



## Electricity Specification 323

Issue 7

February 2020

# 33/11kV OR 33/6.6kV System Transformers

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**Approved for issue by the Technical Policy Panel**

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	<p>specified.</p> <p>22 Control Cubicles section updated.</p> <p>23 New drawing references added.</p> <p>26 Scada specifications modified.</p> <p>29.2.1 DP Test description added.</p> <p>29.2.9 Temperature rise testing modified to match national specifications.</p> <p>29.2.11 Impulse Testing updated to match national specifications.</p> <p>29.2.19 sFRA testing section modified to current practices.</p> <p>Document and Drawing references updated to current standards.</p> <p>Appendix A Schedules G &amp; J and Appendix C updated.</p> <p>Prepared by: M A Kayes</p> <p>Approved by the Technical Policy Panel and signed on its behalf by Simon Rushton.</p>
1  08/12/11	<p>Issue 3 – Amendment 1</p> <p>Section 14.2 Note added.</p> <p>Section 19.5 updated.</p> <p>Section 19.9 updated.</p> <p>Section 29.2.9 (b) updated.</p> <p>Schedule D3 Line 10 updated.</p> <p>Prepared by: M A Kayes</p> <p>Approved by the Technical Policy Panel and signed on its behalf by: Paul Whittaker.</p>
0  16/05/13	<p>Issue 4</p> <p>New Template Applied</p> <p>Section 14.2 updated for Type C Bushings and Capacitor Bushings.</p> <p>Sections 14.3, 14.4 and 14.5 all update to Type C bushings.</p> <p>Section 14.4 cable box requirements updated.</p> <p>Section 29.1 Tests 8 and 9 notes re-worded for clarification.</p> <p>Schedule C updated to include Core, Windings and Tank locations.</p> <p>Schedule D2 (to be completed by purchaser) added.</p> <p>Schedule D3 item numbering corrected.</p> <p>Prepared by: M A Kayes</p> <p>Approved by the Technical Policy Panel and signed on its behalf by: Paul Whittaker.</p>
0  10/08/18	<p>Issue 5</p> <p>New Template Applied</p> <p>Multiple changes throughout. The document should be read in full.</p> <p>Prepared by: M A Kayes</p> <p>Approved by the Technical Policy Panel and signed on its behalf by: Steve Cox, Engineering and Technical Director.</p>

<p>0</p> <p>12/04/19</p>	<p>Issue 6</p> <p>Section 21 updated to add the requirements for all fans (including motors and bearings and pumps to have a C4 minimum coating and option for C5M coastal resistant surface finish.</p> <p>Prepared by: M A Kayes</p> <p>Approved by the Technical Policy Panel and signed on its behalf by: Steve Cox, Engineering and Technical Director.</p>
<p>0</p> <p>28/02/20</p>	<p>Issue 6</p> <p>Section 19.10 updated to detail our current tapchanger requirements following class implementation in preparation for the forthcoming tender.</p> <p>Prepared by: M A Kayes</p> <p>Approved by the Policy Approval Panel and signed on its behalf by: Steve Cox, Engineering and Technical Director.</p>



## 33/11kV OR 33/6.6kV SYSTEM TRANSFORMERS

### 1. SCOPE

This Electricity Specification (ES) sets out the technical requirements for the purchase of 33/11kV or 33/6.6kV system transformers by Electricity North West Limited (Electricity North West) for connection to their network. The transformers shall have long-term emergency cyclic ratings of 8, 15, 23, 32 and 38MVA and have the 11 or 6.6kV neutral earthed directly or through a resistance. Direct earthing will not be applied to transformers of rating in excess of 15MVA. Transformers may be required in either vector group Yyn0 or Dyn11.

### 2. BACKGROUND TO VARIATIONS FROM THE ENERGY NETWORK ASSOCIATION (ENA) TECHNICAL SPECIFICATIONS (TS) 35-2

This Specification refers to transformers with a CONTINUOUS OIL NATURAL AIR NATURAL (ONAN) RATING not less than half of a LONG TERM EMERGENCY CYCLIC (LTEC) RATING for a specific load cycle and ambient temperature. The terms in capitals are not internationally agreed. The long-term emergency cyclic rating may be readily stated by specifying a maximum winding hot spot temperature of 110°C. ENA TS 35-2 Issue 5 moved away from a long term emergency cyclic rating to a CONTINUOUS EMERGENCY (CER) RATING with a maximum winding hot spot temperature of 140°C which precludes the use of switchgear overload ratings.

To maximise utilisation of associated switchgear Electricity North West require a long term emergency rating to match the switchgear nominal rating, a short term emergency rating allowing time to transfer load, and enhanced short term switching backed up by automatic load reduction systems.

Electricity North West will take responsibility for the assigning of short term ratings based on the specification of a long term emergency cyclic rating following ENA TS 35-2 Issue 5.

Electricity North West utilises line drop compensation within the limits of restriction of system highest voltage. This requires a nominal ratio of 33/11kV rather than the 11.5kV used by certain Distribution Network Operators who were involved in the preparation of ENA TS 35-2. For rationalisation when this class of transformer was first designed it was accepted that the same transformer would suit both types of use using a different tap position as the declared nominal, provided that the tapping step could be accepted by one user as a fraction. Electricity North West has for many years accepted a tapping range of +5.72 to -17.16% in steps of 1.43% and for flexibility of re-use and voltage control wishes to retain this standard.

### 3. DEFINITIONS

<b>Approval:</b>	Sanction by the Electricity North West Plant Policy Manager that specified criteria have been satisfied.
<b>Contract:</b>	The agreement between Electricity North West and the Contractor for the execution of the Works including therein all documents to which reference may properly be made in order to ascertain the rights and obligations of the parties under the said agreement.
<b>Contractor:</b>	The person or person's firm or company, including personal representatives, successors and permitted assigns, whose tender has been accepted by Electricity North West.
<b>Guarantee:</b>	A document serving as security for the materials supplied/contract works for the specified period.
<b>Specification:</b>	The Specifications and schedules (if any) agreed by the parties for the purpose of the Contract.
<b>Sub-Contractor:</b>	Any person (other than the Contractor) named in the Contract for any part of the Works or any person to whom any part of the Contract has been sub-let with the consent in writing of the Electricity North West Plant Policy Manager, and the legal representatives, successors and assigns of such person.
<b>Supplier:</b>	Any person or person's firm or company who supply goods to Electricity North West or Electricity North West contractor.
<b>Tender:</b>	An offer in writing to execute work or supply goods at a fixed price.
<b>Tenderer:</b>	The person or person's firm or company, including personal representatives, successors and permitted assigns, invited by Electricity North West to submit a tender.
<b>Works</b>	All materials, labour and actions required to be provided or performed by the Contractor under the Contract.



## **4. STANDARDS**

Transformers shall comply with ENA TS 35-2 except where otherwise stated. ENA TS 35-2 clause numbers appear in brackets after the section headings.

Any items not covered by the above specifications shall comply with requirements of British Standards (BS) and other ENA TS except when otherwise either specified or implied.

The Contract works are also to conform with the Electricity Supply, Quality and Continuity Regulations 2002, as amended, Health and Safety at Work Act 1974, Construction, Design and Management Regulations 2007 and to the Electricity at Work Regulations 1989 and any special regulations issued under the Act.

Tenderers are requested to confirm that the equipment complies with the Electromagnetic Compatibility (EMC) Regulations or to state those items that are not considered a requirement for EMC Conformity.

Electricity North West welcomes innovation and alternatives to traditional designs that still meet the functional requirements of this Specification. Variations shall be clearly identified in Schedule I and prices for compliant and non-compliant equipment detailed separately.

The Tenderer shall complete the conformance declaration sheet in Appendix D.

## **5. GENERAL REQUIREMENTS FOR APPROVALS AND TESTING**

### **5.1 Product not to be Changed**

No change in the product, packaging or labelling shall be made after Approval has been granted without prior notice to the Electricity North West Plant Policy Manager, and receipt of a written agreement to the proposed change from the Electricity North West Plant Policy Manager.

### **5.2 Electricity North West Technical Approval**

The Tenderer shall submit, with this Tender, proposals for testing which will demonstrate, to the satisfaction of the Electricity North West Plant Policy Manager, compliance with this Specification. Such tests shall be carried out without expense to Electricity North West.

Alternatively, the Tenderer may submit technical reports and other data that he considers will demonstrate, to the satisfaction of the Electricity North West Plant Policy Manager, compliance with this specification. Acceptance of this evidence shall be at the discretion of the Electricity North West Plant Policy Manager but will not be unreasonably withheld.

Approval shall be 'factory specific' and is not transferable to another factory without the written Approval of the Electricity North West Plant Policy Manager.

The supplier and product shall comply with all the relevant requirements of Electricity North West documents EPD311 and CP311.

### **5.3 Quality Assurance**

The Tenderer shall confirm whether or not Approval is held in accordance with a Quality Assurance Scheme accredited under ISO 9000. If not, he shall submit a statement of the quality assurance procedures employed to control the quality of the product, including the performance of Suppliers and Sub-Contractors.

The right is reserved for the Electricity North West Plant Policy Manager to require, from time to time, the repeat of such tests as he may deem to be reasonably necessary to demonstrate continued compliance with the Specification.

The Tenderer shall submit, with his Tender, a list of tests and inspections which are carried out on the product prior to despatch which shall demonstrate, to the satisfaction of the Electricity North West Plant Policy Manager, fitness for installation and service.

The Tenderer shall provide free of charge to Electricity North West such samples as may, in the opinion of the Electricity North West Plant Policy Manager, be reasonably required for inspection and/or retention as quality control samples. The Electricity North West Plant Policy Manager will confirm the requirement for samples at the time of Tendering.

The right is reserved for the Electricity North West Plant Policy Manager to make, from time to time, such inspections of the Tenderer's facilities as he may deem to be reasonably necessary to ensure compliance with this Specification and any Contract of which it forms a part.

The Tenderer shall submit, with his Tender, such details of product packaging disposal, as will enable Electricity North West to comply with the requirements of BS EN ISO 14001: 2004 - Environmental Management Systems.

### **5.4 Formulation**

The Tenderer shall submit, with his Tender, such details of the formulation and use of the product and associated substances as will enable Electricity North West to comply with the obligations of the Health and Safety at Work Act 1974 and the Control of Substances Hazardous to Health Regulations 2002, as amended, in the use, storage and disposal of the product. The Tenderer may stipulate, prior to submission of such information, that he requires it to remain confidential and the Electricity North West Plant Policy Manager will, if requested, confirm his agreement to this prior to receipt of the information.

### **5.5 Identification Markings**

The Tenderer shall submit, with his Tender, details of markings which it is proposed to apply to the product or packaging to identify manufacturing batches or items. The forms and content of such markings shall be subject to the Approval of the Electricity North West Plant Policy Manager, and shall in all cases include the Electricity North West Approved Description and Commodity Code Number.

The Tenderer shall submit, with his Tender, such details of marking gross weight on components, assemblies and packages, as will enable Electricity North West to comply with the Health and Safety Manual Handling Operation Regulations 1992, for components, assemblies and packages supplied with a gross weight over 1kg. The forms and content of such markings shall be subject to the Approval of the Electricity North West Plant Policy Manager.

## **5.6 Minimum Life Expectancy**

The minimum life expectancy of all products covered by this Specification is 40 years.

## **5.7 Product Conformity**

Preference will be given to those suppliers who can provide suitable Product Conformity Certification to a recognised or specified standard, or an equivalent certification.

## **6. REQUIREMENTS FOR TYPE AND ROUTINE TESTING.**

The Electricity North West Plant Policy Manager shall set out the requirement of the following tests to be carried out by the supplier at the suppliers' cost.

### **6.1 Requirement for type tests at the suppliers' premises**

These are a series of one-off type tests, which shall be carried out to ensure the satisfactory performance of the product design, under extremes of operating stresses, and of endurance, as may be appropriate, to be determined by the Electricity North West Plant Policy Manager.

These may or may not be destructive tests.

### **6.2 Requirement for routine tests at the suppliers' premises**

These tests shall be carried out on every individual unit or component.

The results of these tests shall be supplied to Electricity North West with each unit purchased and retained for inspection, at a period to be determined by the Electricity North West Plant Policy Manager.

Note: Further details of these tests can be found in Section 30 of this specification.

## **7. DESIGN**

The transformers shall be suitable for installation outdoors and shall comply with ENA TS 35-2, except where modified herein.

The design of accessories shall be co-ordinated so that the thermal rating of the transformers shall not be limited by these accessories.

The transformer shall be designed to ensure a minimum whole life cost; therefore Electricity North West would welcome designs for a self-contained unit, which occupies a small footprint.

The voltage ratio at no load on the principal tap shall be 33/11kV or 33/6.6kV as called for. Occasionally transformers with dual lower voltage ratios may be called for, 33/11/6.6kV.

## 8. RATED POWER (5)

The rated power is defined as the long term emergency cyclic loading on any tap position with cooling in operation with rated voltage supplied and output current as stated below with a winding hot spot absolute temperature of 110°C when tested as detailed in BS EN 60076. The oil temperature shall not exceed 90°C under these conditions.

The ONAN rating shall be not less than 50% of the long-term emergency cyclic rating.

**Table 1: Transformer Ratings**

ONAN Rating MVA	LTEC Rating MVA	LTEC Rating Secondary Amps (11kV)	LTEC Rating Secondary Amps (6.6kV)
4	8	420	700
7.5	15	785	1312
11.5	23	1200	2000
16	32	1679	2800
19	38	2000	See Note 1 Below

Notes: -

1. 33/6.6kV 38MVA transformers are not normally called for.
2. Special cases of high annual load factor requirements which may arise are outside the scope of this Specification.

## 9. TAPPINGS (6)

Tappings shall be provided on the 33kV winding for a variation of the no-load primary voltage of +5.72 to -17.16% in 16 steps of 1.43% per step. ( $\pm 10\%$  based on tap 7; Electricity North West is normally set on tap 5).

## 10. LOSSES (6.6)

Tenderers shall be ensure that all Transformers comply with the Tier 1 losses as stated within the European Union Commission Regulation for Transformers No 548/2014 as part of the European Union Ecodesign Directive (2009/125/EC).which are valid until 2021. In 2021 Tenderers shall be ensure that all Transformers comply with the Tier 2 losses as detailed within the European Union Eco Transformer Directive.

Guaranteed values for the no-load and component losses of each transformer shall be stated in Schedule D3. These losses will be taken as the basis of evaluation of the tender, for acceptance or rejection of the completed transformer and for variation of the contract price in the manner set out in Schedule F1.

The acceptance or rejection of transformers yielding component losses which are either higher, equal to, or below the guaranteed values shall be governed by the sub-clauses as detailed in Schedule F2.

## 11. NOISE (11.14)

### 11.1 Requirements

The transformer noise levels shall be measured in accordance with BS EN 60076-10. The acceptance level of the transformers shall be to the requirements of Section 11.2 below.

Anti-vibration pads shall be provided between the transformer base and the plinth. The material of the pads shall be of oil and weather resisting rubber or other approved material.

All transformers shall be suitably arranged to permit installation of either initially, or at a later date under a separate contract, noise reduction facilities. It is preferable that the noise reduction facilities do not require the construction of a separate freestanding enclosure. Electricity North West would expect that additional noise reduction measures should deliver noise reductions of 15dB beyond the levels set out in Table 2.

### 11.2 Sound Power Levels

The sound power level shall not be greater than those given in Table 2 when measured in accordance with BS EN 60076-10. No anti vibration pads will be mounted between the tank base and floor during this test.

**Table 2; Sound Power Levels**

<b>LTEC Rating (MVA)</b>	<b>ONAN Sound Power Level (dBA)</b>	<b>Cooler Sound Power Level (dBA)</b>
8	61	79
15	63	81
23	65	83
32	67	84
38	68	85

The transformer manufacturer shall state the expected sound power level in Schedule D3.

Sound power measurement tests are required as routine on all transformers and cooler banks. The tests shall be carried out with the transformer and cooler erected. The costs of such measurements are to be included in the basic price.

If the measured sound power level exceeds the guaranteed value the manufacturer will be responsible for the full cost of any and all works necessary either in the factory or on site to achieve the guaranteed sound levels. If remedial work is completed in the factory the noise tests shall be repeated at manufacturer's cost.

## **12. IMPEDANCE (6.5)**

The impedance value shall fall within the envelope attached in Appendix B, Figure 1.

Should it be necessary to replace one transformer of a matched pair or create a matched pair at an existing single transformer site, the new transformer impedance shall be determined using the following statements:-

- (a) Should the original transformer be outside the impedance envelope in Appendix B, Figure 1. The new transformer impedance shall match the impedance of the original transformer.
- (b) Should the original transformer impedance be within the envelope in Appendix B, Figure 1. The new transformer impedance shall also fall within the same impedance envelope.

## **13. TERMINAL ARRANGEMENTS (15.3)**

Oil filled disconnecting chambers in accordance with ENA TS 35-2 Clause 15.3 are required for all terminations other than open bushings.

## **14. TERMINATIONS**

### **14.1 Cable Termination Enclosures**

Where cable termination enclosures are required they shall be suitable for screened elbows.

The cable termination enclosure design shall be to BS 6435 "Specification for unfilled enclosures for dry termination of HV cables for transformers and reactors".

Provision shall be made for securing cable termination enclosures against unauthorised access (additional to studs/nuts).

All gland plates shall be pre-drilled with 85mm diameter holes to accept Heatshrink feedthroughs (one hole per cable core).

Two sets of wooden cleats shall be provided by the manufacturer for each cable box, one at normal height and one at ground level. Wooden cleats to be pre-drilled with a range of sizes from 41mm upto 48mm diameter holes (one hole per cable core). The Specifier shall inform the Supplier at the time of order which size will be used.

A continuous earth bar shall be provided to bond all enclosures together.

The design of the cable termination enclosures shall be agreed with the Electricity North West Circuits Policy Manager before manufacture.

## 14.2 HV Terminals (33kV)

Maximum cable size 500mm<sup>2</sup> for single core cable.

Unfilled terminations are required. Cable termination bushings shall comply with BS EN 50180 Table 14 Type C and be provided with a separate stem. Terminations shall be aligned to allow cables to be mounted vertically.

A cable support bracket shall be provided, designed to allow the cable to be positioned vertically from the termination.

A set of three 60pF capacitor bushings for Neutral Voltage Displacement protection shall be fitted as standard. Type C bushings may be used as capacitor bushings where adequate test evidence can be supplied to prove consistent capacitance and will adequately drive the protection. A rating plate for the capacitor bushings shall be provided at the small wiring terminals clearly stating the capacitance for each phase.

Note:-The requirement is to fit both sets of bushings, connected in series, The capacitor bushings are to be fitted under oil between the main tank and a disconnecting chamber. The type C bushings are to be fitted between the disconnecting chamber and the cable termination enclosure/cable box. Links are supplied and fitted to connect the two sets of bushings together, within the disconnecting chamber.

## 14.3 HV Neutral

A HV Neutral connection shall be supplied for all star/star transformers.

A single pole cable termination enclosure suitable for one single core cable shall be provided in accordance with ENA TS 12-11.

Unfilled terminations are required. Cable termination bushings shall comply with BS EN 50180 Table 14 Type C and be provided with a separate stem. Terminations shall be aligned to allow cables to be mounted vertically.

A cable support bracket shall be provided, designed to allow the cable to be positioned vertically from the termination.

Cable boxes shall comply with the requirements of ENA TS 12-11.

## 14.4 LV Terminals (11/6.6kV)

All 33/6.6kV transformers shall be provided with two three pole boxes each suitable for two single core cables per phase. 33/11kV transformers, below a rating of 11.5/23MVA, shall be provided with one three pole cable box, all 11.5/23MVA and above ratings shall be provided with two three pole cable boxes.

Unfilled terminations are required. Cable termination bushings shall comply with BS EN 50180 Table 14 Type C and be provided with a separate stem.

Terminations shall be designed to allow cables to be mounted vertically.

Cable boxes shall comply with the requirements of ENA TS 12-11.

## 14.5 LV Neutral

A single pole cable termination enclosure suitable for one single core cable shall be provided in accordance with ENA TS 12-11.

Unfilled terminations are required. Cable termination bushings shall comply with BS EN 50180 Table 14 Type C and be provided with a separate stem.

Terminations shall be designed to allow cables to be mounted vertically.

Cable boxes shall comply with the requirements of ENA TS 12-11

## 14.6 Unit Auxiliary Transformer

Where unit auxiliary transformers are called for these shall be three phase 415V rated secondary voltage, vector group Dyn11.

The low voltage secondary terminals shall be connected to two fuses per phase with the live connections individually insulated by approved means. The neutral shall be provided with one bolted link with two separate outgoing terminals. The transformer neutral terminal shall also be provided with a bolted link clearly marked "LV neutral earth" connected to a terminal. The fuses and links shall be enclosed in a weatherproof enclosure with hinged door provided with padlocking facilities. The enclosure shall be provided with three glands each suitable for four core 7/0.67mm PVC/SWA/PVC cable. Where a unit auxiliary transformer is called for the Tenderer shall include for the provision, termination and connection of one of these cables to the incoming supply terminals in the cooler control cabinet.

## 15. GENERAL ARRANGEMENT (14.3)

All oil inlet and outlet connections to the tank shall be fitted with a valve.

Oil sampling points shall be fitted to the transformer main tank so as to allow oil sampling of both the top and bottom oil from ground level and without the need to de-energise the transformer.



## 16. TANKS AND COVERS (15.1)

If an external tap changer is fitted, access is required to permit disconnection and removal without the need to lift the main lid.

All fittings that require manual intervention (i.e. sampling points, topping up points, breathers, etc.) shall be positioned so that they are accessible from ground level, therefore eliminating the need for working at height.

Electricity North West requires access to the tanks and covers for maintenance and operational reasons. This shall be done by the use of portable insulated zip up type scaffolding. The manufacturer shall design suitable anchor points around the transformer tank for secure attachment of the scaffolding. These anchor points shall be clearly identifiable by the operator. In addition, the tank lid shall be painted with anti-slip paint and rails and/or attachment points shall be provided to give a safe method of working on top of the transformer tank lid. Tenderers shall submit full details on the paint and rail system with their Tender. Where ladders are required to access the transformer lid attachment points for the Tetra tethering kits shall be provided and clearly identifiable by the operator.

Each tank shall be of adequate strength such that the transformer can be lifted and transported without permanent deformation or oil leakage.

Each transformer shall be equipped with a suitable bank of radiators. The radiators shall be divided into two 50% cooling banks.

## 17. GASKETS (15.1.3)

In all cases where access is required for erection, jointing, site tests or other pre-commissioning work a working set of gaskets shall be provided in the uncompressed state. A disposable set shall be used for transit and storage.

## 18. OIL (14.2)

Subject to contract negotiations, Electricity North West reserves the right to supply the first on site filling of oil.

Electricity North West reserves the right to enter into a separate contract for the supply of insulating oil for use in any transformers ordered as a result of this enquiry. The names of oil suppliers shall be stated and alternative prices less oil quoted in the price schedule. Should this method be adopted it is envisaged that Electricity North West will order oil to be delivered in reasonable bulk quantities to the works of the Tenderer, free of charge. The timing of such delivery or deliveries is to be negotiated.

Transformers shall be supplied complete with the first filling of insulating oil, unless otherwise specified. For testing and commissioning, the oil shall be naphthenic base and comply with the requirements of BS EN 60296:2004 with the following additions:-

- (a) Gassing tendency shall be less than 5mm<sup>3</sup>/min.
- (b) Polycyclic aromatics shall be less than 3%.
- (c) Additives shall not be used.
- (d) It shall be certified free from Polychlorinated Biphenyls (PCB).

- (e) Corrosive sulphur and potentially corrosive sulphur shall be classified as “Non-corrosive” as determined by the test methods prescribed in BS EN 62535:2012 and ASTM D 1275B.
- (f) Un-inhibited oil shall be used.

For compatibility, the oil shall conform with the requirements of Electricity North West’ current type of oil, particulars of which shall be obtained from Electricity North West at the contract stage. In the event that the oil to be supplied is other than the Electricity North West’ standard oil, the Contractor shall substantiate its compliance with BS EN 60296:2004 and that there will be no long-term detriment to the mixing of oils as a result of chemical reaction between additives from his oil and additives from Electricity North West’ oil. A sample of the oil shall be delivered to Electricity North West Central Oil Reprocessing Department, Whitebirk for testing.

Subject to site fire risk assessments, alternative fluids may be required. Tenderers shall submit with their Tender full technical details of all available alternative fluids. The technical details shall include full fluid details, manual handling, testing and disposal as a minimum. Tenderers shall also detail in full and supply with their Tender, all technical evidence and testing for alternative fluids within the Tendered Tapchanger.

## **19. FITTINGS (15.6)**

### **19.1 Cooling Plant**

It is preferable that the coolers should be tank mounted and avoid the need to provide a separate plinth.

Where separate cooler banks are used, couplings designed to reduce the transmission of vibration shall be provided in all pipework. The Tenderer shall provide Electricity North West with details of the additional costs for a separate cooler bank by using Appendix A Schedule G.

In some instances noise reduction will be required to reduce the noise levels 15dB lower than the values stated in section 11.1 Table 2 of this Specification. Tenderers shall provide details of how this noise reduction can be achieved. The Tenderer shall provide a separate price for this noise reduction requirement.

Drain plugs and air release plugs shall be provided in each radiator element.

A cooler monitoring relay shall be provided in the Marshalling Cubicle (MC). The relay shall monitor the cooler three phase supply and the running current of the individual motors and test run the motors at user defined intervals. The relay will provide volt free contacts for alarm indication of motor failure, supply failure and relay failure.

The cooler monitoring relay shall comply with the requirements of ENA TS 48-5. Tenderers shall provide details of the relay with the tender for Approval by Electricity North West Protection Policy Manager.

### **19.2 Gas and Oil Actuated Relay**

Attention is drawn to the need to start the pump for routine testing purposes when the oil is at a low temperature, on such an occasion the relay shall not operate.

### 19.3 Pressure Relief Device

A pressure relief device of the spring operated self sealing type complete with tripping contacts rated at 10A 125V d.c shall be supplied along with an alarm contact. This shall be vented to within 1 metre of ground level and away from any manual operating position.

### 19.4 Winding Temperature Indicator (WTI)

Ashridge 852 plus Winding temperature indicators shall be provided with a total of four independently adjustable contacts, two being as ENA TS 35-2 to provide separately for control of fan(s) and pump and the other two for alarm and trip.

Capillary tubes shall be armoured and PVC sheathed overall. The length of the capillary from the sensing head to the cooler control cabinet is under the full control of the Tenderer and shall not be of excessive length.

The WTI shall be fitted with a Linear Variable Differential Transformer (LVDT) to provide remote temperature indication to Electricity North West's telecontrol equipment. Variable resistance types are not acceptable.

The output range is 0 - 2 - 10mA for a temperature range 0 - 30 - 150<sup>0</sup>C.

Modern digital WTIs can be proposed which provide equivalent temperature indication and also suitable alarm and trip contacts.

For all transformers rated less than 38MVA (LTEC rating) the Tenderer shall confirm in writing to the Electricity North West Plant Policy Manager, if one WTI is adequate for accurate analysis of the oil and hot spot temperature differences. The Tenderer shall also specify to which winding the WTI shall be connected.

If one is not adequate, two WTIs shall be fitted.

For all transformers rated at 38MVA, two WTIs shall be fitted as standard.

The transducer and any power pack shall be located in the WTI compartment of the MC.

The WTI's shall be equipped with output control contacts typically configured as follows, , however the transformer manufacturer shall advise of alternative temperature limits to ensure the most efficient long term operation of the transformer based its design.

- |     |               |       |
|-----|---------------|-------|
| (a) | Alarm         | 110°C |
| (b) | Trip          | 135°C |
| (c) | Start cooling | 75°C  |
| (d) | Stop cooling  | 50°C  |

The winding temperature indicators which provide the automatic cooler control functionality shall be capable of providing the following functionality:-

- (a) Programmable test feature to run all fans / pumps on a weekly basis and provide alarms in the event of a single fan / pump motor failure. This shall be configured to perform a cooler test at 12:00 during a weekday.
- (b) Manually forcing output contacts for the purpose of checking the operating of the contacts and associated equipment.

The WTI relay shall comply with the requirements of ENA TS 48-5. Tenderers shall provide details of the relay with the tender for Approval by Electricity North West Protection Policy Manager.

## 19.5 Current Transformers

Rated primary currents shall be selected from the range 800A, 1200A or 2000A to match the long term emergency rating of the transformer.

Rated secondary currents shall be 1A.

All current transformers shall be capable of continuous running with the secondary connections short-circuited and the long term emergency rated current applied to the primary, a short-circuiting facility or otherwise a suitable protective device shall be connected direct to the secondary terminals in the tank-top terminal box.

A CT shall be provided in the middle LV phase for Line Drop Compensation. It shall be 1A secondary, 40VA class 1.0.

## 19.6 Other Fittings

Top and bottom valves may be called for as an optional extra for the isolation of individual radiator elements. These shall be of an approved type, which limit the oil flow sufficiently to remove an element and fit gasketed blanking plates without undue spillage of oil.

## 19.7 Oil Level Indicators

Oil level indicators shall be provided and positioned to ensure that viewing is possible at ground level.

Each oil container such as a transformer conservator etc. shall be fitted with direct reading oil level gauge. The range of indicated oil level shall correspond to average oil temperatures from -10°C to +80°C. The normal level at 15°C shall be marked so that it is clearly visible from ground level. In addition, the normal filling level of all removal oil containers is to be marked on the inside. If a dial indicator is used it shall have a scale of at least 150mm diameter and be marked with the normal level at 15°C clearly visible from ground level and be easily dismantled for cleaning.

Oil level alarm outputs shall be provided in line with the requirement below.

Each oil level gauge shall be provided with a volt free alarm contact to provide an alarm to the Electricity North West Network Management System. The contact shall be arranged to be normally open and close under alarm conditions (i.e. Low oil level).

## 19.8 Breathers

Each transformer shall be fitted with a regenerative breather of a design to be approved by Electricity North West. The breathing mechanism used for the tapchanger shall be of the same type as that used on the main tank in order to reduce numbers of spares required.

## 19.9 Accessibility

All fittings that require manual intervention (i.e. sampling points, topping up points, breathers, motors, fans, valves etc.) shall be positioned so that they are accessible from ground level, without restricted access and the need to stretch or strain, therefore eliminating the need for working at height.

## 19.10 On-Load Tap Changers (OLTC)

On-load tap changers shall comply with IEC 60214 and shall be suitable for power flow in both directions. Only designs which have been type tested in accordance with these standards will be accepted.

Component parts of the tap changing equipment shall be accessible for examination, adjustment and repair.

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Equipment shall be designed for minimum maintenance.

An on-tank or in-tank vacuum type on-load tap changer which requires very low or zero maintenance and minimum number of operations of 150 000 operations between maintenance is preferred.

Where the Tapchanger is of a non-vacuum type then the following applies. The switches and the oil of the diverter-switch and selector-switch compartments shall be capable of withstanding a minimum of 30 000 operations at not less than the maximum rated through current, without requiring attention. Contacts used for making and breaking current shall be capable of performing a minimum of 30 000 operations at the maximum rated through-current, without requiring attention. Plus, the minimum periods between recommended maintenances shall be no less than 6 years. Evidence shall be submitted with the Tender return.

An oil sampling facility shall be provided for the diverter chamber of an in-tank tap changer. The sampling facility shall be positioned at ground level.

The manufacturer shall also supply a Tap Position Indicator on the Tap Changer with a scale as detailed in Appendix B Figure 2.

A non-resettable counter shall be fitted to the driving mechanism of the OLTC to indicate the number of operations completed.

## 19.11 Pump Flow Meter

Consideration shall be given to the position of the pump flow meter, if fitted, such that viewing is possible when a noise enclosure is fitted.

## 20. VALVES (15.6.8)

Padlocks shall not be supplied.

## 21. SURFACE FINISH (15.2)

The tank, fans (including motors and bearings), pumps and all radiators surface finishes shall not require maintenance for a period of at least 30 years in a polluted or coastal environment according to EN ISO 12944-2 Category C4 as a minimum. Tenderers shall also supply full details for the option of a C5M finish for coastal locations as part of the Tender return. As detailed in Section 16, The tank lid shall be painted with anti-slip paint. The Tenderer shall provide full details of the surface finish system used and anti-slip finish with the Tender return.

Any damage to the paintwork during the delivery or during erection on site by the Contractor shall be made good to the satisfaction of the Electricity North West Plant Policy Manager.

## 22 Marshalling Kiosks (15.7)

Indoor Control cubicles are the subject of a separate enquiry.

### 22.1 General Requirements

An outdoor marshalling kiosk is to be provided by the Contractor.

All marshalling kiosks shall be mounted on the main tank of the transformer.

The construction and mounting arrangement of marshalling kiosks shall:

- (a) Be weatherproof,
- (b) Prevent the retention of water externally,
- (c) Be proofed against vermin,
- (d) Be ventilated and heated to prevent condensation.

Cables shall enter from the bottom, and removable gland plates shall be provided at not less than 800mm from plinth level or at an increased height which shall be specified at time of order to provide increased flood protection.

Glands, gland plates and cable compartments shall be adequately sealed to prevent moisture entering other compartments.

Paint protection systems shall comply with the requirements of Section 21.

Doors shall comply with the following requirements:

- (a) Be of the lift-off type.
- (b) Have “dished” edges, containing an oil and weather resisting gasket, to create a labyrinth seal against the compartment flange.
- (c) Open through 180°.
- (d) Have integral “stay-bars” for positive location at 90°.
- (e) Be fastened by integral handles; nuts, bolts or carriage keys shall not be used.
- (f) Bearings for handles and fixings for hinges shall be weathertight.
- (g) Be lockable to prevent unauthorised access.
- (h) Incorporate an upwards opening outer door to create an operation rain hood.

Provision shall be made for padlocking. The padlock will have a shackle of 7mm diameter, a shackle height of 20mm and radius of 8mm. Other forms of locking are not acceptable. Handles and padlocking facilities shall not be more than 1500mm above plinth level.

Top covers of marshalling kiosks shall be arranged to carry water clear of all sides. The cover shall be removable, fixed internally with studs which do not pierce the cover.

Terminals shall be grouped according to their function, which shall be identified on the fixed portion of the terminal boards, ie Alarm, Trip, Cooler Control, Remote WTI.

Individual components shall be easily removable without disturbing other apparatus or wiring.

## **22.2 Earthing**

A 25 x 3mm copper bar, mounted on stand-off insulators, shall be provided.

Each metal case of apparatus mounted in marshalling kiosks shall be connected to earth by an insulated wire, coloured green/yellow.

The mid-point of secondary windings of control circuit transformers, shall be earthed through a removable bolted link to the earth bar.

The earth socket of the switched socket outlet shall be separately connected to the kiosk earth by an insulated wire, coloured yellow/green.

## **22.3 Ventilation and Heating**

A 230V a.c. metalclad, anti-condensation, heater(s) shall be provided. The heater shall be protected by a fuse and neutral link, and controlled by a thermostat(s) located within each marshalling kiosk.

The surface temperature of heaters shall not exceed 65°C.

Ventilation louvres shall be provided near the top and bottom on the sides of marshalling kiosks.

The heater circuit shall be supplied from the 'Transformer Auxiliary Supplies' incoming 230V, 1ph, a.c. supply.

## **22.4 Fittings - General**

Unless otherwise specified, the marshalling kiosks shall be fitted with the following:

- (a) 1 off 13 A, 3 pin, 30mA protected (integral) switched socket for 230V a.c. supply. The 13A socket shall comply with BS1363.
- (b) 1 off, 30mA RCD to provide a 230V a.c. supply to a sump pump circuit (by others).

## **22.5 Indoor Tap Change Control Cubicle**

The tap change control cubicle is normally specified separately and ordered from a separate supplier.

The transformer tap change control indication shall be provided with a dedicated bank of eighteen resistors each 400Ω 5 watt wirewound ceramic coated, mounted at a convenient position.

Mounting of the resistors directly on the terminals of the position switch would not be excluded.

## 23. AUTOMATIC VOLTAGE CONTROL SCHEME

The scheme shall be as detailed on the Electricity North West schematic diagram.

The preferred scheme is detailed as per the drawings in the table below:-:

Drawing number	Revision Number	Drawing Title
900480-004.dwg	1	STANDARD CIRCUIT DIAGRAM OF PRIMARY TRANSFORMER COOLER CONTROL & VOLTAGE CONTROL USING SUPERTAPP RELAY (SHEET 1 OF 2)
900480-005.dwg	1	STANDARD CIRCUIT DIAGRAM OF PRIMARY TRANSFORMER COOLER CONTROL & VOLTAGE CONTROL USING SUPERTAPP RELAY (SHEET 2 OF 2)

All other drawings are held in Appendix C where the Specifier requires them on a site by site basis.

## 24 Connections and Wiring

### 24.1 General Requirements

Insulated wires shall comply with BS 6231 or equivalent IEC. Wire sizes shall be the responsibility of the Contractor, however all CT wiring shall be a minimum of 2.5mm<sup>2</sup> cross sectional area. Due consideration shall be given to requirements for fuse grading, current rating, voltage-drop, mechanical strength and terminations.

Fuses shall comply with the requirements of BS 88 or IEC 60269. MCBs shall comply with the requirements of BS EN 60898. Application of MCBs shall follow the general principles as applied to fuses.

### 24.2 Interconnecting Cables

The Tenderer shall provide, for Approval by Electricity North West, a schedule detailing the multi-core cables for interconnection of ancillary equipment.

Each multicore cable shall be given its own unique reference number and identified by a suitable cable marking system.

All AC supplies shall not be in the same multicore as the DC supplies.

External cabling between the transformer fittings and the marshalling kiosk, shall consist of PVC insulated and sheathed steel wire armoured cable with PVC overall.

External cables shall be adequately fixed to cable trays using cleats or saddles. Where cable ties are used they shall be of the stainless steel type.

Cables passing through noise enclosure walls shall be grouped together. A removable panel of weak mix cement, shall be provided.



### 24.3 Small Wiring

The small wiring shall conform to ENA TS 50-18. All internal wiring shall be white.

All insulated wire shall be not less than 19/0.32mm (1.5mm<sup>2</sup>) for 110V and the design of the wiring cleats if used shall be such that only limited pressure can be transmitted to the wire. For CT/VT wiring the minimum size shall be 19/0.41mm (2.5mm<sup>2</sup>). All pilot wiring shall be a minimum size of 2.5mm<sup>2</sup> and comply with Electricity North West Specification ES400C13. Pilot wiring shall be run separate from other protection and control wiring or double insulated where run together.

Each end of each wire or control cable connections shall be provided with a white interlocked ferrule bearing an engraved number in black corresponding to the diagram of connections. The use of printed ferrules may be considered but the system proposed must be approved by the Electricity North West Protection Systems Manager prior to being used. The numbering of all connections shall correspond with the Electricity North West standard schemes, which are based on ENA TS 50-19 – Standard Numbering for Small Wiring.

Terminals for multicore cables of 2.5mm<sup>2</sup> section shall be rail mounted, screw clamp with spring loading, or insertion clamp spring, unit type without isolation facilities. They shall meet the requirements of ENA Technical Specification 50-18 Type “B” with dimension “C” not less than 11mm or BS EN 60998. (Typically Weidmuller WDU10SL or RSF-1 or equivalent for current transformer circuitry and Wedimuller WDU6SL or RSF3 or equivalent for all other protection and control circuitry). All crimps shall be of the insulated type.

For Telecontrol and alarm circuits, the terminals may be required to have an isolation facility. In such cases this shall comprise of a hinged lever having positive positioning in both open and closed positions. Connections shall be of the insertion clamp spring or screw clamp type. These shall be of the Weidmuller WTR4SL or SAKR or equivalent type. The terminals shall have test points suitable for accommodating 2.3mm diameter test plugs.

Terminal rail shall be galvanised steel either TS32 or TS35 as appropriate to match terminals and comply with ENA TS 50-18, and/or BS EN 60715.

All wiring of 1mm<sup>2</sup> (32/02) and larger shall be terminated with suitable insulated crimped terminations. For insertion clamp spring terminals a boot lace ferrule shall be used. For power circuits, CTs and trips, spring loaded terminals shall be used with hook type terminations.

For plain screw clamp terminations, blade type terminations shall be used. For stud type a phosphor bronze spring washer and full nut shall be used. For a plain screw into a tapped hole a phosphor bronze spring washer shall be used.

### 25. DATA SCHEDULES

Tenderers shall complete all necessary schedules in Appendix A. A separate set of data sheets is required for each combination of rating, ratio or vector group included in the enquiry.

A design reference is required to enable identification of the particular design. This may be the manufacturer’s internal reference. The serial number of the transformer type tested for Electricity North West of this particular design reference shall also be quoted if this design has previously been type tested for Electricity North West. Appendix A Schedule D4 shall be completed.

## 26. ENA STANDARD DRAWINGS (ENA TS 35-2 ISSUE 6)

Figure 1 Replaced by Figure 1 of this Specification.

Figure 4 Shall also indicate switching between ONAN and LTEC conditions including details of shunts.

## 27. TELECONTROL

An additional transformer tap position indication switch shall be provided for SCADA indication. This shall comprise of a bank of eighteen resistors each 400Ω 5 watt wire wound ceramic coated, mounted at a convenient position.

Mounting of the resistors directly on the terminals of the position switch would not be excluded.

## 28. TRANSFORMER MANAGEMENT SYSTEMS

The Tenderer shall quote separately for a factory fitted transformer management system. The management system shall include as a minimum the following features:

- Functions required on transformer:
  - Voltage and Current
  - Oil temperature
  - Ambient Temperature
  - Oil level in tank and conservator
  - Control, Monitoring and auto checking of fans, pumps and issuing of alarms on failure and Auto-Test
- Functions for Tap Changer:
  - Monitoring of tapchanger operations – tap position, number of taps carried out, highest tap reached, lowest tap reached, tapchange fail
  - Number of operations per tap position
  - Power Consumption of OLTC mechanism
  - Difference in oil temperature between OLTC and main tank (only for external tapchanger)

The Tenderer shall specify other features on the management system, indicating which are standard and which are optional. Any factory fitted options, which may be available, shall also be described (e.g. continuous partial discharge monitoring of bushings, continuous moisture measurement). The costs of the standard and optional features shall be identified.

The monitoring system shall be capable of interfacing with the Electricity North West SCADA system which operates on an IEC 870-5-103 protocol.

## 29. DRAWINGS, ASSEMBLY, OPERATING AND MAINTENANCE INSTRUCTIONS, MODELS AND SAMPLES

### 29.1 Drawings

Drawings shall be to scale and fully detailed. Dimensions on drawings shall be in SI units. General arrangement drawings submitted shall be to a scale not less than 1 to 50 and all detail drawings not less than 1 to 20. In exceptional circumstances where the use of a scale of 1 to 20 is not practical a scale of 1 to 33 may be adopted. Drawings shall have minimum dimensions 210mm x 297mm. (A4) ISO size, and shall not exceed in one direction 841mm for ISO sizes of sheets. All drawings shall have a clear margin 25mm wide along the bottom. A4 booklets are not acceptable

Any drawing for Approval shall be submitted by the Contractor in duplicate, at all stages of revision, until it is agreed by the Contractor and the Electricity North West Plant Policy Manager that the drawing is in this final form. Drawings, other than those requiring Approval, agreed between the Contractor and the Electricity North West Plant Policy Manager as being appropriate to the Contract, shall be supplied in duplicate. The above drawings shall be in the form of white paper prints.

For final records the Contractor shall supply:

- (a) A Contract drawing list giving the number, title and revision of each drawing.
- (b) Two paper prints of each drawing.

One copy of each drawing and the Contract drawing list shall be provided to the Electricity North West Design Manager, Grid and Primary Programme Delivery (Major Projects) on CD-ROM in either DWG (AutoCAD) or DXF (Drawing Exchange Format) format. A further copy of each drawing and the Contract drawing list shall be provided to the Electricity North West Plant Policy Manager on CD-ROM in PDF (Adobe Acrobat) format.

The Contract drawing list shall be submitted by the Contractor for Approval by the Electricity North West Plant Policy Manager, who will indicate thereon Electricity North West' requirements for final records, which shall be supplied one month before the commencement of the maintenance period or at such earlier date as may be required by the Electricity North West Plant Policy Manager.

When applying for design type Approval, the (sub) contractor shall submit for Approval drawings clearly showing in full detail the equipment for which Approval is being sought. Any change made following Approval may invalidate the Approval given.

The list of Drawings which shall be submitted by the Tenderer with his Tender is detailed in Schedule E.

The Contractor shall submit for Approval the under mentioned Drawings for each type of transformer at the time indicated below, or at such other time as may be agreed with the Electricity North West Plant Policy Manager.

The following Drawings, as applicable, are to be supplied by the date shown in Schedule B Item 1:

- (a) Definite foundation plan drawing and provisional outline drawing for the complete transformer.
- (b) General arrangement of cable entry boxes and disconnecting chamber.

- (c) General arrangement of Marshalling Cubicle.
- (d) Outline drilling templates of all loose apparatus supplied as part of the Contract Works for mounting and wiring on panels under a separate Contract(s).
- (e) Diagram(s) of contacts and sequence of operation of all switches supplied as part of the Contract Works for mounting and wiring on Panel(s) under a separate Contract(s).
- (f) Diagram(s) of connections of all loose apparatus supplied as part of the Contract Works for mounting and wiring on Panel(s) under a separate Contract(s).

The following Drawings, as applicable, are to be supplied prior to the commencement of manufacture:

- (a) Definite outline drawings for complete transformer. This drawing shall be supplied to the Electricity North West Grid and Primary Design Team Manager within one month after any order being placed.
- (b) Sectional arrangement Drawing(s) of the windings, method of coil bracing, core or magnetic (leakage flux) shield construction and core earthing, and any directed oil flow arrangement.
- (c) Name, rating and diagram plate and diagram of connections of transformers and associated equipment showing the relative position of leads taken out of the tank.

The following diagrams shall be supplied to the Electricity North West Grid and Primary Design Team Manager within three months following any order being placed:

- (a) Circuit and wiring diagrams of tap-change control circuits and cooler control circuits including tap changer driving mechanism, marshalling kiosk and standby control panels, as applicable.
- (b) Details and diagram connections of winding temperature alarm trip and cooler control arrangements.
- (c) Detailed Drawing of oil/coolers.
- (d) Multicore cable schedule.
- (e) Drawing(s) showing any special features likely to need special attention during inspection, testing, maintenance or repair.

## **29.2 Assembly, Operating And Maintenance Instructions**

Before the specified completion date shown in Schedule B, Item 4, the Contractor shall submit Assembly, Operating and Maintenance Instructions and Diagrams for Approval by the Electricity North West Maintenance Strategy Manager and after Approval, but no later than one month before the commencement of the maintenance period, shall supply in a durable form, the number of copies specified in Schedule D Item 30. A copy shall be supplied to the Electricity North West Plant Policy Manager in electronic (pdf) format.

As part of the operation and maintenance instructions the Contractor shall include formal risk assessments and method statements for the tasks to be carried out, particular attention shall be paid to those activities which will require working at height.

### 29.3 Models And Samples

The Contractor shall submit models and samples of materials as required from time to time by the Electricity North West Plant Policy Manager.

## 30. TESTS

### 30.1 Tests Before Delivery

**Table 3; Testing Sequence**

Test No	Test	Routine	Type
1	Degree Of Polymerisation	X	
2	Dissolved Gas Analysis	X	
3	Winding Resistance	X	
4	Polarity	X	
5	Losses And Impedance:		
	(a) Load Losses	X	
	(b) No-Load Losses	X	
6	Noise Level	X	
7	Voltage Ratio	X	
8	Harmonic Spectral Analysis		X
9	Zero Phase Sequence Impedance		X
10	Temperature Rise (3 runs)		X
11	Dissolved Gas Analysis		X
12	Applied Voltage	X	
13	Impulse Voltage		X
14	Insulation Resistance	X	
15	Induced Voltage	X	
16	Discharge Measurement	X	
17	Magnetic Circuit Insulation	X	
18	Hydraulic Pressure Tests	X	
19	Oil Leakage Tests	X	
20	Tap Changer	X	
21	Dissolved Gas Analysis	X	
22	Sweep Frequency Response Analysis	X	
23	Physical Dimensions Check	X	X

Tests shall be performed in the sequence indicated except that:-

- Tests 3 to 9 may be in any convenient sequence but prior to all others.
- Test 8 is a Full Harmonic Spectral Analysis and shall be completed on all Transformers.
- Test 9 applies to Star-Star Transformers Only.
- Tests 17, 18, 19, 20 and 23 may be taken at any convenient opportunity during the above sequence.

- Test 22 shall be performed after all other tests have been completed. Should an independent test station be used a Sweep Frequency Response Analysis test shall be completed before the transformer leaves the factory, when the transformer arrives at the test station, before the transformer leaves the test station and again once the transformer arrives back at the factory. The results for this test shall be supplied to the Electricity North West Plant Policy Manager as detailed in section 30.2.19 of this specification.

Two copies of the test results in electronic format (pdf) shall be forwarded; one to the Electricity North West Design Manager, Grid and Primary Programme Delivery (Major Projects) and one to the Electricity North West Policy and Implementation Department for the attention of the Electricity North West Plant Policy Manager.

Electricity North West reserves the right to witness any of the routine or type tests. This will comprise a minimum of all tests on the first of a new design from any factory will be witnessed by Electricity North West. The Contractor shall cover travelling, accommodation and other reasonable expenses incurred whilst two Electricity North West representatives are witnessing the type tests. The Contractor shall provide a minimum of four weeks notice of any intended type testing elements.

Electricity North West reserves the right to witness routine tests on any subsequent units.

## **30.2 Details Of Tests**

Testing shall be carried out as in BS EN 60076 except where otherwise stated. The additional requirements of ENA TS 35-2 are included below.

### **30.2.1 Degree of Polymerisation (DP) (Routine)**

In order to assist with future condition based assessment of the transformer it is necessary to ascertain the DP of the paper. Therefore a DP test shall be carried out on the paper before and after the drying process.

A small sample of paper used for the winding insulation shall be DP tested before the winding is dried. The same sample of paper shall be dried along with the winding and re-tested following the drying process. The DP test results from both tests shall be sent to the Electricity North West Plant Policy Manager.

### **30.2.2 Resistance (Routine)**

Resistance shall be measured for each winding at principal, maximum and minimum tap positions, results being corrected to 75°C.

### **30.2.3 Polarity (Routine)**

As BS EN 60076-1.

### **30.2.4 Losses and Impedance (Routine)**

- The load losses and positive sequence impedance shall be measured on maximum, principal, mean and minimum tapping positions at not less than 50% of corresponding LTEC current.
- The no-load loss and magnetising current shall be measured at principal tap with 90%, 100% and 110% of rated voltage applied.

### **30.2.5 Noise Level (Routine)**

Test in accordance with BS EN 60076-10. Coolers shall be tested as erected, not as separate elements.

### **30.2.6 Voltage Ratio (Routine)**

This test is carried out on each tapping to determine the voltage ratio between HV and LV windings. The vector group shall be determined by comparisons of voltmeter readings measured between appropriate terminals.

### **30.2.7 Harmonic Spectral Analysis (Type)**

A full harmonics test shall be completed per BS EN 60076-1. The ENA TS 35-2 third harmonics requirements shall also be tested:-

The Third Harmonic shall be tested at principal tap and rated voltage shall be applied to the HV winding with the LV open circuited. Readings of fundamental and third harmonic voltages shall be taken phase-phase HV, phase-neutral LV and phase-phase LV, due allowance being made for harmonics in the input voltage (specification limit 0.5% third harmonic).

### **30.2.8 Zero Phase Sequence Impedance (Type)**

Test as BS EN 60076-1 with current not less than 50% of LV LTEC rated phase current in the LV neutral.

### **30.2.9 Temperature Rise (Type)**

During the testing the winding temperature indicator(s) shall be connected and the indications recorded. All test readings, calculation of losses to be applied and calculated hot spot temperatures shall be included in the type test data.

#### **(a) ONAN Rating**

A temperature rise test as BS EN 60076-2 at principal tapping.

#### **(b) Long Term Emergency Cyclic Rating**

A test conducted at the tapping calculated to generate the maximum internal losses (in kW) with test losses calculated for all windings at a maximum absolute hot spot temperature of 110°C, the test being as detailed in BS EN 60076-2. If fitted, the pumps (and fans if so required) shall be kept running during measurement of the cooling curve after shut down. Temperatures of inlet and outlet oil shall be measured by thermocouples placed directly in the oil.

The differential between hot spot temperature and a calculated top winding temperature shall be based on BS EN 60076-2 or any lower value justified by a comprehensive thermal investigation, such lower value to be approved by the Electricity North West Plant Policy Manager.

### **30.2.10 Applied Voltage (Routine)**

Tests as in BS EN 60076-3 and shall include 2kV rms for one minute on the secondary circuits of each current transformer to earth and all other circuits.

### **30.2.11 Impulse Withstand Tests (Type)**

The tests shall be carried out generally as in BS EN 60076-3 using the following chopped wave series:

1-reduced full wave (50 to 75%)

1-100% full wave

1-reduced chopped wave

2-115% chopped wave

2-100% full wave

1-reduced full wave (as in first application)

The tests shall be carried out by application to each line terminal in turn.

### **30.2.12 Induced Voltage (Routine)**

Tests as in BS EN 60076-3 shall include action such that twice normal voltage appears between all terminals, windings, sections, turns and connections for any tap position.

### **30.2.13 Discharge Measurement (Routine)**

(Test combined with induced voltage test).

Discharge measurements shall be made at the HV terminal of each phase of the transformer using an instrument complying with the requirements of BS EN 60270.

The background level shall be measured immediately before and after the induced overvoltage test with all apparatus and the circuit connected as for the test but with the transformer unenergised. The background level so measured shall not exceed 100pC.

The discharge measurement, in pC, at these voltage levels shall not exceed the value(s) specified by the Electricity North West Plant Policy Manager. These measurements shall not be corrected for background level.

Measurements of discharge shall be made for both ascending and descending values of voltage during the induced voltage test at 1.2 times and 1.6 times the nominal voltage to earth of the higher voltage side. The discharge value measured at both values of 1.2 times nominal working voltages to earth shall not exceed 300pC and the discharge values measured at 1.6 times nominal working voltage to earth, whilst not subject to guarantee, shall be noted for record purposes.

### **30.2.14 Insulation Resistance (Routine)**

Shall be measured between each winding and other windings or earthed metal at 2.5kV dc, the mean oil temperature during test being recorded.

### **30.2.15 Magnetic Circuit Insulation (Routine)**

The magnetic circuit and associated insulation components shall be tested by an applied voltage of 2kV rms or 3kV dc for one minute. Insulation resistance shall also be measured for comparison of tests on site.



### **30.2.16 Hydraulic Pressure Test (Routine)**

All oil filled chambers subject to oil head during service or during maintenance shall withstand for 24 hours without leakage of BS EN 60296 oil at 15°C (or lower viscosity) a hydraulic test pressure of 0.7 bar (or normal pressure plus 0.35 bar whichever is the greater).

### **30.2.17 Oil Leakage Test (Routine)**

This test is primarily concerned with inter-chamber leakages. The transformer main tank shall be filled with oil under normal service conservator head with cable disconnecting chambers and tapchanger left open to atmosphere, drained of oil, and dried out. A close examination shall be made to verify the absence of oil leaks after standing in this condition for not less than 24 hours. By filling the disconnecting chamber with oil under normal conservator head the disconnecting chambers to cable box interface shall be tested under similar conditions i.e. the direction of applied pressure shall be as in service. It is not acceptable to combine the two tests by filling the cable boxes with oil under normal conservator head.

### **30.2.18 Tapchanger (Routine)**

The correct functioning of tapchanger, drive mechanism, indication and limit switches shall be proved.

### **30.2.19 Sweep FREQUENCY RESPONSE ANALYSIS (sFRA) (Routine)**

A SFRA test on the transformer shall be carried out after completion of all the type and routine tests. Should an independent test station be used a Sweep Frequency Response Analysis test shall be completed before the transformer leaves the factory, when the transformer arrives at the test station, before the transformer leaves the test station and again once the transformer arrives back at the factory. This test shall be carried out on ALL (phase to phase on the HV and phase to neutral on the LV) phases using a frequency range of 20Hz to 2 MHz.

The measurements shall be done at the following tap positions:-

- (a) At the lowest tap position to ensure that all of the winding is included in the test and all terminals shall be free of earth.
- (b) At the nominal tap position.
- (c) At the highest tap position.

The results shall be displayed graphically and an Excel spreadsheet containing the raw data shall also be supplied to the Electricity North West Policy and Implementation Department for the attention of the Electricity North West Plant Policy Manager.

## **30.3 Tests After Delivery**

### **30.3.1 Sweep Frequency Response Analysis (SFRA)**

The SFRA test shall be repeated using the same instrument and criteria as the factory test when the unit is installed on site but prior to other pre-commissioning tests. The data from the factory test shall be available for comparison purposes. The results shall be displayed graphically and a spreadsheet containing the raw data shall also be supplied to the Electricity North West Policy and Implementation Department for the attention of the Electricity North West Plant Policy Manager.

If the SFRA test has been witnessed at the factory the site test shall also be witnessed.

### **30.3.2 Insulation Resistance**

The insulation resistance shall be measured and checked against the pre-delivery test result.

### **30.3.3 Winding Temperature Indicator**

The winding temperature shall be tested by immersion of the bulb in a heated enclosure simulating the in-service situation, and by injection of a current in both the ON and OFF condition.

### **30.3.4 Gas and Oil Relay**

An operation test by injection.

### **30.3.5 Forced Cooling**

An operation test from both manual control and WTI contacts, checking for non-operation of the gas and oil relay.

### **30.3.6 Tapchanger**

Electrical operation of tapchanger through the range, and operation of limit switches and mechanical stops.

### **30.3.7 Voltage Control Circuits**

Tests will be carried out by Electricity North West in conjunction with the control panel manufacturer. The transformer manufacturer shall be responsible for the correction of any defect revealed in the tapchanger.

### **30.3.8 Oil**

Samples shall be drawn from each separate oil filled chamber, preferably top and bottom of each. Samples shall be tested for breakdown value as in BS EN 60296.

### 31. REFERENCES

Health and Safety at Work Act 1974

Construction Design and Management Regulations 2007

Control of Substances Hazardous to Health Regulations 2002

Electricity Safety Quality and Continuity Regulations 2002

Electricity at Work Regulations 1989

Electromagnetic Compatibility Regulations

Health and Safety Manual Handling Operation Regulations 1992

BS EN 60076 Power Transformers

BS EN 60076-1 Power Transformers: General

BS EN 60076-2 Power Transformers: Temperature Rise

BS EN 60076-3 Power Transformers: Insulation Levels, Dielectric Tests and External Clearances in Air

BS EN 60076-10 Power Transformers. Determination of Sound Power Levels

BS EN 602174 Tap-changers. Performance requirements and test methods

BS EN 60296:2004 Fluids for electrotechnical applications: Unused Mineral Insulating Oils for Transformers and Switchgear

BS EN 62535:2012 Insulating Liquids: Test Method for Potentially Corrosive Sulphur in Used and Unused Insulating Oil

IEC 870-5-103 Telecontrol Equipment and Systems

ASTM D 1275B Test Method for Corrosive Sulphur in Electrical Insulating Oils

BS EN ISO 9000 Quality Management Systems: Fundamentals and Vocabulary

BS EN ISO 12944-2 Paints and Varnishes. Corrosion Protection of Steel Structures by Protection Paint Systems. Classification of Environments

BS EN ISO 14001 Environmental Management Systems: Requirements with Guidance for use

BS EN 60270 High Voltage Test Techniques. Partial Discharge Measurements

BS 6435 Specification for Unfilled Enclosures for Dry Terminations of HV Cables for Transformers and Reactors

BS EN 50180 Specification for Bushings above 1kV up to 36kV and from 250A to 3,15kA for liquid filled transformers

BS 88-3:2207 Specification for Cartridge Fuses for a.c. Circuits in Domestic and Similar Premises

BS 1363	13A plugs, socket-outlets, adaptors and connection units. Specification for fused conversion plugs
ENA TS 12-11	Dry Cable Terminations in HV Switchgear for Service Rated at 12, 24 and 36kV
ENA TS 35-2	Emergency Rated System Transformers 33/11.5kV Delta-Star Connected and Star-Star Connected
ENA TS 48-5	Environmental Test Requirements for Protection Relays and Systems
EPD311	Approval of Equipment
CP311	Equipment Approval Process

## **32. KEYWORDS**

33kV; 11kV; 6.6kV; Transformer, Primary

## APPENDIX A

### SCHEDULES OF INFORMATION

- Schedule A** – General Particulars of Definite Work
- Schedule B** – Commencement Date and Dates of Readiness for Inspection
- Schedule C** – Manufacturers and Places of Manufacture, Testing and Inspection
- Schedule D1** – Technical Details
- Schedule D2** – Cable Details
- Schedule D3** – Emergency Rated System Transformers
- Schedule D4** – Design Reference
- Schedule D5** – Additional Items
- Schedule E** – Drawings
- Schedule F1** – Prices and Quantities for Definite Work
- Schedule F2** – Evaluation of Transformer Losses
- Schedule G** – Optional Extras
- Schedule H** – Access Facilities to the Site
- Schedule I** – Proposed Departures from the Requirements of this Specification
- Schedule J** – Prices for Work at the Option of the Purchaser

## SCHEDULE A

### GENERAL PARTICULARS OF DEFINITE WORK

(Relevant details to be completed by Purchaser)

Item	Description	Units	
1	Section(s) for purposes of payments and taking over	-	
2	Sub Station Name and Address	-	
3	Number of Units required	-	
4	Continuous maximum rating (ONAN)	MVA	
5	Rated higher voltage between phases	kV	
6	Rated lower voltage between phases	kV	
7	Unit auxiliary earthing transformer	-	
8	Continuous maximum rating	kVA	
9	Rated higher voltage between phases	kV	
10	Rated lower voltage between phases (no load)	kV	0.415/0.240 three-phase four wire

**SCHEDULE B**

**COMMENCEMENT DATE AND DATES OF READINESS FOR INSPECTION**

(To be completed by Tenderer)

Commencement Date \_\_\_\_\_ 20\_\_

	Section(s) for purposes of payments and taking over	-	
	Sub Station Name and Address	-	
Times from Commencement Date:-			
1	Within which detailed drawings shall be submitted for Approval	Calendar Months	
2	Within which the material shall be ready for inspection and testing	Calendar Months	
3	Within which the Contractor will require access to the site	Calendar Months	
4	Within which the material shall be delivered to site	Calendar Months	
5	Within which the works shall be completed, tested and ready for continuous use	Calendar Months	

Required delivery date \_\_\_\_\_ 20\_\_

## SCHEDULE C

### MANUFACTURERS AND PLACES OF MANUFACTURE, TESTING AND INSPECTION

(Relevant details to be completed by Tenderer)

Item	Manufacturer's Number and/or Designation	Drawing Type	Manufacturer	Place of Manufacture	Place of Testing and/or Inspection
Transformer Complete					
Transformer Core					
Transformer Windings					
Transformer Main Tank					
On-load Tap-change Equipment					
HV Bushings					
LV Bushings					
Neutral Bushings					
Radiators					
Pipework Expansion Devices					
Oil Valves					
Oil Pumps					
Oil Pump Motors					
Fans					
Fan Motors					
Regenerative Breather					
Cables Boxes					



## SCHEDULE C

### MANUFACTURERS AND PLACES OF MANUFACTURE, TESTING AND INSPECTION

(Relevant details to be completed by Tenderer)

Item	Manufacturer's Number and/or Designation	Drawing and/or Type	Manufacturer	Place of Manufacture	Place of Testing and/or Inspection
Gas and Oil Actuated Relay(s)					
Outdoor Marshalling or Composite Cubicle					
Indoor Control Cubicle					
Temperature Indicating Devices					
Auxiliary Transformer					
Material for Anti-vibration Mounting					
Noise Enclosure					
Pressure relief device					
Transformer Management System					
HV cable connection (if dry or dead break)					
LV cable connection (if dry or dead break)					
Any deviation from this Schedule shall be notified in writing as soon as possible for the Purchasers Approval					

## SCHEDULE D1

### TECHNICAL DETAILS

#### LONG TERM EMERGENCY CYCLIC RATED SYSTEM TRANSFORMERS

One set to be competed for each MVA rating, vector group and voltage ratio offered.

(To be completed by Purchaser)

Item	Description	Units	
1	Section(s) of contract	-	
2	Number of transformers required	-	
3	Purchaser's serial number(s)	-	
4a	Continuous ONAN rating	MVA	
b	Emergency long term rated power - 110°C rise	MVA	
5	HV winding connections	-	Star/Delta
6	Loss capitalisation values:		
	(i) No load loss	£/kW	£2049.20
	(ii) ONAN normal tap load loss	£/kW	£584.02
7	Impedance envelope at 75°C and emergency rated power	-	See Appendix B, Figure 1
8	HV terminations	-	See clause 14.2
9	Whether protective current transformers to be supplied within the termination	-	Yes/No
10	60pF capacitor bushings fitted as standard for Neutral Voltage Displacement protection	-	See clause 14.2
11	HV neutral termination	-	See clause 14.3
12	LV termination		See clause 14.4
13	LV neutral termination	-	See clause 14.5
14	Cabling details:		
	(i) Whether armour clamps for cable glands required		
	a. HV		Yes/No
	b. LV		Yes/No
	(ii) Whether LV cable ferrules required	-	Yes/No
	(iii) Test voltage of gland insulation	kV	10kV DC
15	Whether flange for unit auxiliary transformer required	-	Yes/No
16	Whether resettable max./min tpi required	-	Yes
17	Maximum height of installation	mm	4270

## SCHEDULE D1 (CONTINUED)

### TECHNICAL DETAILS

#### LONG TERM EMERGENCY CYCLIC RATED SYSTEM TRANSFORMERS

One set to be completed for each MVA rating, vector group and voltage ratio offered.

(To be completed by Purchaser)

18	Whether anti-vibration mounting required	-	Yes
19	Whether second WTI required (See Schedule G)	-	No
20	Whether second voltage compounding CT required	-	No
21	Whether oil sampling valves required	-	Yes
22	Whether radiators to be galvanised before painting	-	Yes
23	Type of control cubicle:	-	
24	(i) Outdoor marshalling cubicle	-	Yes
25	(ii) Indoor control cubicle	-	No
26	(iii) Outdoor composite cubicle	-	No
27	(iv) Wall mounted control cubicle	-	No
28	Tap position indicator scale	-	Type 'A' see Appendix B Figure 2
29	Whether load shedding facilities to be wired-up to indoor control cubicle	-	Yes
30	Number of copies of operating and maintenance instruction required	-	One draft pdf for 1 <sup>st</sup> type of transformer and one final pdf per transformer
31	No load voltage ratio at normal tap	kV	33/11 or 33/6.6
32	Tap range		
	(i) +%	%	5.73
	(ii) -%	%	17.16
33	Tap step %	%	1.43

**SCHEDULE D2**

**CABLE DETAILS**

(TO BE COMPLETED BY PURCHASER)

SITE	
Electricity North West ORDER No	
SUPPLIERS REFERENCE	

<b>CABLE PARTICULARS</b>	<b>HV Line</b>	<b>HV Neutral</b>	<b>LV Line</b>	<b>LV Neutral</b>
Number of Cables				
Number of Cores per cable				
Type of Cable				
Conductor size mm				
Overall diameter of cable mm				
Wooden Cable Cleat Pre-Drilled dimension in mm				
<b>CABLE BOX TYPE</b>				
Dry with Bimold bushings or approved equivalent  (Manufacturer to provide cable elbows for all cable connections)				
<b>PLINTH DETAILS</b>				
Distance in mm between centre lines of main tank and radiator bank	4500			
<b>HANDING</b>				
Disposition of radiator bank with respect to main tank when viewed from cable box side of the tank	Left Hand side *  Right Hand Side *			

\* Delete as necessary

### SCHEDULE D3

#### LONG TERM EMERGENCY CYCLIC RATED SYSTEM TRANSFORMERS

(To be completed by Tenderer)

One set to be completed for each MVA rating and voltage ratio offered.

Item	Description	Units	
<b>MAGNETIC CIRCUIT</b>			
1.	Core construction:		
	(i) Taped/banded/bolted limbs	-	
	(ii) Taped/banded/bolted yokes	-	
	(iii) Taping/banding material (as applicable)	-	
2.	Insulation of:		
	(i) Core bolts	-	
	(ii) Core bolt washers	-	
	(iii) Side plates	-	
	(iv) Core Laminations	-	
<b>WINDINGS</b>			
3.	Types and arrangements of:	-	
	(i) HV windings	-	
	(ii) LV windings	-	
	(iii) Tapping windings (as applicable)	-	
	(iv) Winding arrangement i.e. core ..!...!...!...!..	-	
4.	Conductor Insulation:	-	
	(i) HV windings		
	(ii) LV windings	-	
	(iii) Tapping windings (as applicable)	-	
5.	Oil circulation (e.g. natural/partially directed/directed) to windings:		
	(i) HV windings		
	(ii) LV windings		
	(iii) Tapping windings (as applicable)		
6.	Short circuit capability:		
	(a) Potential axial thrust for worst fault condition of each winding		
	(iv) HV windings	tonnes	
	(v) LV windings	tonnes	
	(vi) Tapping windings (as applicable)	tonnes	
	(b) Coil Clamping short circuit withstand capacity		
	(i) HV windings	tonnes	
	(ii) LV windings	tonnes	
	(iii) Tapping windings (as applicable)	tonnes	
	(c) Current density in windings (at normal tapping positions)		
	(i) HV windings (LTEC)	A/mm <sup>2</sup>	
	(ii) LV windings (LTEC)	A/mm <sup>2</sup>	
	(iii) Tapping windings (as applicable) (LTEC)	A/mm <sup>2</sup>	

## SCHEDULE D3 (CONTINUED)

### LONG TERM EMERGENCY CYCLIC RATED SYSTEM TRANSFORMERS

(To be completed by Tenderer)

One set to be completed for each MVA rating and voltage ratio offered

Item	Description	Units	
<b>PERFORMANCE CHARACTERISTICS</b>			
7.	No load loss at normal tap (excluding cooling plant loss)	kW	
8.	Cooling plant loss	kW	
9.	Load losses:		
	(i) ONAN rating at 65°C maximum winding temperature rise, nominal tapping	kW	
	(ii) LTEC at 90°C maximum oil temperature at extreme negative tapping (110°C maximum absolute hot spot temperature). LTEC rating reference ambient temperature is 5°C.	kW	
10	Sound Pressure Level:		
	(i) ONAN Rating	dB(A)	
	(ii) LTEC Rating	dB(A)	
<b>TANK AND COOLER</b>			
11.	Thickness of tank:		
	(i) Sides	mm	
	(ii) Base	mm	
	(iii) Cover	mm	
12.	Thickness of radiator plates	mm	
13.	Total oil required (including cooling system)	litres	
14.	Volume of oil to be removed:		
	(i) To gain access to core earthing link	litres	
	(ii) To effect in-site change HV bushing	litres	
15.	Total volume of conservator(s)	litres	
16.	Volume of oil in conservator between highest and lowest visible levels	litres	
17.	Continuous rating of oil pump motor	shaft kW	
18.	Starting current of oil pump motor	Amps	
19.	Total number of fans	-	
20.	Nominal diameter of fans	mm	
21.	Speed of fans	rev/min	
22.	Continuous rating of each fan motor	shaft kW	
23.	Starting current of each fan motor	Amps	
<b>GENERAL</b>			
24.	Filling medium for transport	-	
25.	Total weight as installed in service, including cooler plant, all fittings and oil	tonnes	
26.	Weight of cooler, complete with oil, conservator etc.	tonnes	

**SCHEDULE D4**  
**DESIGN REFERENCE**

(To be completed by Tenderer)

100     Design Reference

The above design reference is applicable to an identical transformer previously supplied to Electricity North West on which the type tests are applicable to the transformer now offered.

Serial number of transformer on which type tests were performed .....

Date of test .....

Detail differences are:-

Signed \_\_\_\_\_

for : \_\_\_\_\_

If the above statement can be completed items 101 to 111 of the following schedule need not be entered.

## SCHEDULE D5

### ADDITIONAL ITEMS

(To be completed by Tenderer)

101	Flux density at normal voltage, tap, and frequency		
	(i) Limbs	Tesla	
	(ii) Yokes	Tesla	
102	Type of core joints		Mitre/Butt
103	Grade of core material		
104	Conductor material:		
	(i) HV		
	(ii) LV		
	(iii) Tapping		
105	No load loss at normal voltage and -17.16% tap	kW	
106	Impedance voltage at 75%:		
	(i) on minimum tap	% per MVA	
	(ii) on normal tap	% per MVA	
	(iii) on maximum tap	% per MVA	
107	Regulation:		
	(i) at 75% and ONAN rating	%	
	(ii) at 90% and LTEC rating (110°C rise)	%	
	(iii) at 115°C and LTEC rating (135°C rise)	%	
108	Thermal time constant of oil		
	(i) ONAN	minutes	
	(ii) ODAF	minutes	
	Thermal time constant of windings	minutes	
109	Weight of core and winding assembly	tonnes	
110	Weight of copper	tonnes	
111	Number of cooler elements		



## SCHEDULE E

### DRAWINGS

The following is a list of Drawings which shall be submitted by the Tenderer with his tender.

	DESCRIPTION	Tenderer's Drawing No
(a)	A preliminary outline giving side and end elevation and plan of the tank including tap changer, terminals/cable boxes and cooling equipment. The principal dimensions shall be given and parts to be removed for transport shall be indicated. The maximum dimensions and weights not to be exceeded shall also be shown.	
(b)	A preliminary diagram and rating plate.	
(c)	Circuit and wiring diagrams of connections showing electrical control of on-load tap change and forced cooling equipment.	
(d)	A preliminary internal arrangement drawing fully illustrating the type of transformer offered.	

## SCHEDULE F1

### PRICES AND QUANTITIES FOR DEFINITE WORKS

(Relevant Details to be completed by Tenderer)

The prices (other than the provisional sums) entered below include the whole of the definite work specified in this Specification

1	Section(s) for purposes of payment(s) and taking over	-	
2	Site of Station	-	
3	Number of Units required	-	
4	Continuous maximum rating	MVA	
5	Rated higher voltage between phases	kV	
6	Rated lower voltage between phases	kV	
7	Number of Unit Auxiliary Transformers required	-	
8	Continuous maximum rating	kVA	
9	Rated higher voltage between phases (no load)	kV	0.415/0.240 Three Phase four wire
11	(a) Price of each three phase main transformer (Temperature rise tests and Class A impulse tests to be quoted as an extra in Schedule G)	£	
	Loss Evaluation (Each main transformer):	-	
	(b) Schedule D No load loss £ 2049.20 x kW	£	
	(c) Schedule D load loss (at ONAN rating) £ 584.02 x kW	£	
12	Total evaluated cost: (a+b+c)	£	
13	Price of each Auxiliary Transformer	£	
		-	
14	Total evaluated cost of Section	£	

Work at Time and Material Rates

## SCHEDULE F2

### EVALUATION OF TRANSFORMER LOSSES

#### 1. GENERAL REQUIREMENTS

For the purpose of acceptance or rejection of the tender, the tolerance on guaranteed losses shall be in accordance with BS EN 60076-1.

Electricity North West shall have the right to reject a transformer having tested losses, corrected to Continuous Maximum Rating (CMR) and the reference temperature, exceeding either or both of the guaranteed losses when adjusted by the appropriate tolerance.

#### 2. EVALUATION OF TEST LOSSES AND CONTRACT PRICE VARIATION

The values of no-load and load losses obtained on test, corrected to CMR and the reference temperature where necessary, shall be used to determine a total evaluated cost of loss and shall be compared with the total evaluated guaranteed losses.

Cooler losses shall not be taken into account. The relevant rates of loss evaluation shall be those declared in Schedule F1.

Based on the comparison stated above, the contract price may be varied in accordance with the provisions stated below but in no case shall be an increase in the contract price if: -

- i) The test impedance on any tapping falls outside the impedance envelope in Appendix B.
- ii) Individually either the no-load or load loss exceeds its guaranteed value plus the BS EN 60076 tolerance.

Variations to the contract price shall be calculated to the nearest pound sterling, values of one half being rounded up.

#### 3. CALCULATIONS OF PENALTY/BONUS PAYMENT

- (a) For transformers where the total evaluated cost of losses is neither greater than 105% nor less than 95% of the total evaluated guaranteed losses, no variation to the contract price shall be made.
- (b) For transformers where the total evaluated cost of losses exceeds 105% of the evaluated guaranteed losses, the contract price shall be reduced by two times the difference between the total evaluated cost of losses and 105% of the total evaluated guaranteed losses.
- (c) Subject to Clause 2 for transformers with a total evaluated cost of losses less than 95% but not less than 90% of the total evaluated guaranteed losses, the contract price shall be increased by half the difference between the total evaluated cost of losses and 95% of the total evaluated guaranteed losses.
- (d) Subject to Clause 2 for transformers with a total evaluated cost of losses less than 90% of the total evaluated guaranteed losses, the contract price shall be increased by the different between the total evaluated cost of losses and 92½% of the total evaluated guaranteed losses.

**SCHEDULE G**  
**OPTIONAL EXTRAS**

<b>Item</b>	<b>Price (£)</b>
Addition of 33kV neutral bushing	
Cable box	
19kV/63.5V Voltage transformer	
Addition of 50kVA unit auxiliary transformer	
Addition of 100kVA unit auxiliary transformer	
Addition of isolating valves on each cooler element, total for transformer	
Addition of cooling reduction measures	
Addition of second WTI (Capillary type) (38MVA only)	
Addition of capacitor bushings	
Addition of island layer insulation in glands	
Addition of equipment to create a separate cooler bank	
<b>Extra for Type Testing (one set)</b>	
Full set of type tests as specified	
<b>Extra for Special Routine Test (per transformer)</b>	
Discharge tests (to be taken during routine induced over voltage tests)	
Oil leakage test (Clause 26.2.17)	
<b>Extra for Special Paint Finish</b>	
Additional Paint system for adverse service environment.	

## SCHEDULE H

### ACCESS FACILITIES TO THE SITE

(To be completed by Purchaser)

1	Section	
2	Site of station	
3	Ordnance Survey Grid Reference	
4	Whether direct road access is available to the site	
5	Approximate distance from the site to the nearest road	
6	Whether transport by rail is required	
7	Whether there is a railway siding near to the site	
8	Nearest railway goods station and appropriate distance from the site to the nearest goods station	
9	Whether there are any known transport restrictions in the immediate locality of site	



## SCHEDULE J

### PRICES FOR WORK AT THE OPTION OF THE PURCHASER

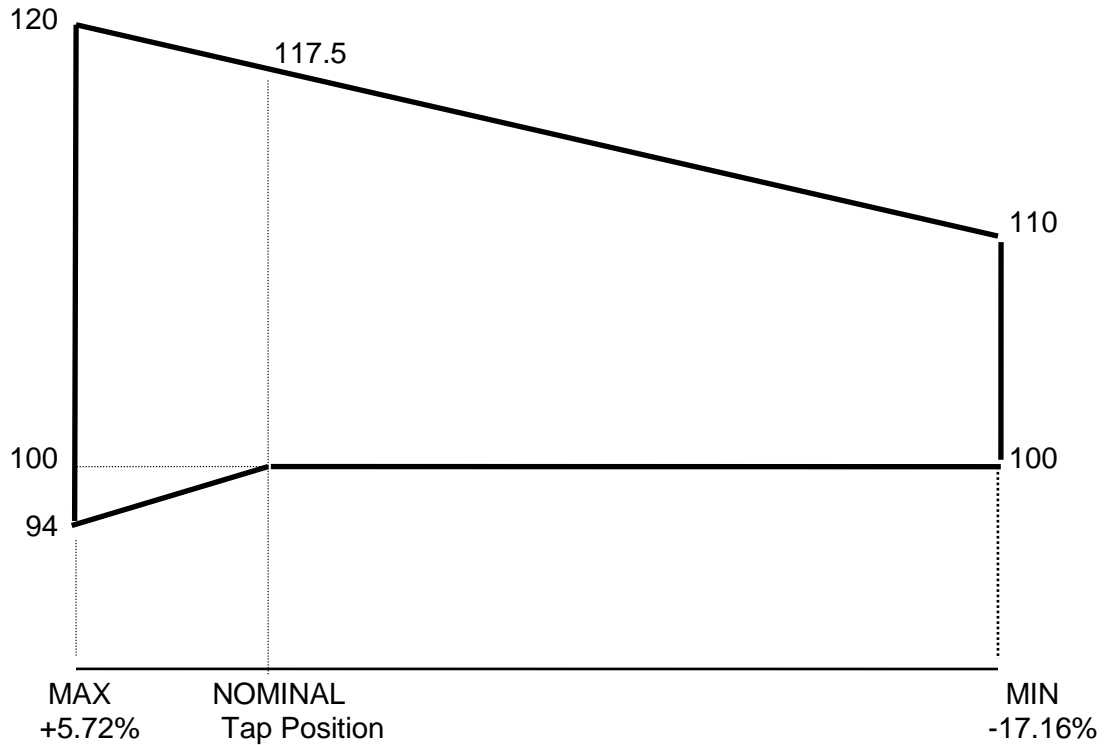
Item	Description	Price of each item £
1.	Extra for supply and fitting of anti-vibration pads	To be included in main price
2	Extra for noise enclosure if required from the outset	-
3	Extra for full type tests	
4	Extra for discharge tests	
5	Extra for oil leakage tests	
6	Recommended spares	
	(i) HV bushing insulator complete (per bushing)	
	(ii) HV neutral bushing insulator complete (per bushing)	
	(iii) LV bushing insulator complete (per bushing)	
	(iv) LV neutral bushing insulator complete (per bushing)	
	(v) HV Cable box bushing insulator complete (per bushing)	
	(vi) LV Cable box bushing insulator complete (per bushing)	
	(vii) Any other recommended spares	

APPENDIX B

FIGURES

Figure 1 Impedance % (Referenced to Emergency Rated Power)

Replaces ENA TS 35-2 Figure 1.



Shown as percentages of nominal impedance

Nominal impedance shall be 1.3% per MVA for 8 MVA transformers

1% per MVA for 15 and 23 MVA transformers

0.725% per MVA for 32 and 38 MVA transformers

For example impedance of a 23 MVA shall be within the ranges:-

At maximum (+ve tap) 21.62 to 27.6%

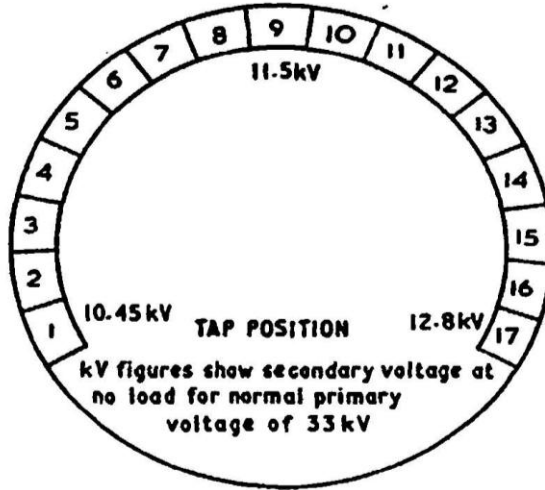
At nominal 23 to 27.0%

At minimum (-ve tap) 23 to 25.3%

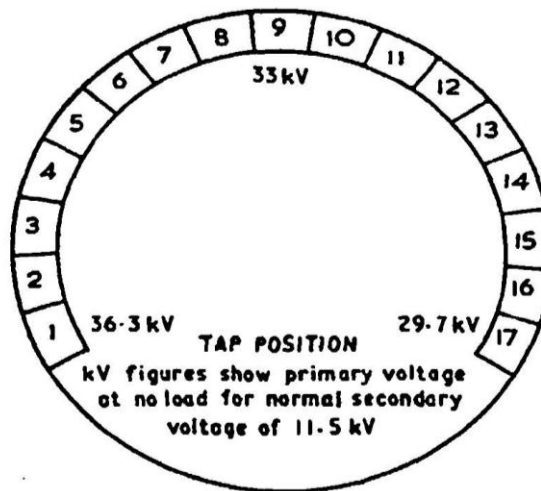
Impedance characteristics, transformers not covered by ENA TS 35-2.



Figure 2 Tap Position Indicator Scales



TYPE A



TYPE B

## APPENDIX C

### DRAWING REFERENCES

Drawing number	Revision Number	Drawing Title
900480-004.dwg	1	STANDARD CIRCUIT DIAGRAM OF PRIMARY TRANSFORMER COOLER CONTROL & VOLTAGE CONTROL USING SUPERTAPP RELAY (SHEET 1 OF 2)
900480-005.dwg	1	STANDARD CIRCUIT DIAGRAM OF PRIMARY TRANSFORMER COOLER CONTROL & VOLTAGE CONTROL USING SUPERTAPP RELAY (SHEET 2 OF 2)
900480-006.dwg	1	STANDARD CIRCUIT DIAGRAM OF PRIMARY TRANSFORMER COOLER CONTROL & VOLTAGE CONTROL USING SUPERTAPP RELAY WITH TPI TRANSDUCER (SHEET 2)
900480-020.dwg	3	STANDARD CIRCUIT DIAGRAM OF TAP CHANGE WALL MOUNTED PANEL AVC 21 (SUPER TAPP) 2 X RESISTOR CHAINS
900480-021.dwg	2	STANDARD WIRING DIAGRAM OF TAP CHANGE WALL MOUNTED PANEL AVC 21 (SUPER TAPP) (BOTTOM ENTRY)
900480-022.dwg	2	STANDARD WIRING DIAGRAM OF TAP CHANGE WALL MOUNTED PANEL AVC 21 (SUPER TAPP) (TOP ENTRY)
900480-023.dwg	2	STANDARD GENERAL ARRANGEMENT OF TAP CHANGE WALL MOUNTED PANEL AVC 21 (SUPER TAPP) (BOTTOM ENTRY)
900480-024.dwg	2	STANDARD GENERAL ARRANGEMENT OF TAP CHANGE WALL MOUNTED PANEL AVC 21 (SUPER TAPP) (TOP ENTRY)
900480-030.dwg	1	STANDARD CIRCUIT DIAGRAM OF TAP CHANGE WALL MOUNTED PANEL AVC 22 (SUPER TAPP) 1 X RESISTOR CHAIN
900480-031.dwg	1	STANDARD WIRING DIAGRAM OF TAP CHANGE WALL MOUNTED PANEL AVC 22 (SUPER TAPP) (BOTTOM ENTRY)
900480-032.dwg	1	STANDARD WIRING DIAGRAM OF TAP CHANGE WALL MOUNTED PANEL AVC 22 (SUPER TAPP) (TOP ENTRY)
900480-033.dwg	1	STANDARD GENERAL ARRANGEMENT OF TAP CHANGE WALL MOUNTED PANEL AVC 22 (SUPER TAPP) (BOTTOM ENTRY)
900480-034.dwg	1	STANDARD GENERAL ARRANGEMENT OF TAP CHANGE WALL MOUNTED PANEL AVC 22 (SUPER TAPP) (TOP ENTRY)
900480-035.dwg	2	STANDARD CIRCUIT DIAGRAM OF CONTROL CIRCUIT FOR WALL MOUNTED TAP CHANGE PANEL (AVC 31 - NON DNP3 SWITCHGEAR)
900480-036.dwg	2	STANDARD CIRCUIT DIAGRAM OF CT AND VT CONNECTIONS FOR WALL MOUNTED TAP CHANGE PANEL (AVC 31 - NON DNP3 SWITCHGEAR)
900480-037.dwg	3	STANDARD WIRING DIAGRAM OF WALL MOUNTED TAP CHANGE PANEL (AVC 31 - NON DNP3 SWITCHGEAR)
900480-038.dwg	3	STANDARD GENERAL ARRANGEMENT OF WALL MOUNTED TAP CHANGE PANEL (AVC 31 - NON DNP3 SWITCHGEAR)
900480-039.doc	2	STANDARD AVC31 PROTECTION PANEL EQUIPMENT LIST

Drawing number	Revision Number	Drawing Title
900480-040.dwg	1	STANDARD CIRCUIT DIAGRAM OF CONTROL CIRCUIT FOR WALL MOUNTED TAP CHANGE PANEL (AVC 32 - DNP3 SWITCHGEAR)
900480-041.dwg	1	STANDARD CIRCUIT DIAGRAM OF CT AND VT CONNECTIONS FOR WALL MOUNTED TAP CHANGE PANEL (AVC 32 - DNP3 SWITCHGEAR)
900480-042.dwg	1	STANDARD WIRING DIAGRAM OF WALL MOUNTED TAP CHANGE PANEL (AVC 32 - DNP3 SWITCHGEAR)
900480-043.dwg	1	GENERAL ARRANGEMENT OF WALL MOUNTED TAP CHANGE PANEL (AVC 32 - DNP3 SWITCHGEAR)
900480-044.doc	1	STANDARD AVC32 PROTECTION PANEL EQUIPMENT LIST

**APPENDIX D**

**SELF CERTIFICATION CONFORMANCE DECLARATION  
CLAUSE BY CLAUSE CONFORMANCE WITH THIS SPECIFICATION**

The manufacturer shall declare conformance or otherwise, clause by clause, using the following levels of conformance declaration codes.

Conformance declaration codes

- N/A = Clause is not applicable/appropriate to the product/service.
- C1 = The product/service conforms fully with the requirements of this clause.
- C2 = The product/service conforms partially with the requirements of this clause.
- C3 = The product/service does not conform to the requirements of this clause.
- C4 = The product/service does not currently conform to the requirements of this clause, but the manufacturer proposes to modify and test the product in order to conform.

**Manufacturer:**

**Product/Service  
Description**

**Product /Service  
Reference :**

Assessor

<b>Name:</b>	<b>Company s</b>	<b>Signature</b>	<b>Date</b>
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Clause/Sub-Clause		Requirement	Conformance Code	Remarks (Must be completed if Conformance Code is not Cs1)
4		Standards		
5	1	Product not to be changed		
5	2	Electricity North West Technical Approval		
5	3	Quality Assurance		
5	4	Formulation		
5	5	Identification Markings		
5	6	Minimum Life Expectancy		
5	7	Product Conformity		
6		Requirements for Type and Routine Testing		
7		Design		
8		Rated Power		
9		Tappings		
10		Losses		
11	1	Noise Requirements		
11	2	Sound Power Levels		
12		Impedance		

13		Terminal Arrangements		
14	1	Cable Termination Enclosures		
14	2	HV Terminals		
14	3	HV Neutral		
14	4	LV Terminals		
14	5	LV Neutral		
14	6	Unit Auxiliary Transformer		
15		General Arrangement		
16		Tanks and Covers		
17		Gaskets		
18		Oil		
19	1	Cooling Plant		
19	2	Gas and Oil Actuated Relay		
19	3	Pressure Relief Device		
19	4	Winding Temperature Indicator		
19	5	Current Transformers		
19	6	Other Fittings		
19	7	Oil Level Indicators		

19	8	Breathers		
19	9	Accessibility		
19	10	On-Load Tap Changers		
19	11	Pump Flow Meter		
20		Valves		
21		Surface Finish		
22	1	Marshalling Kiosks – General Requirements		
22	2	Marshalling Kiosks - Earthing		
22	3	Marshalling Kiosks – Ventilation and Heating		
22	4	Marshalling Kiosks – Fittings (General)		
22	5	Indoor Tap Change Cubicle		
23		Automatic Voltage Control Scheme		
24	1	Connections and Wiring – General Requirements		
24	2	Connections and Wiring – Interconnecting Cables		
24	3	Connections and Wiring – Small Wiring		
25		Data Schedules		
26		ENA Standard Drawings		
27		Telecontrol		

28		Transformer Management Systems		
29	1	Drawings		
29	2	Assembly, Operating and Maintenance Instructions		
29	3	Models and Samples		
30	1	Tests Before Delivery		
30	2	Details of Tests		
30	3	Tests After Delivery		
Schedule B		Commencement date and Dates of Readiness for Inspection		
Schedule C		Manufacturers and Places of Manufacture, Testing and Inspection		
Schedule D3		Long Term Emergency Cyclic Rated System Transformers		
Schedule D4		Design Reference		
Schedule D5		Additional Items		
Schedule E		Drawings		
Schedule F1		Prices and Quantities for Definite Works		
Schedule F2		Evaluation of Transformer Losses		
Schedule G		Optional Extras		
Schedule I		Proposed Departures from the Requirements of This ES		



Schedule J	Prices for Work at the option of the Purchaser		
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Additional Notes: