Electricity Transmission

Oil markers

Transformer research dissemination

Gordon Wilson - 28/11/24

nationalgrid

Overview

Research into switch oil markers in transformer oil

01	Why do we want a switch oil marker?
02	Marker options – fuel tracer and ester
03	Results
04	Measuring mineral oil in an ester

Background – a transformer with known issues

- **275/132 kV**
- **180 MVA**
- **Manufactured 1962**
- **AEI H13 tapchanger**
  - Prone to coking

History of issues

Long history of troubles with the transformer

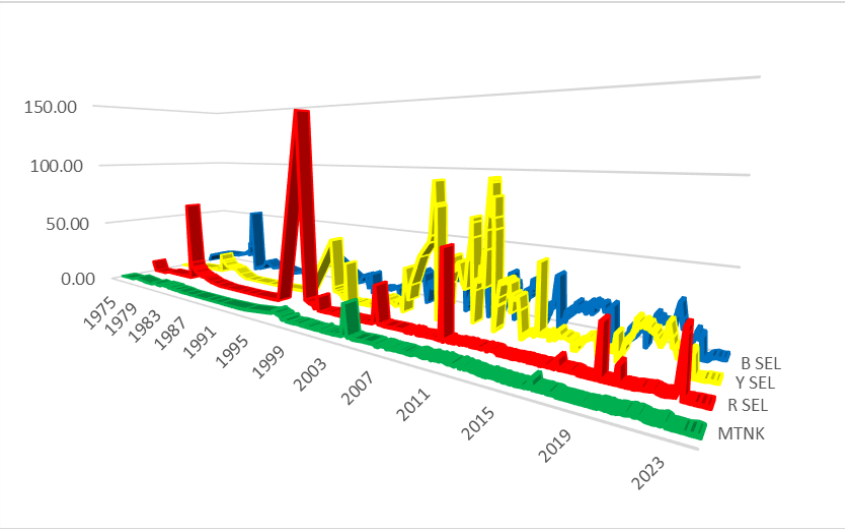
Acetylene shows multiple points over the decades in different selector tanks (phases)

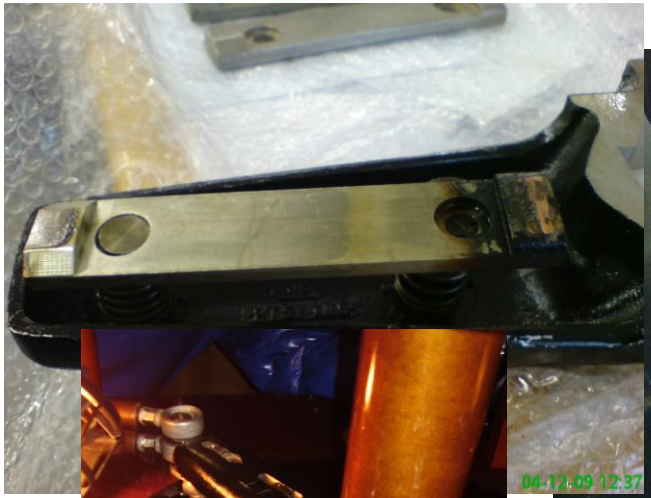
1995, 2007, 2009 coked contacts

2011 slipped changeover ring

2013 misaligned contacts

2018 contact wear

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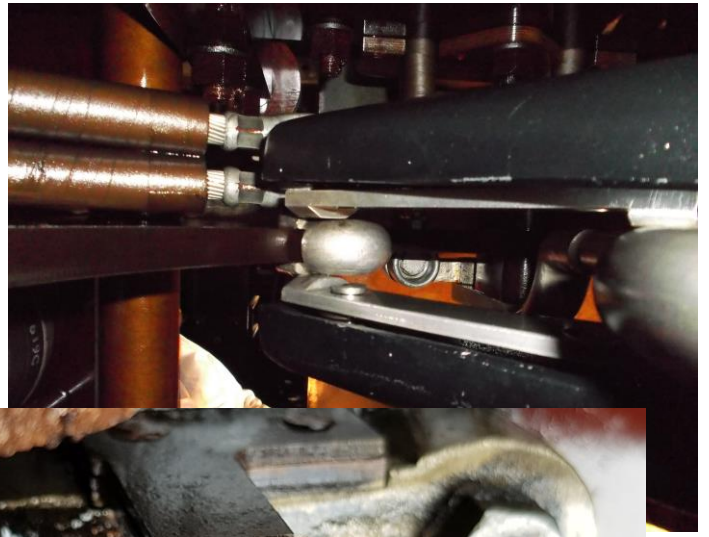
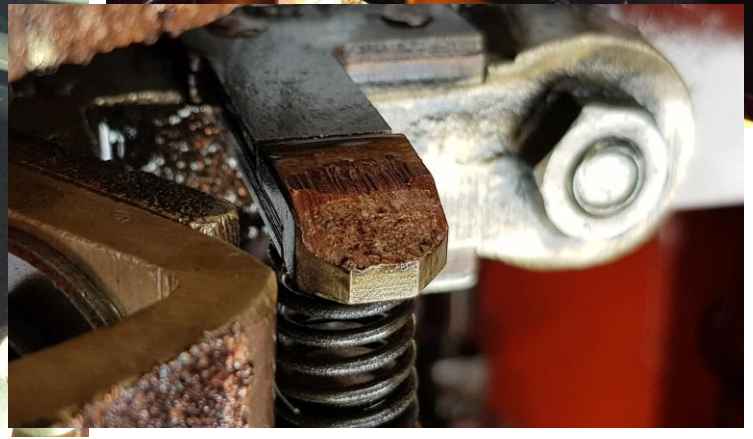
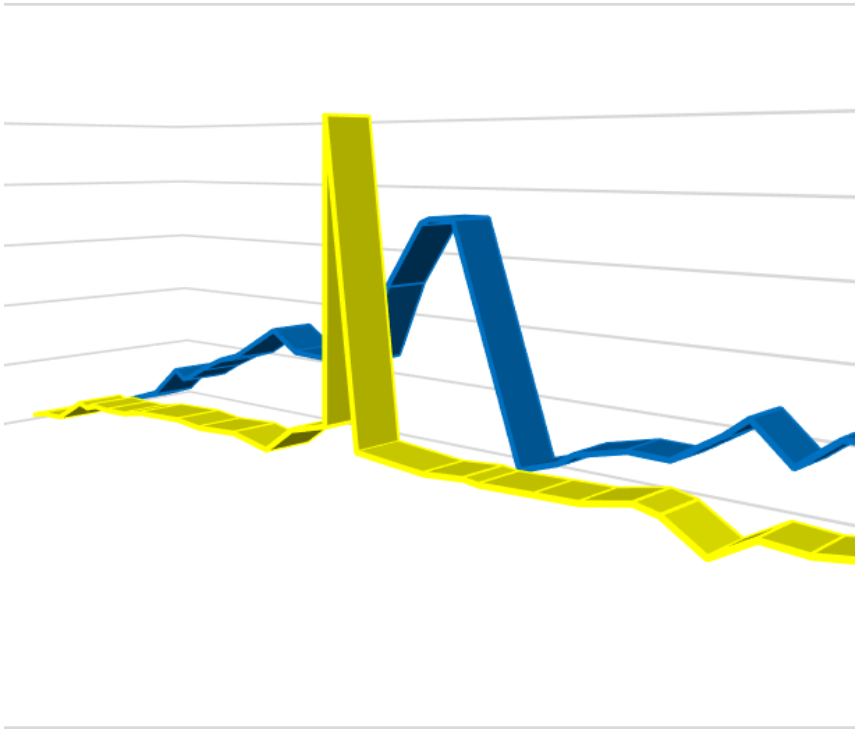




- **Sometimes the source of acetylene is harder to find…**
  - After an episode of coking acetylene rose in two phases
  - Switched out for investigation
  - No coking on contacts
  - No high resistance joints founds
  - Degraded seals between div/sel?
  - How do you return this unit to service?



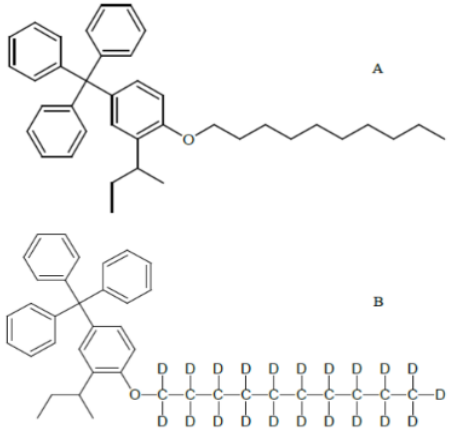
Proposal for markers in switch oil

Established tracer - Nynas

Used in fuels

Using GCMS detectable down to 5-25 ppb

Establish suitability in dielectric

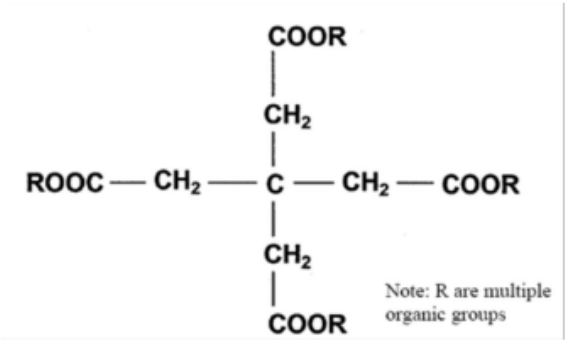


Known dielectric – University of Manchester

Synthetic ester suitable for transformers

Can be used at any concentration

Analytical technique to be developed



Fuel marker testing

The suggested marker previously used in fuels needed to be investigated for effect on switch oil function

But since it could mix with the selector all dielectric properties would be of concern – primarily dielectric properties

Different concentrations – 0.1%, 0.5% and 1%

Effect on IFT, Dissipation factor, BDV, Cu Corrosion and Oxidation stability

Results

Property	Method	Unit	Oil	0.1 % marker	0.5 % marker	1 % marker
Odour	NA	NA	Normal	Normal	V.slight petrol	Slight petrol
IFT	IEC 62971	mN/m	48.3	47.1	42.3	40.5
DDF @ 90 °C	IEC60247	NA	0.00058	0.00079	0.0014	0.0016
BDV	IEC60156	kV	92.1			90.6
Cu Corrosion	IEC62535	NA	-ive			-ive
Oxidation stab.	IEC61125					

Detection

Although methods for detection at low level are known there are sometimes matrix effects, so it was tested in unused and aged mineral oil

Sample	Spike 1	Spike 2	Spike 3	Spike 4	Spike 5	Average	SD	%RSD	Calibration R^2
Unused	108.3	118.3	98.9	118.0	68.3	102.4	20.7	4.96	0.99
Aged 1	120.2	124.2	114.0	77.0	99.4	107.0	19.2	5.57	0.99
Aged 2	102.9	107.6	126.0	119.6	-	114.0	10.6	10.7	0.99

Synthetic ester testing

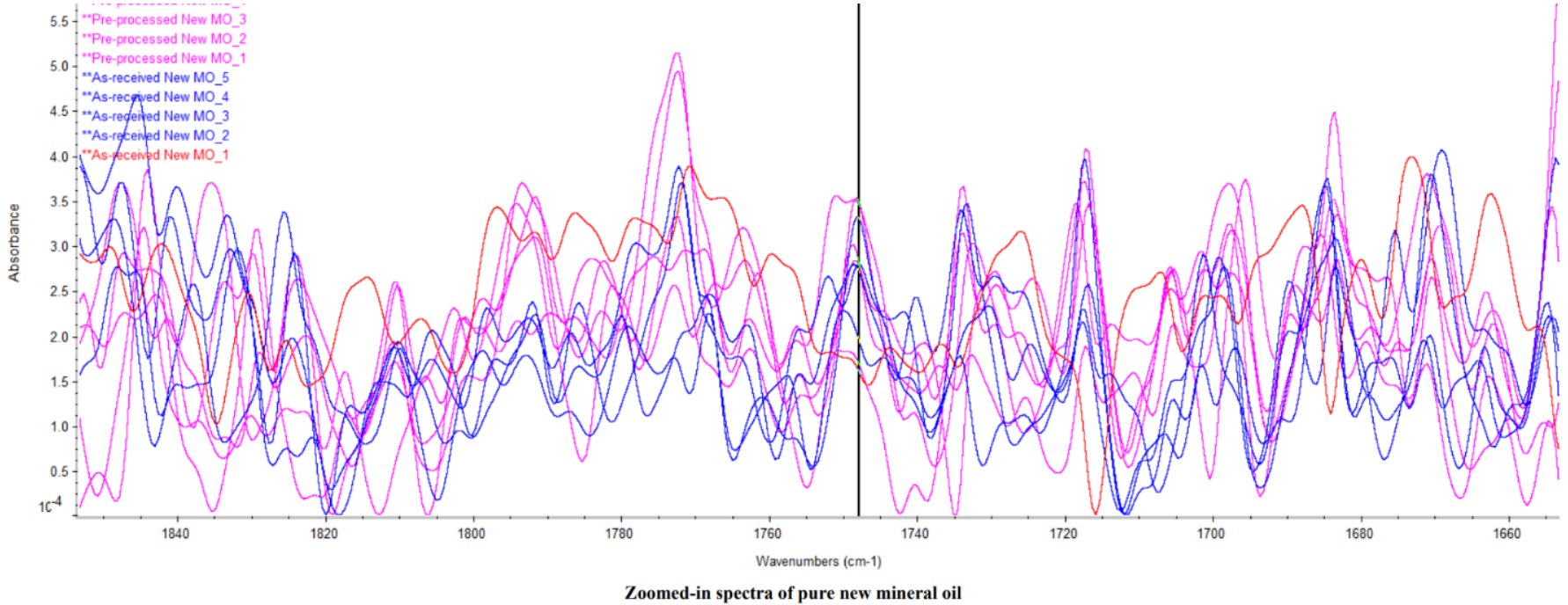
The properties of synthetic ester are understood, even in mixtures with mineral there are no concerns about its performance

The requirement was to determine low concentrations in mineral oil

FTIR was chosen for initial investigation

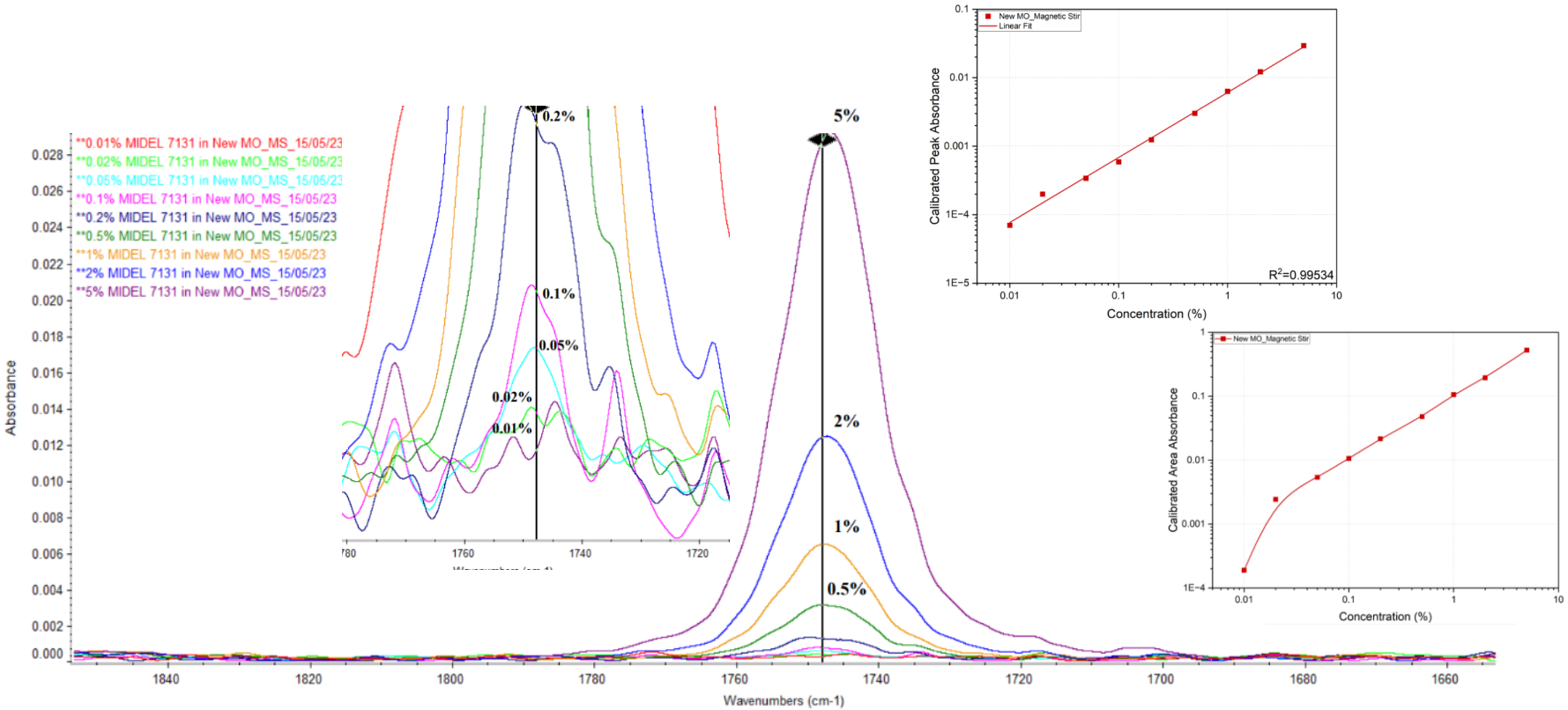
Concentrations from 0.01 % up to 5 % evaluated

Reference spectra



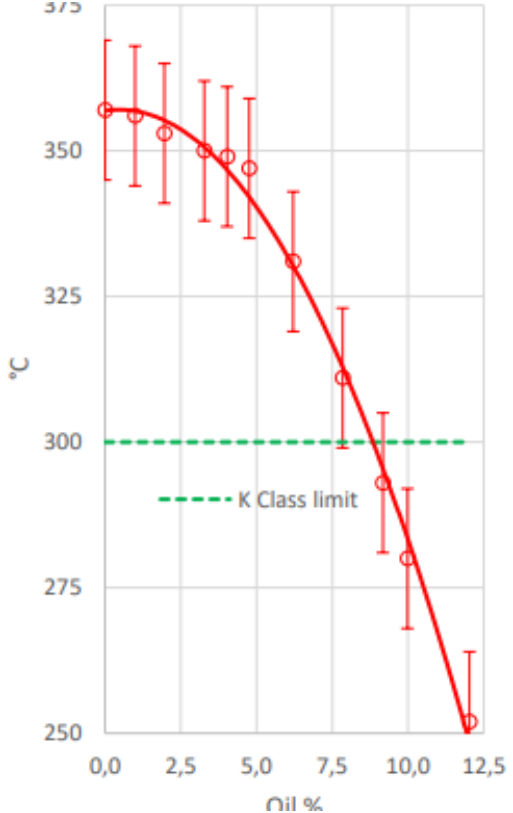
Zoomed-in spectra of pure new mineral oil

Calibration

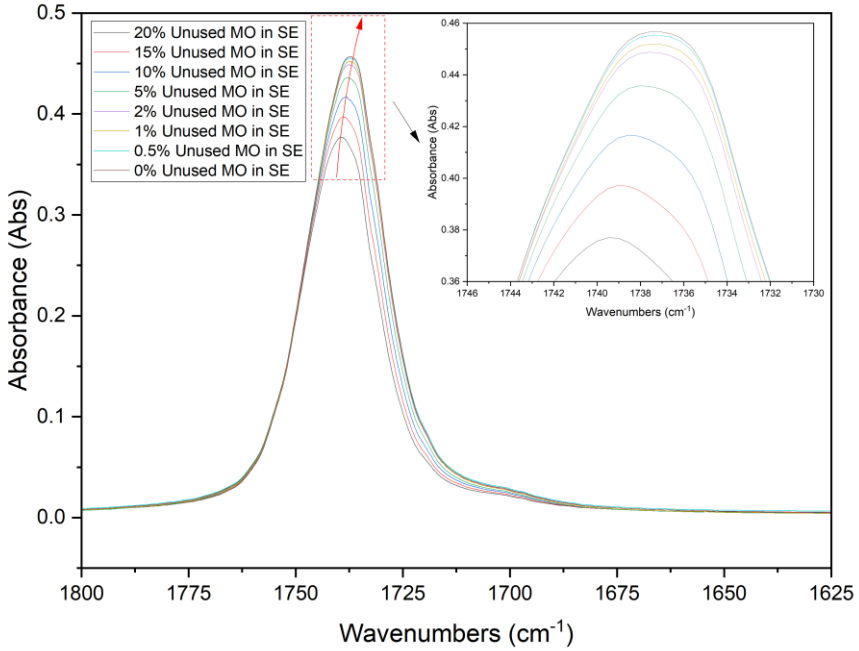


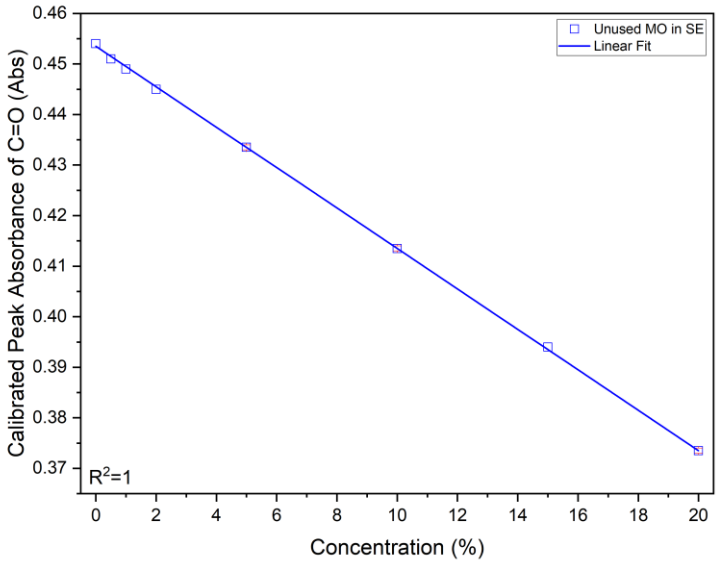
Remaining mineral oil after retrofill

- Why determine remaining mineral oil concentration in ester liquid?
  - Ensure you get the performance you are expecting
  - Flash and fire points
- Existing methods
  - Viscosity
  - Iodine value



Calibration





Summary

Accutrace S10 at 1% reduces the IFT and increases DDF but within spec – LoD is 100 ppb

FTIR is a sensitive method for detection of synthetic ester in mineral oil (0.05 %) and also of mineral oil in synthetic ester (0.5%)

Both techniques unaffected by aged oil

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