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# NSP/009/001 – Network Service Procedure for Transformer Insulating Oil Regeneration

## 1. Purpose

The purpose of this document is to detail the technical requirements of on-site oil regeneration to maintain the serviceability of insulating oil in power transformers connected to the Northern Powergrid distribution network.

This document supersedes the following documents, all copies of which should be destroyed;

Document Reference	Document Title	Version	Published Date
NSP/009/001	Network Service Procedure for Transformer Insulating Oil Regeneration	2.0	April 2020

## 2. Scope

Within the context of this document, oil regeneration refers to a combination of chemical and physical processes to eliminate or reduce soluble and insoluble polar contaminants from the oil with the effect of reducing moisture and acidity concentrations in transformer insulating oil. The processes are; filtration, reclaiming by percolation and vacuum conditioning as described in BS EN 60422 Mineral insulating oils in electrical equipment – Supervision and maintenance guidance.

The predominant purpose of Transformer Insulating Oil Regeneration is to reduce the acidity of the insulating oil.

The process of solely reducing physical contamination through physical processes such as filtration, drying or degassing is outside the scope of this document.

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### 3. Technical Requirements

#### 3.1. General

The service provider shall supply an appropriate oil regeneration plant that is portable and can operate in a typical substation environment, together with appropriately trained operatives with experience of running the plant in live substation compounds.

The plant shall be capable of operating independently of a mains power supply and processing insulating oil from 132kV, 66kV, and 33kV transformers, typically with volumes between 15000 and 50000 litres at a minimum rate of 1000 litres per hour.

Depending upon the specific site conditions, the transformer to be treated may be energised and on load during the oil regeneration process with short outages taken to facilitate the connection and disconnection of hydraulic pipes.

The service provider shall have appropriate methods of safe working and risk assessments established to undertake regeneration of the insulating oil with the transformer live and on load. Site specific risk assessments will be undertaken and the method statement modified to reflect the site conditions.

The service provider shall have the facilities on site to carry out the following on-site oil tests; visual inspection (colour and appearance), breakdown voltage, water content, and acidity in accordance with Northern Powergrid's internal standards which are listed in the table shown in Appendix 1.

The service provider shall also ensure a site log is kept with details of oil characteristics provided by the on-site tests with records being taken a minimum of once per regeneration cycle.

In addition to tests taken on site, samples shall be taken at key stages of the work and analysis undertaken by a Northern Powergrid approved accredited laboratory. All tests listed in the table shown in Appendix 1 (based on BS 148) shall be carried on these samples to ensure the oil meets Northern Powergrid's standards.

Sampling shall be carried out in accordance with BS EN 60475: Method of sampling insulating liquids, with care taken that samples provide an accurate representation of the oil condition as a whole.

#### 3.2. Reclaiming Treatment Specifications

##### 3.2.1. General

Before carrying out the reclamation process, a laboratory feasibility test shall be carried out by the service provider.

The service provider shall reduce water content to less than 5mg of water per kg of oil prior to regeneration commencing as per BS EN 60814: Insulating liquids. Oil-impregnated paper and pressboard. Determination of water by automatic coulometric Karl Fischer titration.

The service provider will produce and follow a method statement to ensure that no air is trapped in any part of the plant or interconnecting pipework before the transformer valves are opened.

##### 3.2.2. Reclaiming by Percolation

Oil shall be circulated through fuller's earth (or an equivalent) a minimum of 3 times at 60°C to 80°C. Depending on the initial degree of contamination, a greater number of cycles may be necessary to ensure the oil quality meets the required standard.

The service provider shall supply reclaimed oil to BS 148: Recycled mineral insulating oil for transformers and switchgear – Specification, and NPS/003/019 – Technical Specification for Electrical Insulating Fluids for use in Plant & Switchgear, to replace the oil absorbed during the treatment.

The service provider shall ensure that the disposal or re-activation, of contaminated adsorbent is carried out strictly in accordance with local regulations. The service provider shall minimise the impact of the operation on local residents by reducing noise and odour as far as reasonably practicable. Consideration

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shall be given to the use of acoustic barriers where appropriate. The plant shall have a catalytic converter fitted to reduce the impact of re-activation on local air quality.

The service provider shall have in place the appropriate environmental permit to undertake re-activation of the adsorbent at the identified Northern Powergrid substations.

The service provider shall ensure that their plant is maintained and cleaned to eliminate any risk of contamination, particularly adsorbent that may be contaminated with PCB.

### 3.2.3. Renewal of Additives

The service provider shall determine the quantity of inhibitor that needs to be added to the insulating oil following reclamation. Additives shall be replaced in the reclaimed oil after the reclaiming process and before the equipment is re-energized. The most widely used additives are 2,6-di-tert-butyl-paracresol (DBPC) and 2,6-di-tert-butyl-phenol (DBP).

At the end of the process, oxidation stability tests shall be undertaken to demonstrate that the mineral oil has sufficient anti-oxidant properties.

## 3.3. Handling and Storage

Handling and storage of insulating oil shall be undertaken to meet the requirements stated in BS EN 60422: Mineral insulating oils in electrical equipment — Supervision and maintenance guidance.

Hydraulic pipe-work and pumps shall be carefully inspected to ensure that they are free from water and other contamination. The system shall be flushed with clean oil before use.

Strict control shall be undertaken to avoid accidental spills to the environment. Slam-shut valves shall be fitted to connections to the transformer such that in the event of a leakage alarm, no further oil will pass from the transformer. All pipes, pumps and hoses shall be carefully inspected for tightness.

If the treatment is performed on on-load equipment, a site specific method statement and risk assessment shall be implemented to avoid risks to staff. Also, safety measures shall be taken to avoid any damage to the equipment itself.

Due care shall be taken when working with hot oil. Staff shall use personal protective equipment as required by Northern Powergrid and the Risk Assessment.

## 3.4. Equipment

### 3.4.1. Filters

The filter medium shall be capable of removing particles larger than 10µm.

An indicator of water content within the filter medium shall be available to monitor the process efficiency.

Used filters (which will be contaminated with used oil and solid contaminants) shall be either recycled or disposed of with strict adherence to local regulations.

### 3.4.2. Waste and Disposal

The service provider shall ensure waste is kept to a minimum at all stages of the regeneration process and where possible materials are recycled.

All waste products generated by the process shall be disposed of by the service provider according to Environmental Protection (Disposal of Polychlorinated Biphenyls and other Dangerous Substances) Regulations SI 2000/1043 and Hazardous Waste Regulations SI 2005/894 (as amended by Hazardous Waste (Amendment) Regulations SI 2009/507).

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## 4. References

### 4.1. External Documentation

Reference	Title
BS 148: 2020	Reclaimed mineral insulating oil for transformers and switchgear – Specification
BS EN IEC 60475: 2022	Method of sampling insulating liquids
BS EN 60422: 2013	Mineral insulating oils in electrical equipment — Supervision and maintenance guidance
BS EN 60814: 1997	Insulating liquids – Oil-impregnated paper and pressboard – Determination of water by automatic coulometric Karl Fischer titration
SI 2000/1043	Environmental Protection (Disposal of Polychlorinated Biphenyls and other Dangerous Substances) Regulations
SI 2005/894 SI 2009/507	Hazardous Waste Regulations (as amended by Hazardous Waste (Amendment) Regulations)

### 4.2. Internal Documentation

Reference	Title
IMP/001/402	CoP for Power Transformer Refurbishment
NPS/003/019	Technical Specification for Electrical Insulating Fluids for use in Plant & Switchgear

### 4.3. Amendments from Previous Version

Reference	Description
3.1	Reflect replacement of BS 5263 with BS EN 60475: Method of sampling insulating liquids
3.2.2	Reflect change in title of BS 148 from 'Reclaimed mineral insulating oil to' to 'Recycled mineral insulating oil'
4.1	Update external references
4.2	Include reference to NPS/003/019
Appendix 1	Reflect revised BS 148 and remove reference to molecular sieves which is outside the scope of this document.

## 5. Definitions

Term	Definition
Local Regulations	Regulations pertinent to the particular process in the country concerned
PCB	Polychlorinated biphenyl
Reclamation	A process which eliminates or reduces soluble and insoluble polar contaminants from the oil by chemical and physical processes.

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## 6. Authority for Issue

### 6.1. CDS Assurance

I sign to confirm that I have completed and checked this document and I am satisfied with its content and submit it for approval and authorisation.

		<b>Date</b>
Liz Beat	Governance Administrator	31/05/2023

### 6.2. Author

I sign to confirm that I have completed and checked this document and I am satisfied with its content and submit it for approval and authorisation.

**Review Period** - This document should be reviewed within the following time period;

Standard CDS review of 3 years?	Non Standard Review Period & Reason	
No	<b>Period:</b> 5 years	<b>Reason:</b> to align with procurement cycles
<b>Should this document be displayed on the Northern Powergrid external website?</b>		Yes
Joe Helm	Senior Policy & Standards Engineer	01/06/2023

### 6.3. Technical Assurance

I sign to confirm that I am satisfied with all aspects of the content and preparation of this document and submit it for approval and authorisation.

		<b>Date</b>
Paul McAdoo	Senior Policy & Standards Engineer	02/06/2023

### 6.4. Authorisation

Authorisation is granted for publication of this document.

		<b>Date</b>
Paul Black	Head of System Engineering	09/06/2023

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## Appendix 1 – Reclaimed Oil Specifications

The table below states the Northern Powergrid required standards for reclaimed transformer oil.

Property	Test method	Limits	Conformance and Details
<b>1 – Function</b>			
Viscosity at 40 °C	BS EN ISO 3104	Max. 12 mm <sup>2</sup> /s	
Viscosity at –30 °C	BS EN ISO 3104	Max. 1800 mm <sup>2</sup> /s	
Pour point	ISO 3016	Max. –40 °C	
Water content	BS EN 60814	Max. 30 mg/kg A)/ 40 mg/kg B)	
Breakdown voltage	BS EN 60156	Min. 30 kV / 70 kV C)	
Density at 20 °C	BS EN ISO 3675 or BS EN ISO 12185	Max. 0.895 g/ml D)	
DDF (Dielectric Dissipation Factor) at 90 °C	BS EN 60247	Max. 0.005	
<b>2 – Refining/stability</b>			
Appearance	–	Clear, free from sediment and suspended matter	
Colour	ISO 2049	Max 1.5	
Acidity	BS EN 62021-1 BS EN 62021-2	Max. 0.01 mg KOH/g	
Interfacial tension	BS EN IEC 62961	40 mN/m	
Corrosive sulphur	DIN 51353	Not corrosive	
Potentially corrosive sulphur	BS EN 62535	Not corrosive	
DBDS	BS EN 62697-1	Not detectable ( <5 mg/kg)	
Anti-oxidants of BS EN 60666	BS EN 60666	(U) uninhibited oil: not detectable (< 0.1 g/kg) (T) trace inhibited oil: < 0.8 g/kg (I) inhibited oil: 0.8 – 4 g/kg	
2-Furfural and related compounds content	BS EN 61198	Not detectable (<0.05 mg/kg) for each individual compound	

Property	Test method	Limits	Conformance and Details
<b>3 – Performance</b>			
Oxidation stability	BS EN IEC 61125:2018 Method C Test duration (U) Uninhibited oil: 164h	Oils with other antioxidant additives and/ or metal passivator additives	

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	(T) Trace inhibited oil: 332h (I) Inhibited oil: 500h	shall be tested at 500 h	
-Total acidity F)	BS EN IEC 61125:2018 <b>4.8.4</b>	Max. 1.2 mg KOH/g	
-Sludge F)	BS EN IEC 61125:2018 <b>4.8.1</b>	Max. 0.8 mg KOH/g	
-DDF at 90 °C F) G)	BS EN IEC 61125:2018 <b>4.8.5</b>	Max. 0.500	
<b>4 – Health, safety and environment (HSE)</b>			
Flash point	BS EN ISO 2719	Min. 135 °C	
Carcinogenicity	ASTM E1687-10	Non-carcinogenic	
PCB content	BS EN 61619	Not detectable (<2 mg/kg)	