

# Refurbish not replace

Tata Steel uses EOS oil  
regeneration process to  
extend transformer  
life-time

**UK** steelworks have gone through a turbulent time in recent years, but there is now some stability as the UK and global marketplaces once again appears more attractive. Although investment is being made, money has to be spent wisely, and transformer refurbishment, with a focus on the health of the insulation system (oil and paper), has become a priority for Tata Steel Port Talbot's engineers who look after the high voltage feed to this 2,000 acre site in South Wales.

Tom Larney, EOS Vice President, believes that with pressure to reduce the carbon

footprint of all maintenance and replacement activities, the need to deliver good value and the sheer good sense of not replacing transformers just because they are "getting old" makes refurbishment a technical and economically viable option. Tata Steel, one of the largest steel producers in Europe, engaged Electrical Oil Services (EOS) at an early stage to discuss options for treating the insulation system as part of their transformer refurbishment programme. EOS is the leading supplier of both reclaimed and unused electrical insulating oils and associated services throughout the UK and parts of Europe, and a strong brand of HCS Group.

## Health screening: assessing the transformer population

With 17 supply transformers, each of them 66 kV and many of them feeding critical parts of the steelworks, a wholesale replacement programme was never a viable option for Tata Steel. Instead, each transformer was sampled with the support of EOS engineers. In addition, a Transformer Condition Assessment (TCA) analysis was carried out by the leading UK laboratory TJ|H2b Analytical Services Limited. This in-depth analysis gave



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EOS engineers and Glen Evans, Tata Steel's Area Engineering Manager for High Voltage Systems, a comprehensive baseline assessment of the insulating system specifically the current oil condition and, more critically, the state of the paper insulation.

The baseline information on the 17 supply transformers, together with the critical assessment of the physical state of each transformer, was the prerequisite for Tata Steel to put together a risk-based refurbishment plan focusing on the most critical transformers for steel production at Port Talbot.

### **Benefit of oil regeneration versus oil-change**

With detailed TCA results, outage times and an assessment of transformer criticality level completed, EOS and Tata Steel focused on the oil test results and the physical condition of the paper insulation in order to develop a customized treatment plan using in-situ oil regeneration. The advantage of in-situ oil regeneration is that the process treats the entire transformer and not just the oil. If done correctly, acids and early-stage sludge formation from ageing transformers' cooling ducts and papers are efficiently removed during

the process. This "deep cleaning" effect ensures that there is only minimal residual "acid oil" left in the paper at the end of the regeneration operation.

Advantages of oil regeneration over oil changes:

- a) "Deep cleaning" of the insulation system – a function of time and temperature and enhanced through vibration when the transformer is energized
- b) Treatment without removing the oil which is the support mechanism for the paper insulation
- c) Transformer constantly available to carry load – only short outages needed

Table 1. Classification of oil-in-service

BSEN 60422:2013	Good	Fair	Poor	BS148:2009
Acidity Neutralisation (mgKOH/g)	<0.1	0.1 – 0.2	>0.2	0.03 MAX
Dielectric Dissipation Factor - DDF (90 °C)	<0.1	0.1 – 0.5	>0.5	0.005 Max
Resistivity (GΩm)	>60	4 – 60	<4	NR
Interfacial Tension - IFT	>25	20 – 25	<20	NR

**If the oil regeneration is done correctly, acids and sludge formation from transformers' cooling ducts and papers are efficiently removed**

- f) Fewer associated environmental risks compared to multiple road tanker activities
- g) Lower carbon footprint due to reduced tanker movements

### Best time for oil regeneration

When a transformer is filled for the first time with brand new unused insulating oil, the acidity neutralization figure will be <0.01 mgKOH/g. As the transformer ages, the action of heat and oxygen results in the oil oxidizing as the oils "natural" inhibitors are depleted. Polar compounds in the oil such as acids and early-stage sludge are produced. It is these complex compounds which attack the transformer paper insulation, leading to weakening of the insulation and an inability to withstand close-up faults and through faults. Once the paper is damaged it cannot be repaired. Therefore, it is recommended that a complete oil regeneration programme is conducted at the earliest stage possible.

IEC 60422:2013 "Mineral insulating oils in electrical equipment – Supervision and maintenance guidance" gives guidance based on "good", "fair" and "poor" oil condition – for 132 kV or critical transformers, Table 1.

The "Supervision and maintenance guidance" recognizes the research that has been carried out over the years, and recommends reclamation of the oil from an acidity value of 0.15 mgKOH/g. Figure 1 shows the exponential rise in an insulating oil's acidity once the "natural" inhibitors are depleted – regenerating at 0.1 – 0.2 mgKOH/g is a good target value, providing there is sufficient paper strength to make the process worthwhile.

Figures 1 and 2 are useful practical guides to oil and paper ageing and when to intervene, in this case regenerating the

- to make connections and/or disconnections
- d) Far less (contaminated) oil left in the paper insulation following the regeneration exercise compared to oil replacement

- e) Cost effective when compared to oil replacement

### Acidity Over Time

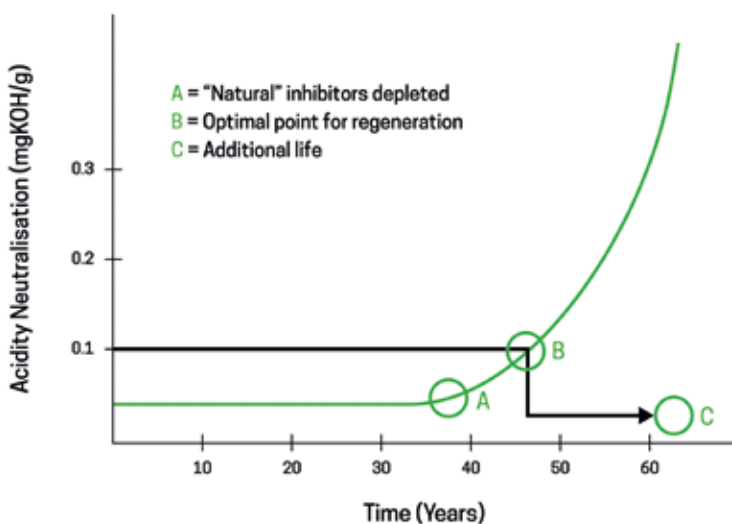


Figure 1. Acidity over time curve

### Neutralisation Value versus Interfacial Tension

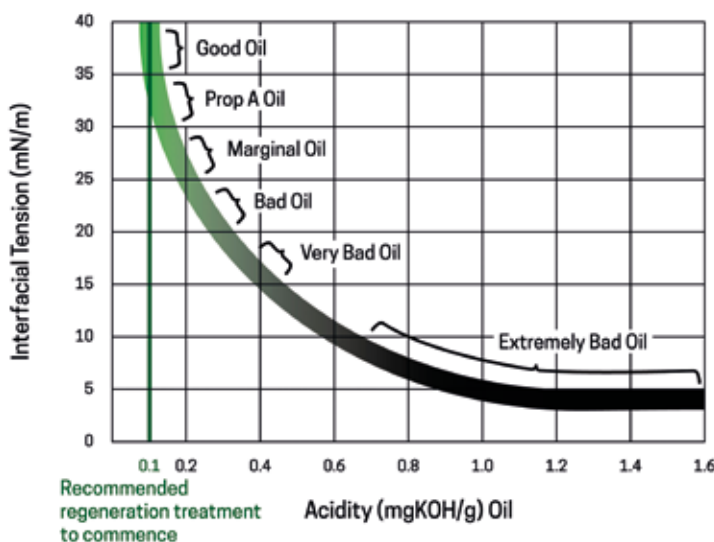


Figure 2. Neutralisation value versus IFT Curve

insulating oil in such a manner as to “deep clean” the solid, paper insulation.

The water content of the oil is another important aspect and should be taken into consideration before any “live” treatment. Together with Tata Steel engineers, the EOS experts carefully reflected on all areas of the assessment before proceeding further.

## Supply Transformer ST9

The jointly concluded health assessment suggested that the supply transformer ST9 would be a good candidate to begin with; this 1959 10 MVA 66 kV transformer contained 17,000 litres of oil.

Oil test results:

- Acidity: 0.18 mgKOH/g
- Interfacial Tension (IFT): 20
- Dielectric Dissipation Factor (DDF): 0.22.

IFT and DDF are good indicators of the level of polar contaminants in the oil, usually present from oil degradation. The removal of contaminants from the paper and oil will confirm the efficiency of in-situ oil regeneration.

## The mechanics of oil regeneration

The EOS Mobile Regeneration Unit (MRU) comprises of two articulated trailers; one contains standard oil reconditioning equipment such as heaters, filters and vacuum chambers. The other contains columns of activated bauxite material for the adsorption (contaminants “stick” to the bauxite) of dissolved polar contaminants in the oil such as acids and sludge (caused through ageing of the oil by heat, and oxygen in the presence of copper and iron). Passing the oil through each plant in series restores the insulating oil to “as new” condition and extracts much more of the oil trapped deep in the paper insulation than what is removed by a conventional oil change operation.

**Time, temperature and vibration inside the energized transformer enhance “deep cleaning” of the insulation system**

The amount of acidity removed from the paper insulation is directly proportional to time and temperature. Vibration and movement resulting from on-line/live regeneration will also benefit acidity removal.

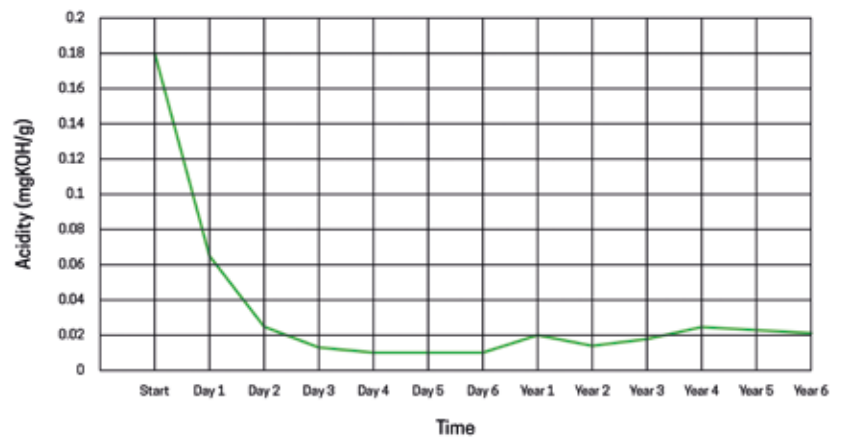
Getting the transformer core to around 70 °C is key to the successful removal of acids and sludge from a transformer. Ambient temperature and general weather conditions, along with the cooling effect of radiators and pumps, can limit temperature rises in some cases.

For the regeneration of energised and/or load carrying transformers, EOS has worked closely with a leading Distribution System Operator (DSO) to develop safe systems of working to limit associated risks.

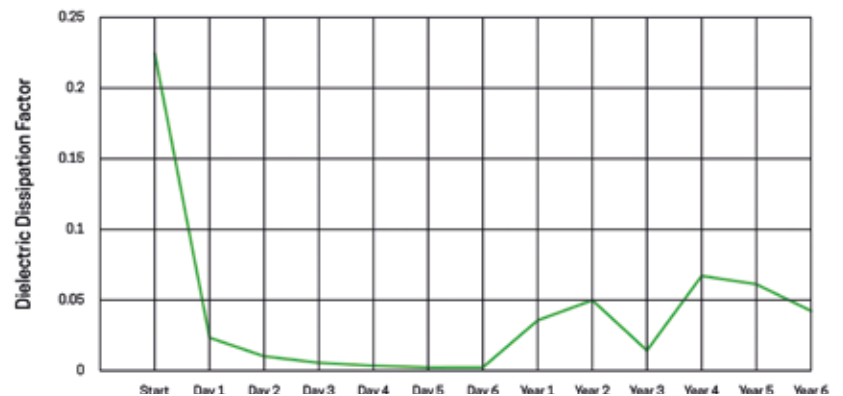
## ST9 test results

EOS has taken its considerable experience of oil reclamation at its large static plant in the UK and employed it for in-situ oil regeneration. This includes highly experienced operators, on-site testing of acidity,

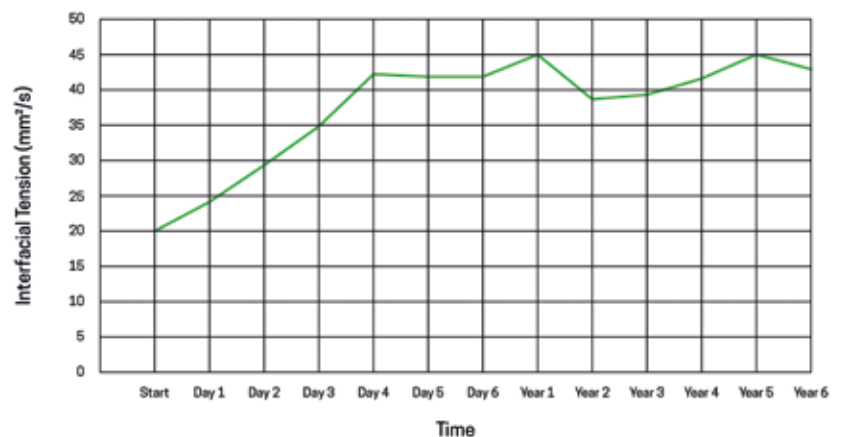
### Acidity



### Dielectric Dissipation Factor



### Interfacial Tension



## During the regeneration process a transformer is constantly available to carry load



IFT, DDF, resistivity, breakdown voltage and dissolved water.

The previous graphs show the progress of the site operation testing of the oil during the initial process and yearly thereafter at the Tata Steel site at Port Talbot.

### Follow up and conclusions

At the end of day 6, an artificial inhibitor was added to the oil via the site treatment plant, and dosing was carried out to 0.4 % or “fully inhibited”. The inhibitor content is measured annually, and to date has not needed topping up. After 6 years colour remains at 1.0 with acidity, DDF and IFT all within the limits of BS148:2009. Acidity remains stable at 0.02 mgKOH/g.

Tata Steel’s Glen Evans confirms:

*“The work that EOS has carried out on ST9 has demonstrated the clear benefits for oil regeneration as part of an overall transformer health improvement programme. Our plan is to target other transformers in the fleet for the same treatment over the coming years, reducing capital spend, carbon footprint and generally making good use of well-made transformers that we hope will give us many more years of reliable service.”*

Andy Bartram, EOS Sales Manager, explains: *“Our mobile regeneration service is well established and accepted in the UK. Now that the EOS brand is part of the HCS Group, we will be setting up further regeneration units based at a Group site in Germany in order to assist with our transformer health improvement services in continental Europe.”*



### Author

**Andy Bartram** has worked in the electrical oil industry for 27 years and with EOS since its formation in 1999. As Sales manager for the UK’s leading insulating oil and services provider Andy Bartram leads a team of three Electrical Engineers offering guidance on all aspects of insulating oil management, testing and treatment. Prior to joining the electrical oil business, Andy Bartram was employed by the CEGB as a 400 kV SAP in the transmission division which became National Grid shortly before he left to join Carless.

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For more information on EOS please visit [www.eosl.co.uk](http://www.eosl.co.uk)

### About EOS

Electrical Oil Services (EOS) is a key brand of HCS Group GmbH and a leading supplier of unused and reclaimed insulating oils and associated services in Great Britain and Continental Europe. EOS specialists have 60 years’ experience in the production and marketing of insulating oils and supply both large and small customers in the electricity distribution industry with tailor-made solutions. For further details please visit [www.eosl.co.uk](http://www.eosl.co.uk)

### About HCS Group

The HCS Group is a leading international supplier of solutions for high-value hydrocarbon specialties. The Group includes the brands Haltermann Carless, ETS Racing Fuels and EOS. The HCS Group has about 500 employees and is headquartered in Frankfurt am Main, Germany. The company belongs to H.I.G. Europe, a subsidiary of the US private equity company, H.I.G. Capital. For further details please visit [www.h-c-s-group.com](http://www.h-c-s-group.com)

### About Tata Steel

Tata Steel is one of Europe’s leading steel producers, with steelmaking in the UK and Netherlands, and manufacturing plants across Europe. The company supplies high-quality steel products to the most demanding markets, including construction, automotive, packaging, lifting & excavating, energy and aerospace. The combined Tata Steel group is one of the world’s largest steel producers, with a steel capacity of more than 28 million tonnes and 75,000 employees across five continents. For further details please visit [www.tatasteeleurope.com](http://www.tatasteeleurope.com)

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