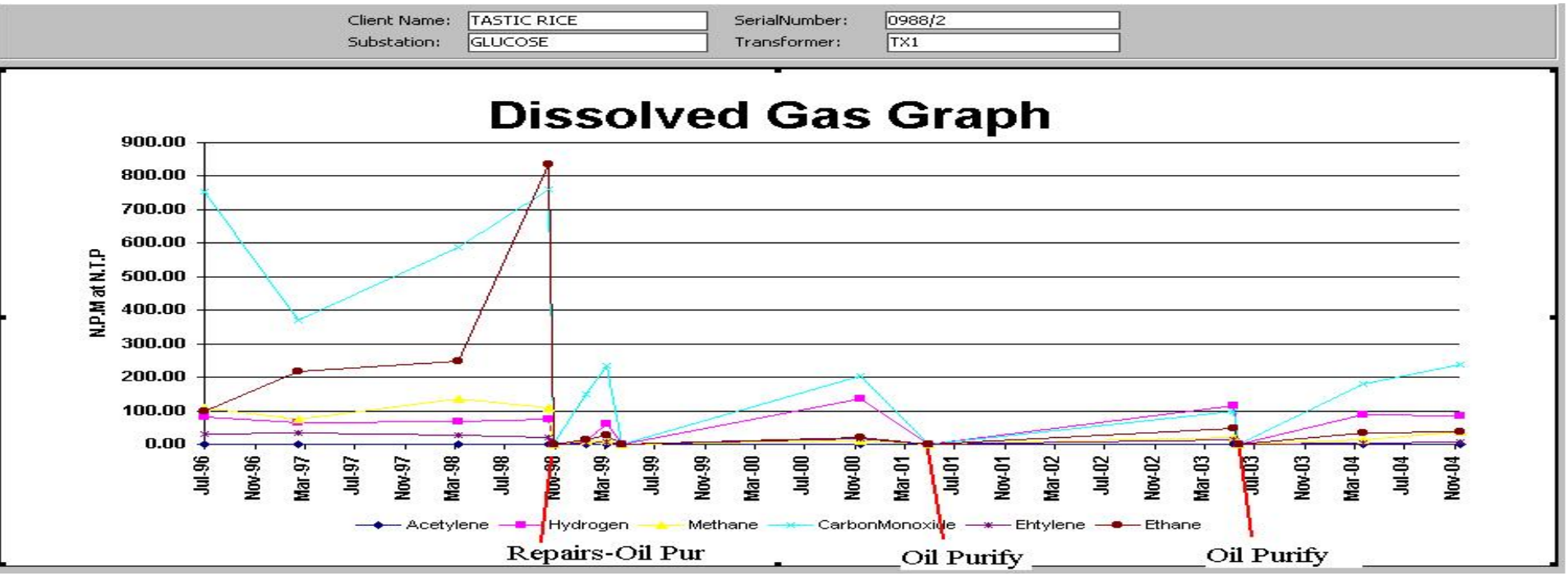
Savings: The unit was properly repaired at a works facility
Note: In service failure could have resulted in significant production losses

Transformer Failure caused by contaminated insulating oil

Introduction.

The unit was removed from service recommended a full internal inspection to identify a possible thermal fault of low temperature

BACKGROUND/HISTORY



The Dissolved Gas from this point indicates normal internal operation i.e. there has been no significant production of Fault Gases.

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The transformer circuit breaker tripped 2-3 minutes after Re-energising on load

The mechanism of failure is as follows.

The primary fault was a flash over on the center phase of the Off Load Tap Changer Mechanism

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This process of maintenance resulted in contamination of the insulating oil by water and particulate matter. This combination of water and particulate matter lowers the dielectric strength (kV) of the insulating oil unto 90%

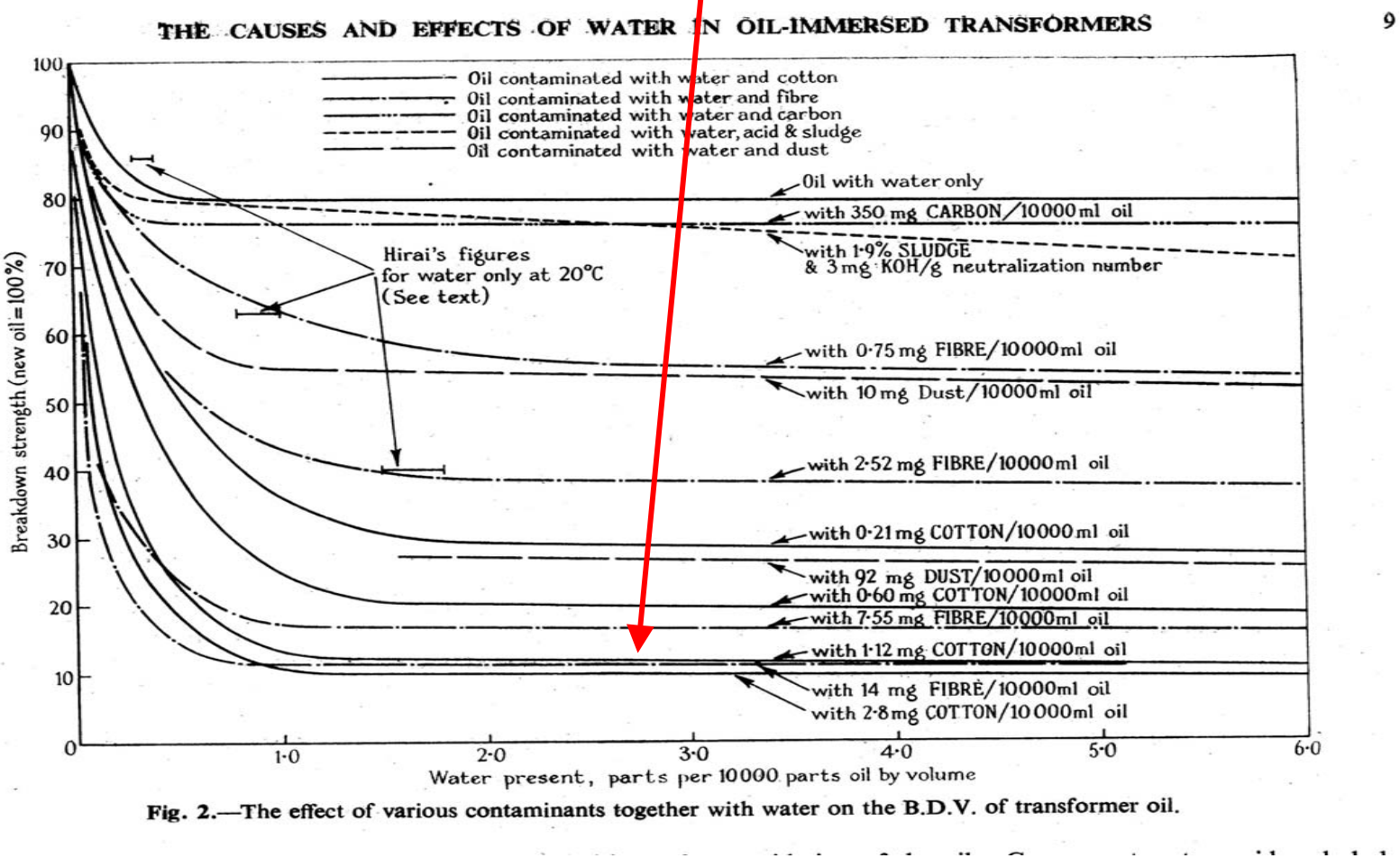

Fig. 2.—The effect of various contaminants together with water on the B.D.V. of transformer oil.

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IEC 422 Section 12.1 Replacement of oil transformers rated below 72.5 kV and in switchgear and associated equipment ”There should be as little aeration as possible during the filling of tanks and, as far as possible the end pipe should be held below the surface of the oil in order to avoid splashing; alternatively the tanks should be filled from the bottom. There should be a standing period of not less than 12 hours to allow de-aeration before commissioning transformers (one hour may be adequate for switchgear)

The vertical or axial force causes the low voltage and high voltage windings to shift with respect to each other, a condition called “telescoping” These forces make the windings take positions that will increase the magnetic flux of the system. If two windings are in series, the electromagnetic force varies as the square of current e.g. a short-circuit 20 times normal will produce 20^2 (or 400 times) the normal stress.

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Failure costs

Rewinding

PRICE STRUCTURE FOR THE 1000 KVA – 11000/400 VOLT POWER TRANSFORMER WORKSHOP RESTORATION PROGRAM ON SERIAL NUMBER 0988/2 COLLECTED ON SUNDAY, THE 13TH OF FEBRUARY 2005.

1.	Transport (Collect from Mobeni to Dbn) – Crane hire included	R Already done
2.	Labour (Off load, detank, inspect, test and report)	R 975.00
3.	Labour (Dismantle, active part, re-wind, reassemble)	R 5 695.00
4.	Labour (Oven dry cycles, final test)	R 1 800.00
5.	Labour (paint, regasket, vacuum, refill)	R 2 975.00
6.	Materials (Inter layer edge packing and blocking)	R 4 848.00
7.	Materials (New enhanced insulated copper conductors – HV)	R14 880.00
8.	Materials (New enhanced insulated copper conductors – LV)	R16 720.00
9.	Materials (paint, gasketing, insulation, seals)	R 2 848.00
10.	*New temp. indicator with bucholz relay and marshalling kiosk (For protection)*	R 3 800.00(Optional)
11.	Litres of replacement Tx oil (1400 Lt) – on exchange	R 2 800.00
12.	1 x Post full oil analysis with certification	R 279.00
13.	Transport (from Dbn to Mobeni – off load, install – Crane hire included)	R 4 554.00
	Sub Total	R62 174.00
	14 % VAT	R 8 704.36
	Total	R70 878.36

Not Included
Down time
Transformer Hire costs etc

CONCLUSION.

The transformer prior to 12-02-2005 was indicating normal operation.

There was no evidence of any internal fault occurring based on the Transformer Oil analysis.

The recommendation for an internal inspection was not based on any accepted Diagnostic codes and appears to be based on financial gain.

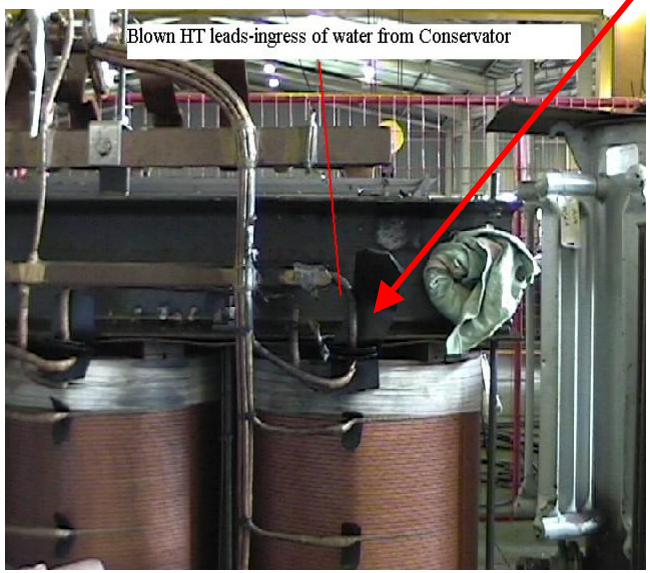
The maintenance procedures resulted in the transformer failure and they must accept liability

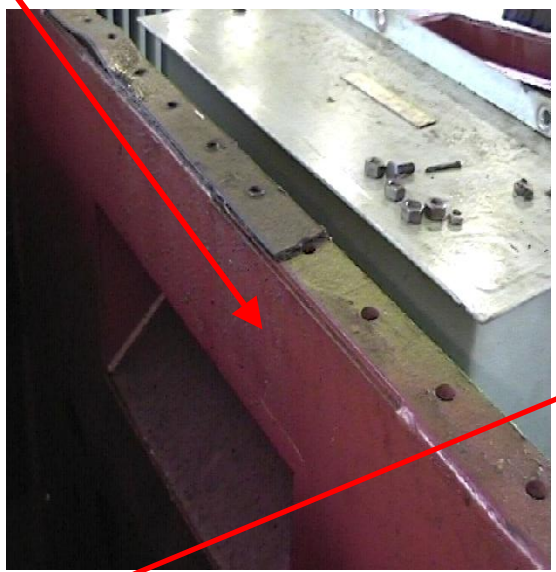
ENGEN REFINERY

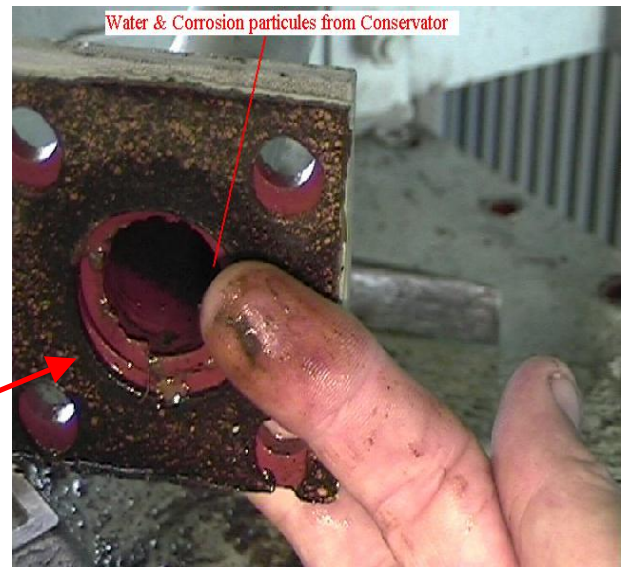
Failure of 11/0.4 kV: 800 KVA Transformer

Unit failure 2 days after Oil purification-maintenance

Primary Fault: Arcing from HT leads to the side of the Main Tank: Distance of arc ± 300 mm







Ingresses of contaminated oil into the unit causing failure at the Peak Loading cycle
Caused by improper maintenance: The Conservator tank was not Inspected or purified:

Cost of failure: Repair: rigging: transport: Generator Hire etc

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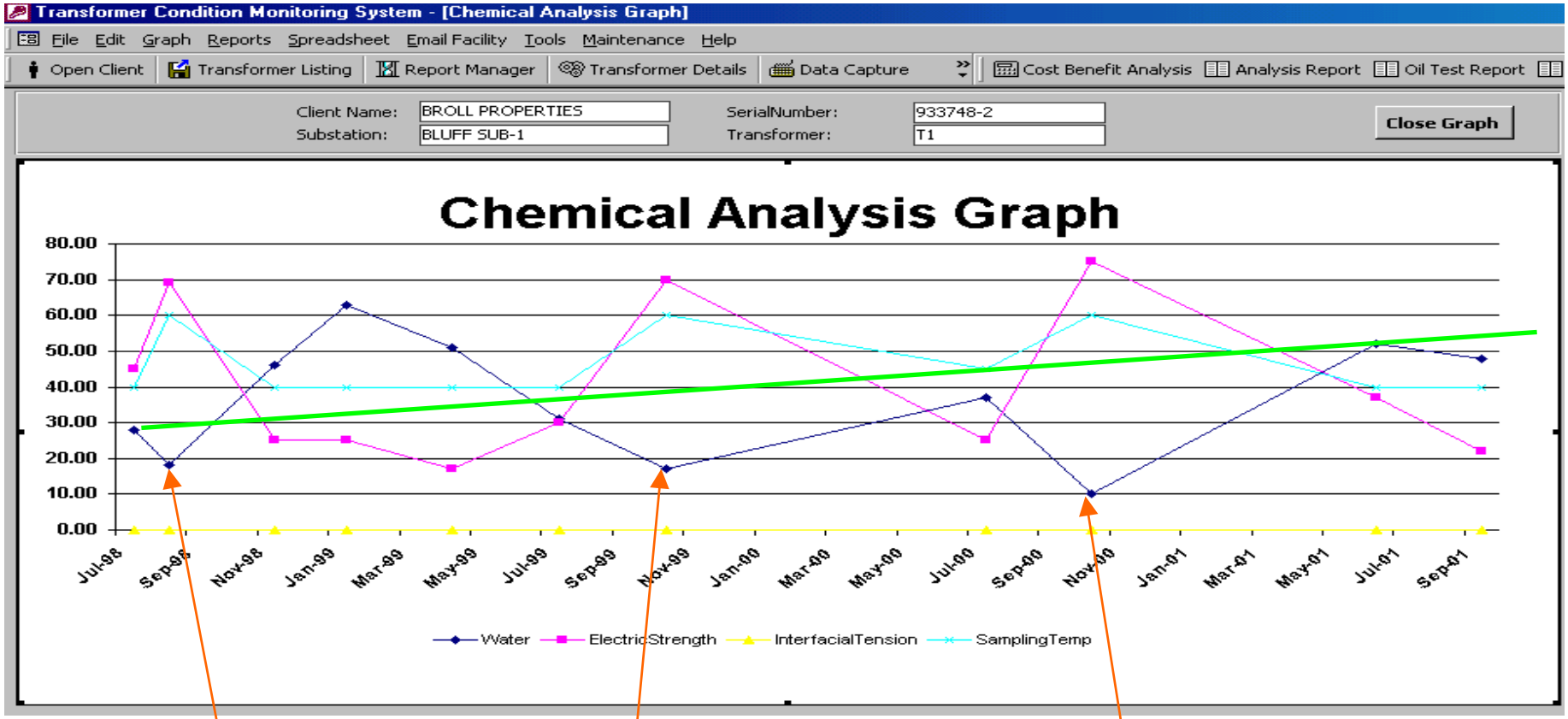
Broll Property : 11 kV : 800 KVA



Purify

Purify

Purify

Water ingress from oil purification: Note Trend Line

The moisture content of a transformers solid insulation plays a major role in determining a transformers length of life. The expected life of a transformer is reduced by 50%, every time the moisture content of the solid insulation doubles.

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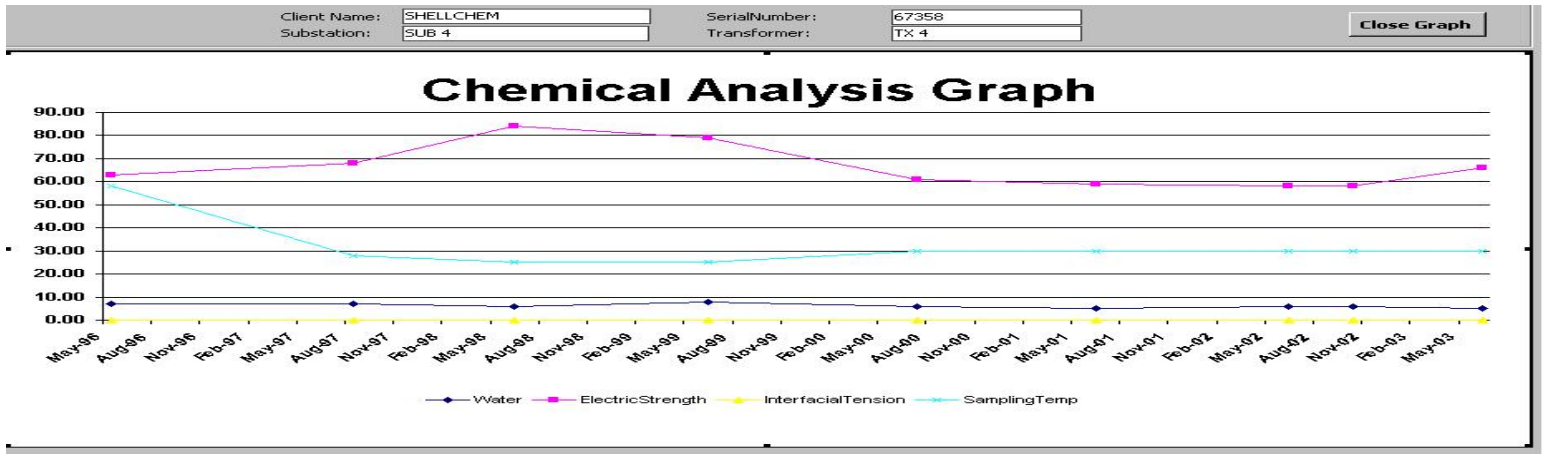
Transformer Maintenance/purification cost comparison

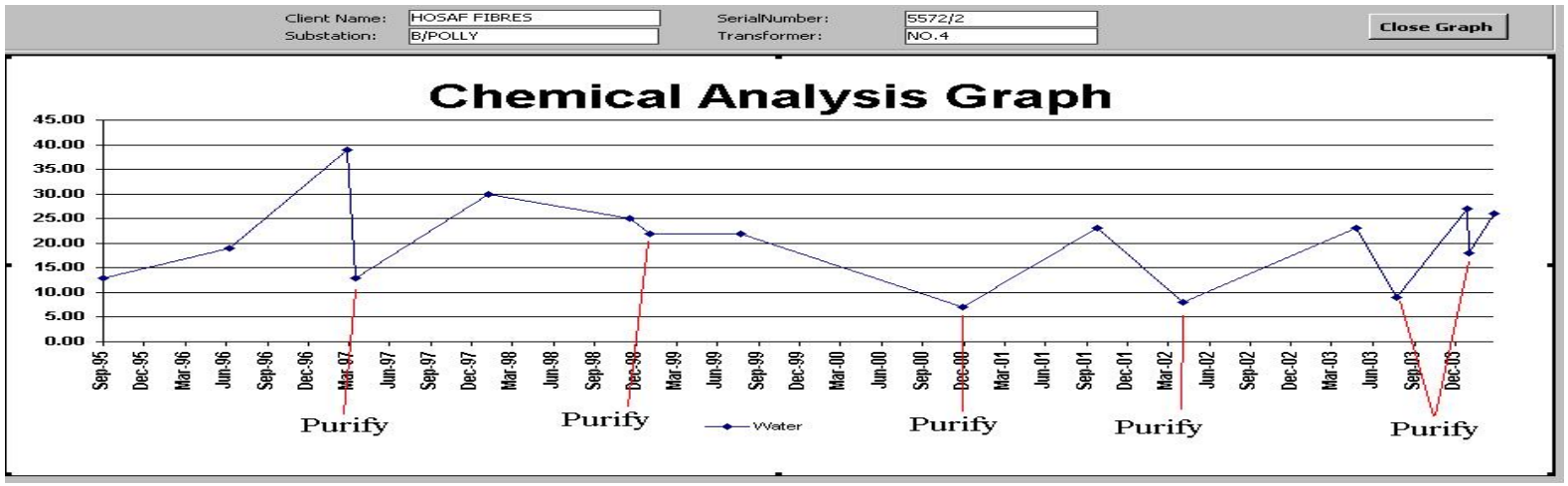
	SHELLCHEM	HOSAF FIBRES
Number of purification	3	35
Cost of purification @ R 2500	R 7 500	R 87 500

This comparison is drawn to the Shell Chemicals Plant that has five transformer of a similar Voltage classification and KVA rating with data used from 1996 to 2004.

Example: Shellchem showing what is a normal trend



Example: Hosaf showing what trend ?



Are you doing cost effective maintenance?