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Electricity Specification 324

Issue 9 August 2023

132kV/Lower Voltage Transformers and Earthing/Auxiliary Transformers

Amendment Summary

ISSUE NO. DATE	DESCRIPTION
Issue 8 **July 2022**	New template applied in preparation of the forthcoming Tender. Section 8 updated to ensure all Tenderers submit the required EAT / AT information where sub-contractors are used. Section 13.1 updated to clarify coastal coatings for fans. Prepared by: Matthew Kayes Approved by: Policy Approval Panel and signed on its behalf by Steve Cox, Engineering and Technical Director
Issue 9 **August 2023**	Section 15.6 part (n) section c updated on impulse testing to add one reduced chopped wave application in the test sequence. Prepared by: Matthew Kayes Approved by: Policy Approval Panel and signed on its behalf by Paul Turner, PAP Chairperson.

Contents

1 Foreword

This specification sets out the technical requirements for the purchase of 132kV/Lower Voltage transformers and Earthing Auxiliary Transformer (EAT)/Auxiliary Transformer (AT) by Electricity North West Limited, hereinafter referred to as Electricity North West, for connection to its network. The specification does not purport to include all the necessary provisions of a contract and reference to "the Contractor" within this specification means the transformer manufacturer with whom the contract for the complete equipment is placed.

2 Scope of Work

This specification covers the requirements for transformers of 132/33kV or 132/11kV and associated Earthing Auxiliary Transformer (EAT)/Auxiliary Transformer (AT) connected to the public distribution network of Electricity North West Ltd, or to individual large customers. The Continuous Maximum Rating (CMR) under forced cooled conditions, will be as specified in Appendix A, Schedule D (Requirements) with a naturally cooled rating not less than 50% of the forced cooled condition. The transformers will be operated on a 132kV neutral solidly earthed network. The lower voltage windings for 132/33kV transformers will be earthed through an Earthing Auxiliary Transformer and Neutral Earthing Resistor and lower voltage windings of 132/11kV transformers will be earthed directly via a Neutral Earthing Resistor unless otherwise stated in the Tender enquiry.

3 Definitions

The following definitions are relevant to this Specification:

Approval	Sanction by the Electricity North West Plant Policy Manager that specified criteria have been satisfied
Contract	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.
Contractor	The person or person's firm or company, including personal representatives, successors and permitted assigns, who's Tender has been accepted by Electricity North West.
Specification	The Specifications and schedules (if any) agreed by the parties for the purpose of the Contract.
Sub-Contractor	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.
Supplier	Any person or person's firm or company who supplies goods to Electricity North West or to its Contractor.
Tender	An offer in writing to execute work or supply goods at a fixed price.
Tenderer	The person or person's firm or company, including personal representatives, successors and permitted assigns, invited by Electricity North West to submit a Tender.
Works	All materials, labour and actions required to be provided or performed by the Contractor under the Contract.

4 General Requirements for Approvals and Testing

4.1 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.

4.2 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, technical reports and other data may be submitted that the Tenderer 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 document CP311.

4.3 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, the Tenderer 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 repeat of such tests, from time to time, that the Electricity North West Plant Policy Manager may deem to be reasonably necessary to demonstrate continued compliance with the Specification.

The Tenderer shall submit, with the 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 inspections to be made of Tenderer's facilities, from time to time, as deemed reasonably necessary by the Electricity North West Plant Policy Manager to ensure compliance with this Specification and any Contract of which it forms a part.

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

4.4 Formulation

The Tenderer shall submit, with the 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, in the use, storage and disposal of the product. The Tenderer may stipulate, prior to submission of such information, that it is to remain confidential, and the Electricity North West Plant Policy Manager will, if requested, confirm agreement to this prior to receipt of the information.

4.5 Identification Markings

The Tenderer shall submit, with the 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 the 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.

4.6 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.

5 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 Supplier's cost.

5.1 Requirement for Type Tests at Suppliers Premises

These are a series of one-off type tests, which are 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.

5.2 Requirement for Routine Tests at the Supplier's Premises

These tests may be required to be carried out on every individual unit or component, as specified, or at some regular frequency to be determined by the Electricity North West Plant Policy Manager.

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

5.3 Requirement for On-site Tests

These will normally be included within the scope of onsite commissioning but may be included if appropriate.

6 General Requirements

6.1 Standards

Unless another standard is specifically mentioned in this specification, all materials used and provided under the contract, and all design calculations and tests, must be in accordance with the latest amendments of the standards of the International Electrotechnical Commission (IEC) or British Standards Institution (BSI) where specified and in particular the standards listed in Section 19.

Suppliers who do not normally manufacture to IEC or BSI Standards may offer equipment in accordance with other recognised National Standards provided that they draw attention to any essential differences between their Standards and IEC/BSI Standards. Also, the quality, finish and performance of the equipment shall be subject to the satisfaction of Electricity North West and be comparable to equipment complying with IEC or BSI requirements.

6.2 Compliance with Specification

Notwithstanding any descriptions, drawings or illustrations which may have been submitted with the Tender, all details other than those shown in Appendix A, Schedule J of Departures will be deemed to be in accordance with the Specification and the standard specifications and codes referred to therein.

No departures from the Specification except those shown in Appendix A, Schedule J of Departures shall be made without the written Approval of Electricity North West. If a contractor is in doubt concerning the application of a Standard, then clarification shall be sought from Electricity North West. It is the contractor's responsibility to ensure that all suppliers/sub-contractors comply with the relevant specification and standards.

The Tenderer shall complete the Conformance Declaration sheets in Appendix B. Failure to complete this declaration sheet may result in an unacceptable bid.

6.3 Safety

The Contract Works shall meet the Health and Safety requirements, current at the date of delivery, when transported, erected, commissioned, operated and maintained in accordance with agreed procedures. These requirements shall include but not be limited to: -

- Health and Safety at Work etc. Act 1974 and subordinate Regulations
- Factories Act, 1961
- All Regulations pertinent to work on sites.
- Distribution Network Operator Safety Rules
- Electricity at Work Regulations 1989
- Electricity Supply, Quality and Continuity Regulations 2002
- Construction Design and Management (CDM) Regulations 2007

Proper regard shall be taken of the environmental and operating duty to which the equipment is to be subject.

6.4 Environmental Conditions

The Contract Works shall be suitable for use both outdoors and indoors below an altitude of 1,000 metres.

The following ambient conditions shall apply: -

Maximum Ambient Temperature	40°C
Minimum Ambient Temperature	-25°C
Wind Loading	In accordance with BS 6399-2
Ice Loading	The maximum radial ice thickness shall be assumed to be 12.5mm.

6.5 System Conditions

Particulars of the System (See Table 1 below)

Table 1 – System Particulars

	RATED VOLTAGE BETWEEN PHASES (KV)			
	132	**33**	**11**	**0.400**
Earthing of System	Solid	Resistance / Reactance as specified		Solid
System Frequency (Hz)	50	50	50	50
Max. System Continuous Voltage (kV rms)	145	36	12	0.433
Min. Lightning Impulse Withstand (kVp)	650	170	95	-
Symmetrical Short Circuit Current at Rated Voltage (kA rms)	21.9	17.5	21.9	

Maximum Operating Voltage will not normally exceed $1.1U_n$, the nominal system voltage.

System frequency may vary between 47Hz and 51Hz.

The Contract Works shall be capable of continuous operation, without damage to the equipment, under the conditions stated above.

6.6 Electrical Clearances

The minimum air clearances on outdoor transformers shall be as shown in Table 2 below.

For assistance in applying these clearances to substation design reference should be made to BS 7354, Tables 3 and 4.

Table 2 – Minimum Clearances

MINIMUM CLEARANCE	RATED VOLTAGE BETWEEN PHASES/HIGHEST SYSTEM VOLTAGE (KV)		
	132/145	33/36	11/12
Minimum Clearance between Live Metal and Earth (mm)	1100	400	200
Minimum phase to phase clearance (mm)	1400	430	250

The safety clearances to enable operation, inspection, cleaning, repairs, painting and normal maintenance work to be carried out are shown in Table 3 below. The safety clearances are measured from any point where a man may need to stand. (Position of feet):

Table 3 – Safety Clearances

SAFETY CLEARANCES	RATED VOLTAGE BETWEEN PHASES (KV)		
	132	33	11
To the nearest unscreened live conductor (mm)	3500	2900	2600
To the nearest point not at earth potential of an insulator (mm)	2400	2400	2400

6.7 Terminal Points of Contract

Unless otherwise specified, the terminal points of the Contract for each transformer and auxiliary/earthing transformer shall be in accordance with the following.

(a) The HV bushing palms or stems and cable boxes.

(b) The LV bushing palms or stems and cable boxes.

(c) The neutral bushing palms or stems plus the neutral bar connection to the HV Neutral Current Transformer (CT) and cable boxes, as applicable.

(d) The terminal blocks and field multicore cable gland plates in the marshalling kiosk/cubicle.

(e) All earthing terminals and, where required, terminals for cathodic protection.

(f) All holding-down bolts, cooler and conservator steel structures, ladders, anti-vibration pads and noise enclosure, as required.

(g) Tank, cooler and pipework oil filling/filter/drain sampling valves and devices complete with their blanking plates or caps.

6.8 Design Equipment

Transformers shall be designed to ensure satisfactory operation under such sudden variations of load and voltage likely to occur in service including direct-on-line starting, traction loads, transient short circuits etc.

Transformers shall withstand being switched whilst connected to overhead lines and/or cable circuits as applicable.

Internal and external metal parts shall be either earthed or maintained at a definite potential.

The equipment design shall minimise:

(a) The risk of accidental short circuits due to animals, birds and vermin,

(b) The risk of fire,

(c) Damage in the event of a fire.

Fabricated under-bases shall be ventilated to prevent corrosion.

Rubbing and wearing surfaces shall be either machined or ground and prevent production of metallic swarf.

Weather-tight and oil-tight joints employing a packing material shall be constructed to ensure that the packing is maintained under compression to give an effective joint in service, without the use of jointing compounds.

Outdoor equipment shall avoid pockets in which water can collect.

All fittings that require manual intervention (e.g. 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.

6.9 Rating of Ancillaries

Ancillary equipment supplied with transformers, e.g. temperature indicators, tap changer auxiliary equipment, cooling equipment, etc., shall be fit for purpose, at the responsibility of the Contractor. Equipment shall comply with recognised National and International Standards. Where items are supplied which are not so covered, then the Contractor shall, on request, make available Type Test Reports in order that the purchaser may verify that the equipment supplied meets the declared performance requirements.

Ancillary equipment, e.g. tap change equipment, bushings, internal shielding etc., shall not be damaged when the transformer is carrying the specified load current (or, where not specified, implicit by virtue of compliance with IEC 60076-1 and IEC 60354) with the transformer operating on any tap position, subject to the following loading/duration limitations:

(a) 2 p.u. $\leq$ 12 minutes

(b) 1.5 p.u. $\leq$ 22 minutes

(c) 1.3 p.u. $\leq$ 8 hours

6.10 Quality of Material

Materials within the Contract Works that may be dangerous to health shall be disclosed, in writing, to Electricity North West at the Contract stage.

Materials shall be suitable for the service duty. They shall withstand the variations of temperature and atmospheric conditions occurring in service without damage, deterioration or the creation of abnormal stresses, and without significantly affecting the strength and the suitability of the various parts.

Materials shall be inherently dimensionally stable.

Defective parts shall not be repaired and subsequently supplied without the prior consent of Electricity North West, in writing. This includes repairs involving welding, filling or plugging.

Where dissimilar metals are connected other than under oil, approved means shall be provided to prevent electro-chemical action and corrosion.

6.11 Fasteners and Fittings

Where brass is used it shall be to BS EN 12163.

Nuts, bolts and studs shall comply with the following:

(a) <M6 Threads: ISO metric

NOTE:

- Brass bolts or studs <M6 nominal diameter shall not be used for electrical connections,
- Where, for electrical connections, a small diameter is necessary, either stainless steel to BS 970, Grade En5B, or phosphor bronze to BS EN 12163, may be used down to and including M5 nominal diameter, providing the current carrying capacity is adequate.

(b) >M6 Threads and hexagon: ISO metric coarse to BS 3643, BS 3692 and BS 4190, but see (c),

(c) >M16 Threads of all current carrying stems shall be of 2mm pitch in accordance with BS 3643, Part 1, Table 2.

Threads in aluminium shall not be used except where an approved form of thread insert is incorporated.

Nuts shall be locked in position by one of the following methods:

(a) <M25 - lock washers,

(b) Locking plates,

(c) Additional lock-nuts,

(d) Proprietary locknuts of a type approved for the duty involved

Wherever practicable, bolts shall be fitted so that, in the event of a nut working loose and falling off, the bolt will remain in position and the nut(s) etc. will fall into a harmless electrical and mechanical position.

Bolts or studs shall not project through their nut(s) by more than 6mm or four threads, except for terminal board studs or relay stems.

If bolts or nuts are positioned such that they are inaccessible for ordinary spanners, special spanners shall be provided as part of the Contract Works.

Any joints/connections used within windings shall meet the required mechanical and electrical capability.

Links shall be readily accessible: internal links and fixings shall be captive.

On outdoor equipment all bolts, nuts and washers shall be of non-rusting material where they are in contact with non-ferrous parts in conductor clamps and fittings and elsewhere where specifically required by the Electricity North West Plant Policy Manager.

All washers shall be included under this Contract, including locking devices and anti-vibration arrangements, which shall be subject to the Approval of the Electricity North West Plant Policy Manager. Taper washers shall be fitted where necessary.

6.12 Interchangeability

Standardised and interchangeable components shall be used for the Contract Works wherever the applications permit.

Corresponding components which are liable to renewal shall be interchangeable and, when required by Electricity North West, the Contractor shall demonstrate this quality.

6.13 Insulating Oil

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 IEC 60296 with the following additions:

(a) Gassing tendency shall be less than 5mm^3/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 content shall be classified as “Non-corrosive” as determined by the test methods prescribed in IEC 62535 and ASTM D 1275B.

For compatibility, the oil shall conform to the requirements of Electricity North West’s 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 IEC 60296 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.

6.14 Tests

Transformers and all materials used in the manufacture of the Contract works shall satisfactorily withstand the tests specified in Section 15.

6.15 Transformer Management Systems

When requested, the Tenderer shall include as an option a factory fitted transformer management system. The management system shall include as a minimum the following features:

Functions required on transformer:

- Voltage, Current, Watts and VArs (transducer signals from lower voltage switchgear)
- 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 required on on-load tap changer (OLTC):

- Monitoring of OLTC 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
- 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.

7 132kV/Lower Voltage Transformers

7.1 General Design Requirements

7.1.1 Windings

Transformer 132 kV windings shall be star connected with non-uniform insulation as defined in IEC 60076. 33kV and 11kV windings shall have uniform insulation as defined in IEC 60076. All neutral points shall be insulated to withstand a minimum of 44kV.

On 132/11kV Star/Star Vector Group Transformers a tertiary winding shall be provided. This shall be rated at 30% of the transformer rating.

7.1.2 General

The transformers shall be oil immersed and suitable for outdoor installation and shall comply with IEC 60076. Electrical clearances shall not be less than those in the appropriate sections of BS 7354, or as stated in Section 4.6 of this specification whichever is the greater.

7.1.3 Cooling

The type of cooling shall be as stated in Appendix A, Schedule D of Requirements and the letters relating to the method of oil circulating and cooling used in this specification and schedules shall be in accordance with IEC 60076.

Where a combination of two methods of cooling is applied to one transformer, the transformer shall be capable of operating under the naturally cooled condition not less than half full load of the forced cooled rating.

7.1.4 Parallel Operation

Pairs or groups of transformers manufactured to this specification shall be designed to operate satisfactorily in parallel when operating on the same tap position.

7.2 Ratings and Loadings

Transformers shall have the Continuous Maximum Rating (CMR) as specified in Appendix A, Schedule D of Requirements.

The transformers shall also be designed such that they can be subjected to a 24 hour emergency cyclic overload of 8hrs at 130% and 16hrs at 75% with an ambient of 5ºC and a maximum winding temperature rise of 100ºC for periods not exceeding a cumulative total of 6 months. Electricity North West will accept a 5% loss of insulation life under these conditions. It is considered that a hot spot temperature of 125°C based on an ambient of 0°C would be acceptable during these emergency overloads. The tenderer's design shall have oil temperature rises and winding gradients which will be conducive to achieving this objective. Should these measures result in a larger cooler than would be necessary to meet IEC specified temperature rise limits, the tenderer should identify the extra cost resulting from this increased cooler size in the pricing schedules.

All transformers and their ancillary equipment shall comply with relevant temperature rise limits specified in IEC 60076 when operating under all specified cooling conditions and on any tap position irrespective of the direction of power flow. In addition, they shall not suffer injurious heating, i.e. which would significantly change concentrations of diagnostic gases in Dissolved Gas Analysis (DGA), when operating on any tap position and at the loadings above CMR and/or over-voltages directly specified or, where not so specified, implicit by virtue of compliance with IEC 60076 and IEC 60354 subject to a maximum current of 1.5 times normal.

7.3 Voltage Ratio and Taps

The value of the normal ratio of transformation of the transformer at principal tap shall be as stated in Appendix A, Schedule D of Requirements. At no-load, the line voltages at all tap positions shall be subject to the tolerances permitted by IEC 60076.

Tap change equipment shall be provided for selecting the appropriate taps under local manual and electrical control and under remote electrical control.

Tap positions shall be numbered consecutively ranging from one upwards. The tap positions shall be numbered so that by raising the tap position number, the low voltage value is increased.

7.4 Winding Connections and Vector Group

Transformer windings shall be connected in accordance with the IEC 60076 vector group symbols and as specified in Appendix A, Schedule D of Requirements.

Unless otherwise specified, the neutral of the star connected 132 kV transformer winding shall be brought outside the tank to a neutral bushing terminal.

7.5 Losses and Evaluation of Losses

Guaranteed values for the no-load and load losses of each transformer shall be stated in Appendix A, Schedule E of Particulars and Guarantees. In all cases losses shall meet the requirements of Commission Regulation (EU) No. 548/2014. 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.

For the purpose of evaluating Tenders, the total losses guaranteed by the Tenderer will be capitalised by adding to the cost of transformers in Appendix A, Schedule G of Prices a sum which shall be computed from the information in Table 4 below.

Table 4 – Cost per kW of Guaranteed Loss

(to be completed by Electricity North West)

1.	Site of Station	
2.	Number of units required	
3.	Continuous maximum rating (MVA)	
4.	Cost per kW of No Load Loss (£)	
5.	Cost per kW of Load Loss at 50% CMR (£)	

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 listed below.

7.5.1 General

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

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

7.5.2 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 Table 4.

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: -

(a) The test impedance on any tapping falls outside the impedance envelope in Appendix A, Figure D1 of Schedule D of Requirements.

(b) Individually either the no-load or load loss exceeds its guaranteed value plus the IEC 60076 tolerance.

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

7.5.3 Calculations of Penalty/Bonus Payments

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.

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.

Subject to Section 7.5.2 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.

Subject to Section 7.5.2 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.

7.6 Impedances

The value of impedance measured between the higher voltage and lower voltage terminals on any tap position shall be within the envelope of impedance characteristic included in Appendix A, Schedule D of Requirements. The minimum and maximum values stated in the envelope shall not be subject to tolerance.

7.7 Duty Under Fault Conditions

All transformers shall be capable of withstanding for 3 seconds, on any tappings and without damage, thermal and dynamic effects of external short circuits under the conditions stated in IEC 60076 - 5. For this purpose, the design short circuit level for each system voltage is stated in Section 4.5 - System Conditions.

Evidence shall be submitted with the Tender as to the extent to which the manufacturer has proved or is able to prove either by calculation or test the ability of the specified Transformers to withstand short circuit.

The Tenderer shall provide with his Tender a brief description of those transformers or parts thereof which have been subjected to short circuit test or for which short circuit calculations are available. It is preferred that this information relates to designs comparable with the transformers tendered but in the event, this is not so the Electricity North West Plant Policy Manager reserves the right to require calculations to prove that the design of transformers tendered will satisfactorily comply with this clause.

7.8 Magnetic Circuit

The magnetic circuit shall comply with the requirements of Section 9 - Internal Requirements.

The separable connections for earthing the magnetic circuit and supporting framework shall be easily accessible. The magnetic circuit shall be insulated from all structural parts and shall be capable of withstanding a test voltage to core bolts and to the frame of 2000V rms for one minute.

7.9 Flux Density

The maximum flux density in any part of the magnetic circuit shall be designed such as to give the most economic design whilst ensuring that when operating within the allowable limits of the supply voltage and frequency which may be applied to the high voltage terminals. The flux density shall not exceed 1.9 Tesla at any point in the core when operating at any tap position under the most onerous condition represented by the range of system voltages and frequencies set out in clause 6.5.

7.10 Vibration

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

7.11 Noise

The transformer noise acceptance level shall conform to the requirements set out in Table 5 below. The sound power level shall not be greater than that stated in the table when measured in accordance with IEC 60076-10. There shall be no anti-vibration pads between the tank base and floor during this test.

Table 5 – Sound Power Levels

RATING (MVA)	ONAN SOUND POWER LEVEL (DBA)	COOLER SOUND POWER LEVEL (DBA)
15/30	66	84
30/60	68	86
45/90	70	90

The transformer manufacturer shall state the expected sound power level in the Appendix A, Schedule D3 of Particulars and Guarantees.

Sound power measurement tests are required as routine on all transformers and cooler banks. The tests must 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.

The transformer shall be suitably arranged to permit installation of noise reduction facilities. Preference will be given to add on panels rather than the option to surround the main transformer tank with a noise control building. Where such facilities are required to be provided, a reduction in sound power levels of 15dBA on the levels specified in Table 5 is required. Where this requirement for noise control is not specified as part of this contract, provision for fitting at a later date under a separate contract shall be demonstrated.

7.12 Terminal Connections

Terminal bushings and connections shall be provided as stated in Appendix A, Schedule D of Requirements. All bushings shall comply with IEC 60137 and Section 12 of this specification. Outdoor type bushing insulators shall be provided with adjustable arcing horns. For arcing horn setting requirements refer to Section 12.2.1.

Each 132 kV bushing shall be suitable to accommodate up to three current transformers. The performance specification of these current transformers shall be detailed in Appendix A, Schedule D. Where specified, current transformers for HV neutral terminations shall be supplied. These shall be mounted on the transformer tank.

7.13 Tanks and Coolers

Tanks fittings and ancillary equipment shall comply with the requirements of Section 10 and cooling equipment shall comply with Section 13.

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.

The electrical control of cooling equipment shall be in accordance with Section 14.

7.14 Voltage Control

As called for in the Appendix A, Schedule D of Requirements, transformers shall be provided with tap changers for varying the effective transformation ratio. On-load tap changers shall comply with IEC 60214 and the electrical control requirements of Section 14 of this Specification.

On-load tap change equipment shall be suitable for local manual control, electrical standby control and for control of transformers operating in parallel. The standby control panel will be supplied under a separate contract.

8 Earthing Auxiliary Transformers and Auxiliary Transformers

The Tenderer shall provide a fully compliant Tender Submission in accordance with this Specification for the Grid Transformer and Associated Earthing Auxiliary Transformer (EAT) and Auxiliary Transformer (AT). Where the EAT and AT is supplied by a Sub-Contractor. The Tenderer shall supply all the relevant Technical Information, Test Information and complete clause conformance declarations for the EAT and AT with their Tender. Where sub-contractors are used for the EAT and AT they will be subject to the same Approval process as the Grid Transformer Manufacturer as detailed in Section 4 of this specification. The EAT and AT will be required to be Type Tested in accordance with Section 15.8 of this Specification.

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8.1 General

Earthing Auxiliary Transformers (EAT) and Auxiliary Transformers (AT) shall comply with IEC 60289 and shall be of the oil immersed ONAN type as defined in IEC 60076.

EATs shall have a main interconnected star winding which will be directly connected to the lower voltage terminals of the associated 132kV/33kV Transformer. All EATs shall be provided with lower voltage star windings to give a 400/230V, 3 phase, 4 wire supply unless this requirement is specifically excluded in Appendix A, Schedule D of Requirements and the transformers are to be supplied for earth fault duty only.

ATs shall have a main delta winding which will be directly connected to the lower voltage terminals of the associated 132kV/11kV Transformer. All ATs shall be provided with lower voltage interconnected star windings to give a 400/230V, 3 phase, 4 wire supply unless this requirement is specifically excluded in Appendix A, Schedule D of Requirements and the transformers are to be supplied for earth fault duty only.

The neutral point of the interconnected star winding shall be brought out of the tank through a bushing insulator and this point is normally connected to earth through a neutral earthing resistor in order to provide an earthing point for the neutral of the system. The resistor will be supplied under a separate contract.

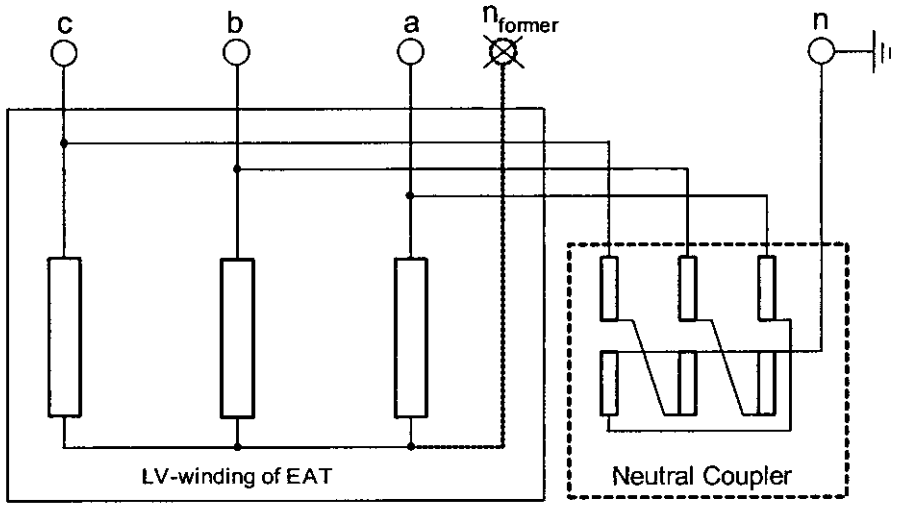
Where taps are specified for EAT's in Appendix A, Schedule D of Requirements, they will be provided on the windings for variation of the normal voltage. Tap selection shall be by means of an externally operated off-circuit tap changer. A mechanical tap position indicator shall be provided with tap position 1 corresponds to the highest tap voltage. Tappings shall not be provided for earthing transformers.

All 400V cables shall be mechanically protected and enter the fuse box from below.

The HV windings shall be fitted with terminal bushings as detailed in Appendix A, Schedule D of Requirements.

In order to overcome a possible problem of LV phase to earth voltage displacement and overvoltages under earth fault conditions, the EAT shall be supplied with a neutral coupler as defined in IEC 60289. The purpose of the neutral coupler is to provide a new independent neutral for the LV winding of the EAT as shown in the drawing (Figure 1).

Figure 1



The neutral coupler shall be preferably be mounted within the main transformer tank, when this is not practical the neutral coupler shall be mounted in a separate tank external to the EAT and in all cases the principle connections shall be as shown in the diagram (Figure 1). Where the neutral coupler is mounted within a separate tank it shall be connected to the EAT conservator via the gas and oil actuated relay.

The EAT and associated neutral coupler shall be designed to ensure the electrical clearances in Section 6.6 are met. If necessary, this can be achieved by the use of a support stand.

8.2 Electrical Characteristics

Insulation levels of the HV terminal shall be as stated in Table 6 below.

Table 6 – Insulation Levels

	SYSTEM VOLTAGE	
	11kV	**33kV**
Lightning impulse withstand	75kV	170kV
Power frequency test 1 min.	28kV	70kV

The vector symbol for all 33kV EAT's shall be ZNyn1 with changeover links on the HV winding to reconnect to ZNyn11, where specified in Appendix A, Schedule D of Requirements.

The positive sequence impedance between windings shall be a maximum of 5.5% for a 33kV earthing transformer and 4.75% for a 11kV earthing transformer. With 0% tolerance on these maximum levels.

8.3 Short-Time Current Rating

With the standard resistance earthing arrangement, the rated short-time current through the HV neutral of the earthing transformer shall be 1000A for 30s, for either the 33kV or 11kV systems. Should the neutral earthing resistor flashover, the earthing transformer shall be capable of carrying the resulting current limited by the zero sequence impedance of the interconnected star winding alone, for 3s.

The minimum value of zero sequence impedance of the earthing transformers shall be as shown in Table 7 below:

Table 7 – Zero Sequence Impedance

	SYSTEM VOLTAGE	
	33kV	**11kV**
Impedance (ohms per phase)	21	7
Tolerance (%)	±20	±20

8.4 Tanks and Fittings

Tanks shall comply with the requirements of Section 4.

The following fittings shall be provided:

(a) Oil conservator

(b) Regenerative breather

(c) Pressure relief device

(d) Gas and oil actuated relay

(e) Filter valve and combined drain/filter valve

(f) Oil sampling device

(g) Rating plate

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.

The oil conservator vessel shall be provided with a removable end cover and prismatic oil gauge.

The pressure relief device shall be the spring operated self-sealing type complete with tripping contacts rated at 10A 125V d.c. The operating pressure shall be 530mbar ±50mbar. This should be vented to within 1 metre of ground level and away from any manual operating position.

8.5 Lower Voltage Windings

Unless a higher rating is specified, the rating for the lower voltage winding shall be 200kVA. The three phase, four wire lower voltage winding shall be terminated at a three-pole combined switch-fuse unit with bolted neutral link and gland entry for a 4-core cable. This shall be accommodated in a lockable, fully weather proof compartment together with the neutral earthing link, which shall be connected between the transformer winding end and a suitably located earthing terminal to which the system earth can be connected. The 400v neutral connection within the supplied fuse-switch shall be equipped with an additional connection point for a 120mm^2 earth connection from Electricity North West substation earth grid on the un-switched side of fuse-switch. The fused switch shall be capable of accepting (i.e. glanding and terminating) a 120mm^2, 4c XLPE/PVC/SWA/PVC cable without need for additional extension boxes.

8.6 Multicore Cable Connections

All field multicore cables shall be connected to the EAT / AT via the main transformer kiosk. Multicore connections from protection devices on the EAT / AT shall be terminated on a terminal rail via a fuse switch within the marshalling box compartment for termination to outgoing field cables by others.

The bottom of the fuse box shall be at least 800mm above ground level unless specified at the time of order by Electricity North West for increased flood protection.

8.7 EAT / AT Noise

The sound power level shall not exceed 52dB(A).

9 Internal Requirements

9.1 General

Transformer core and winding assemblies, and all other internal parts, shall be firmly located within the tank and capable of withstanding shocks to which they may be subjected during normal conditions of lifting, transport and installation.

Current transformers shall be located to minimise errors due to stray magnetic fields. Secondary leads shall be contained in insulating tubes for the maximum length possible and positioned so as to maintain a satisfactory clearance to other electrical connections.

9.2 Magnetic Circuit

9.2.1 General Requirements

The magnetic circuit arrangement shall minimise the no-load loss and no-load current. The no-load loss and no-load current shall be stated under items of Appendix A, Schedule E. Unless otherwise specified, the measured values shall be subject to the tolerances specified in IEC 60076.

The method of clamping magnetic circuits shall ensure that laminations are evenly compressed.

Magnetic circuits incorporating packets (groups) of laminations coated with an epoxy adhesive to provide ultimate structural support, shall have the adhesive cured before being assembled into the magnetic circuit.

The arrangement of the magnetic circuit, magnetic shields, flux control devices, etc., and their supporting frameworks and clamping structures, shall

(a) Minimise mechanical vibration and its transmission to the tank,

(b) Ensure that vibration is not detrimental to the apparatus either under test or in service,

The use of special resilient materials within the apparatus for the specific purpose of reducing the transmission of vibration shall be agreed with Electricity North West at the contract stage.

Electrostatic shields within the core windows shall incorporate connections to permit the application of the withstand voltage tests to earth and across any insulated breaks, in accordance with the schedule of tests in Section 15.

Oil ducts shall be provided where necessary to ensure adequate cooling. The material of the separators forming the ducts shall be suitable for the mechanical, thermal and electrical insulation conditions involved and the design shall allow for unrestricted flow of oil throughout the ducts.

With the transformer operating at CMR on any tapping position, the temperature of any part of the surface of the magnetic circuit, the associated metal-work and flux control devices in contact with oil and/or insulation, shall not exceed 100°C at an ambient (cooling medium) temperature of 20°C.

NOTE:

- For localised areas where it is considered a concentration of flux cannot be avoided, the Contractor may submit a written request, with his Tender, for a relaxation of this temperature limit. In such cases, Electricity North West may, at the Electricity North West Plant Policy Manager's discretion, permit a temperature not exceeding 130°C under the following conditions:

  (a) At 100% CMR and 20°C ambient or,

  (b) At 130% CMR and 10°C ambient.

- Special tests, which Electricity North West may require to support this relaxation, shall be agreed at the Contract stage.

The temperature class and type of insulating material used for banding or taping of cores, and for the insulation of core bolts, under nuts and side plates, and frame to core, shall be stated under Appendix A, Schedule E. The insulation shall comply with the requirements of BS 2757, Class "B", or better.

Magnetic circuits, their supporting frameworks and clamping structures shall be maintained at earth potential and shall comply with the requirements of Section 9.4. The contractor shall state, on the core or shield drawing, whether the metal supporting framework and clamping structure is deliberately insulated from earth with any frame earthing link removed.

Insulations between magnetic circuits and metal supporting frameworks and clamping structures, including metal flitch (side) plates, shall comply with the withstand requirements of Separate Source Voltages - One Minute Withstand test.

Insulations between the core (or shield), frame feet and tank base, shall withstand the routine separate source voltage test specified.

Magnetic circuits, their supporting framework and clamping structures shall be designed and manufactured so that:

(a) Gas will not be trapped in any part of the complete assembly either during oil filling or in service and,

(b) The presence of pockets which would prevent complete emptying of the tank through the relevant drain valves, is avoided.

The magnetic circuit shall be insulated from all structural parts and shall be capable of withstanding a separate source test voltage to core bolts and to the frame of 2000Vrms for one minute.

9.2.2 Laminations

Laminations shall be produced from cold rolled electrical steel complying with the appropriate requirements of IEC 60404 (BS 6404) and may be grain oriented or non-grain oriented, depending upon the duty.

Each lamination shall be insulated with a material stable under the action of pressure and hot oil.

The characteristics of the lamination insulation shall be stated in the Tender and to demonstrate the quality of the materials, tests shall be made when requested by Electricity North West.

9.2.3 Structural Framework

The use of material other than steel or aluminium for the main supporting framework and clamping structure shall be agreed with Electricity North West.

Supporting frameworks and clamping structures shall ensure proper support of the assembled magnetic circuit.

The surface of all steel supporting framework and clamping structures shall be finished with an oil resisting paint protective system complying with the requirements of Section 10.12.

9.2.4 Core Bands

Core bands shall be positively located. Insulation between metallic bands and the magnetic circuit shall be subject to voltage test and for acceptance there shall be no electrical failure of the insulation. Resin bonded bands, either preformed or formed, shall be cured before the windings are positioned.

9.2.5 Flux Density

Design shall be such that there will be no adverse effects due to core or stray flux heating with the quality of steel employed, and that when operating under the onerous conditions envisaged in IEC 60076 and IEC 60354, the maximum flux density at any tap position with the rated tap voltage and 50Hz does not exceed a level which will cause damage to any part of the transformer.

9.3 Windings, Connections and Terminal Markings

9.3.1 General Requirements

Windings and connections shall be designed and manufactured to meet the maximum voltage, thermal and mechanical requirements for test, transport and service conditions.

Conductors shall be of high conductivity (HC) copper complying with the requirements of BS 1432 and BS 1433. Alternative designs may be acceptable subject to the Tenderer clearly demonstrating a satisfactory service history over a significant period of time, subject to the Approval of the Electricity North West Plant Policy Manager.

9.3.2 Winding

Windings shall be located in a manner which will ensure that they remain electromagnetically balanced and that their magnetic centres remain coincident under all conditions of operation.

The windings shall also be thoroughly dried and shrunk by the application of axial pressure for such length of time as will ensure that further shrinkage will not occur in service.

The windings and leads of all transformers shall be braced to withstand the shocks which may occur through rough handling and vibration during transport, switching and other transient service conditions including external short circuit.

If the winding is built up of sections or of disc coils separated by spacers, the clamping arrangements shall ensure that equal pressures are applied to all columns of spacers.

9.3.3 Connections

Busbars and leads shall be supported throughout their length to ensure they will not move under test, during transport and in service. Connections shall be arranged to minimise effects of magnetic and electrostatic fields.

All electrical connections within windings shall be brazed but subject to Approval, mechanically crimped joints may be used for round stranded conductors on tapping, bushing or earthing connections and on bundle conductors where design has been proved by type test and application is subject to rigorous quality control.

9.3.4 Terminal Markings

Transformer terminals and terminal marking plates shall be marked for the appropriate phase(s) in accordance with IEC 60076.

Markings shall be of a permanent form either by punch stamping or by engraving. These markings shall have no deleterious effect on the performance of the equipment.

Markings to identify main terminals and link boards to which access is provided, shall be clearly visible from the relevant hand-hole, with the filling medium at the maximum practicable level.

9.4 Internal Earthing and Connections

9.4.1 General Requirements

All metal parts of the transformer with the exception of the individual core laminations, core bolts and associated individual clamping plates and metallic core bands and their fixings shall be maintained at some fixed potential. All links contained within the transformer tank for earthing, polarity selection or other purposes shall be readily accessible and the links and their fixings shall be of the captive type.

9.4.2 Earthing of Core Clamping Structure

The top main core clamping structure shall be connected to the tank body by a disconnectable copper strap. The bottom main core clamping structure shall be earthed by one or more of the following methods:

(a) By connection through vertical tie rods to the top structure;

(b) By direct metal-to-metal contact with the tank base maintained by the weight of the core and windings;

(c) By connection to the top structure on the same side of the core as the main earth connection to the tank.

9.4.3 Earthing of Magnetic Circuits

The magnetic circuit shall be earthed to the clamping structure at one point only through a removable link placed in an accessible position just beneath an inspection opening in the tank cover and which, by disconnection, will enable the insulation between the core and clamping plates, etc., to be tested at voltages up to 2000V. The link shall have no detachable components and the connection to the link shall be on the same side of the core as the main earth connection. These requirements are compulsory.

All insulating barriers within magnetic circuits shall be bridged by means of aluminium or tinned copper strips so inserted as to maintain electrical continuity.

9.4.4 Earthing of Coil Clamping Ring

Where coil clamping rings are of metal at each potential, each ring shall be connected to the adjacent core clamping structure on the same side of the transformer as the main earth connection.

9.4.5 Size of Earthing Connections

Internal earth connections shall be capable of withstanding the prospective fault currents for a minimum of three seconds, and shall be unaffected by vibration encountered during continuous service.

9.5 Drying Out

All transformers shall be dried out by an approved method at the manufacturer's works and so arranged that they might be put into service without further drying out on site.

Clear instructions shall be included in the Maintenance Instruction regarding any special precautionary measures (e.g. strutting of tap changer barrier or tank cover) which must be taken before the specified vacuum treatment can be carried out. Any special equipment necessary to enable the transformer to withstand the treatment shall be provided with each transformer.

10 Tanks and Fittings

10.1 Safety and Clearances

Safety clearances to enable operation, inspection, cleaning, repairs, painting and normal maintenance work to be carried out, and the minimum electrical clearances in air on outdoor transformers shall comply with the requirements of Section 6.6.

Protection (co-ordinating) gaps shall be of the screened type, be mounted in such a way as to minimise the risk of arc damage to transformer bushing porcelains and any fittings. The gap supporting structure shall be bonded by a separate connection to one of the tank earthing terminals. Co-ordinating gaps shall be capable of achieving the minimum values detailed in Section 12.2.1.

10.2 Transformer Tanks

Each transformer shall be enclosed in a suitably stiffened welded steel tank such that the transformer can be lifted and transported without permanent deformation or oil leakage. The construction shall employ weldable structural steel of an approved grade to BS EN 10029. If rail transport is required, this shall be stated by Electricity North West.

Lifting lugs shall be provided, suitable for the weight of the transformer, including core and windings, fittings, and with the tank filled with oil. Each tank shall be provided with at least four jacking lugs, and where required, with lugs suitably positioned for transport on a beam transporter. Haulage lugs shall also be provided to enable a cable to be used safely for haulage in any direction.

The transformer tank shall be capable of withstanding full vacuum when empty of oil and hydraulic pressure test with no leakage or oil ingress.

The base of each tank shall be so designed that it is possible to move the complete transformer unit in any direction without injury when using rollers, plates, or rails. A design which requires that slide rails be placed in a particular position is not to be used.

The tank and cover shall be designed in such a manner as to leave no external pockets in which water can lodge, no internal pockets in which oil can remain when draining the tank or in which air can be trapped when filling the tank, and to provide easy access to all external surfaces for painting.

Where cooling tubes are used, each tube shall be of heavy gauge steel welded into the tank sides, top and bottom.

Each tank cover shall be of adequate strength, must not distort when lifted and shall be provided with suitable flanges having sufficient and properly spaced bolts. Welding of tank covers is acceptable. Inspection openings shall be provided to give access to the internal connections of bushings, winding connections and earthing links. Each opening shall be correctly located and must be of ample size for the purpose for which it is intended. All inspection covers shall be provided with lifting handles.

It shall be possible to remove any bushing without removing the tank cover.

Where called for in Appendix A, Schedule D of Requirements, accommodation shall be provided for outdoor weatherproof neutral current transformers.

10.3 Conservator Tanks and Breathers

Each transformer shall be provided with an overhead conservator tank formed of substantial steel plates and arranged above the highest point of the oil circulating system. Connections into the main tank shall be at the highest point to prevent the trapping of air or gas under the main tank cover.

The capacity of each conservator tank shall be adequate for the expansion and contraction of oil in the whole system under the specified operating conditions. Conservator tanks shall also be provided with a cleaning door, filling cap, drain valve with captive cap and an oil level indicator with minimum and maximum levels indicated. The normal level at an oil temperature of 15°C shall be indicated and the minimum and maximum levels shall also be correlated with oil temperature markings. The temperature markings shall preferably be integral with the level indicating device.

The location of the conservator tank shall be so arranged that it does not obstruct the passage of high voltage conductors immediately above the transformer.

The pipework between the conservator and the transformer tank shall have regard to the minimum safety and external air clearances stated in Section 6.6 and a valve shall be provided at the conservator to cut off the oil supply to the tank.

Each transformer shall be fitted with a regenerative breather of a design to be approved by Electricity North West. The breather 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. The control circuitry shall be contained in a weatherproof housing mounted on the cooler supporting structure. The housing shall comply with the appropriate requirements of Section 14.

10.4 Earthing Connections

Two substantial steel flag type terminals shall be located one on either side and near to the bottom of the transformer to facilitate connection to the substation earthing system. The contact area and pressure shall be designed to withstand the maximum prospective earth fault currents.

All tank attached cubicles, cooling fan motors, tap changer drive mechanism, etc. shall be bonded to their supporting structures via paint free surfaces.

10.5 Pressure Relief Devices

A spring operated self-sealing valve type pressure relief device of sufficient size shall be fitted for the rapid release of over pressure that may be generated in the transformer. It shall be provided with one set of normally open contacts rated at 10A 125V dc for alarm/trip function.

The relief device is to be mounted on the tank and is to be provided with a skirt to project at least 25mm into the tank to prevent gas accumulation. Discharge of oil shall be directed away from the transformer top cover and clear of any operating position and ducted to a position approximately 1m from ground level.

When the total oil quantity exceeds 45,000litres, two pressure relief devices, effectively diagonally opposite, shall be fitted.

10.6 Joints and Gaskets

All joint faces shall be arranged to prevent the ingress of water or leakage of oil with a minimum of gasket surface exposed to the action of oil or air.

The gaskets shall be of a suitable material such that replacement is not required over the life of the unit.

Gaskets shall be as thin as is possible consistent with the provision of a good seal and full details of all gasket sealing arrangements shall be shown on the Plant drawings.

10.7 Valves and Plugs

Valves, drain and air release plugs and oil sampling devices shall be suitable for use with insulating oil at temperature of 120°C. These shall be capable of being padlocked in the closed or open positions by locking pins, which shall be of an anti-rattle design so as not to add to noise emission. Such locking pins shall incorporate 8mm holes for padlocks.

Each transformer shall be fitted with the following valves as a minimum requirement: -

Main Tank

(a) One 50mm bore gate valve located near to the top of the tank.

(b) One 50mm bore gate valve located near to the bottom of the tank and diagonally opposite to the gate valve required against (a). Where design permits, this valve may be combined with item (c).

(c) One 50mm gate valve with such arrangements as may be necessary inside the tank to ensure that the tank can be completely drained of oil as far as practicable. This valve shall also be provided with an approved oil sampling device.

Conservator

(d) One valve between the conservator and gas actuated relay for the main tank and, where appropriate, for the tap change diverter switch tank.

(e) One gate valve for oil conservator tank so arranged that the tank can be completely drained of all oil.

Tap Changer

(f) Two 50mm gate valves where selector switches are contained in a separate tank.

Diverter Switch

(g) One gate valve to be fitted to each tank to allow draining of the oil.

Radiators and Cooler Banks

(h) Valves at each point of connection to the tank.

Valves of 50mm nominal bore and over are to be provided with indicators showing when the valve is open or closed.

Blank flanges, plates or captive screw caps shall be fitted to all valves and pipe ends not normally connected in service.

The omission of any, or the provision of alternative arrangements to the above requirements, will not be accepted unless approved in writing by Electricity North West before manufacture.

10.8 Oil Level Indicators

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 of Section 14.6.

10.9 Winding Temperature Indicators (WTI)

Each transformer shall be provided with an approved device for indicating the top oil temperature and hottest spot winding temperatures in both the high and low voltage winding. The specification of the device shall meet the requirements of Section 14.5.3.

10.10 Gas and Oil-Actuated Relays

Each transformer shall be fitted with an approved design of gas and oil-actuated relay equipment having alarm contacts which close on collection of gas or low oil level, and tripping contacts which close following oil surge and low oil level conditions.

Each gas and oil-actuated relay shall be provided with a test cock to take a flexible pipe connection for checking the operation of the relay by air and oil injection.

Each relay shall be fitted with a calibrated glass window with two visible scales, one each side, for indication of gas collection. The relay shall be suitable for operation with insulating oil over the temperature range of -25°C to +105°C.

To allow gas to be collected at ground level, a small bore pipe shall be connected to the gas release cock of the gas and oil-actuated relay and brought down to a point approximately 1400mm above ground level, where it shall be terminated by a cock which shall have an approved form of locking to prevent unauthorised operation.

The design of the relay mounting arrangements, the associated pipework and the cooling plant shall be such that maloperation of the relay will not take place under normal service conditions, including starting or stopping of oil circulating pumps whether by manual or automatic control under all operating temperatures.

The pipework shall be so arranged that all gas arising from the transformer will pass into the gas and oil-actuated relay. The oil circuit through the relay must not form a delivery path in parallel with any circulating oil pipe, nor is it to be teed into or connected through the pressure relief vent. Sharp bends in the pipework shall be avoided.

When a transformer is provided with two conservators the gas and oil-actuated relays shall be arranged as follows:-

(a) If the two conservators are connected to the transformer by a common oil pipe one relay shall be installed in the common pipe.

(b) If the two conservators are piped separately to the transformer two relays shall be installed, one in each pipe connection.

The clearance between oil pipework and live metal shall be not less than the minimum clearances stated in Section 6.6.

10.11 Rating, Diagram and Valve Plates

The following plates, or an approved combined plate, shall be fixed to each transformer tank at an average height of 1700mm above the plinth level:-

(a) A rating plate bearing the data specified in IEC 60076-1. This plate shall also include the short-circuit current rating, time-factor for each winding.

(b) A diagram plate showing in an approved manner, the internal connections and the voltage vector relationship of the several windings, in accordance with IEC 60076-1 with the transformer voltage ratio for each tap and, in addition, a plan view of the transformer, giving the correct physical relationship of the terminals and outline dimensions.

(c) A plate showing the location, function and normally open or closed position of all valves and air release cocks or plugs. This plate shall also if necessary warn operators to refer to the Maintenance Instructions before applying vacuum.

Plates are to be of stainless steel or other Approved material capable of withstanding the rigours of continuous outdoor service at site. Where the Tenderer does not use stainless steel they shall submit the material technical specification and samples for Approval by Electricity North West Plant Policy Manager.

10.12 Cleaning and Painting

The tank and any radiators shall not require maintenance for a period of at least 30 years in a polluted / coastal environment according to EN ISO 12944-2 Category C4.

Metallic surfaces of all equipment and components shall be prepared and finished before coating in accordance with the requirements of BS 2569. Any protective coatings shall be applied after tests have been carried out.

The final coat colour shall be to BS 381C, reference Admiralty Grey, shade 632. Cubicles for indoor and outdoor use shall be to the same colour. The Transformer lid or any surface on which someone is expected to stand on shall be painted with Anti-slip Paint.

Where painting is carried out at the manufacturer's works and where erection at Site is the responsibility of the Contractor, any damage during delivery or erection at Site shall be made good to the requirements including, where deemed necessary, application of a complete finishing coat of an approved colour and quality paint.

10.13 Surge Arrestors

The tank design shall accommodate the installation of Surge Arrestors. Where they are not installed at the time of manufacture supports shall be supplied for future installation of Surge Arrestors.

11 Tap Change Equipment

11.1 General Requirements

Transformers shall be provided with tap changers for varying the effective transformation ratio.

Winding taps as called for in Appendix A, Schedule D of Requirements shall be provided on the high voltage winding.

The tap changer, when mounted on the associated transformer must be suitable for operation over the ranges of ambient temperature of the medium surrounding the tap changer, as follows:

(a) External-tank mounted type: -25°C to +55°C

(b) In-tank mounted type: -25°C to +100°C

Tap positions shall be numbered consecutively ranging from one upwards. The tap positions shall be numbered so that by raising the tap position, the LV voltage is increased.

11.2 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.

Tapchangers shall preferably to be of the combined selector diverter switch type. It shall not be possible for the oil in the diverter switch compartments to mix with the oil in the transformer main tank or any other compartment. Access for inspection, diverter switch maintenance and manual operation of the tap changer shall be from ground level or from a permanently fixed work platform.

Tap changers shall not suffer overheating when used on transformers operating on any tapping position at the loadings directly specified or, where not so specified, implied by virtue of compliance with IEC 60076 and IEC 60354. The rating of the tap changer must allow for the magnitude and duration of any transformer loading exceeding the requirements of IEC 60354.

On-load tap changers shall be of the high speed, resistor transition type, driven by an electrically operated mechanism, having the capability of manual operation and preferably of the combined selector diverter switch type. Non-linear resistors for voltage grading and limitation purposes shall not be used unless specifically approved by Electricity North West. Transition resistors shall be mounted in the diverter switch or selector switch compartment, and the nominal resistance shall be inscribed on the tap changer rating plate.

Neutral end connected tap-changers shall have provision to enable the transformer neutral connection to be made either externally or within the transformer tank.

Current making and breaking switches associated with the tap selectors or otherwise combined with tap selectors shall be contained in a tank in which the head of oil is maintained by means completely independent of that on the transformer itself. Details of maintaining oil separation, oil levels, detection of oil surges and provision of alarm or trip contacts will be dependent on the design of tap-changer and be to the Approval of Electricity North West.

Equipment shall be designed for minimum maintenance. The switches and the oil of the diverter-switch and selector-switch compartments shall be capable of withstanding 40 000 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 100 000 operations at the maximum rated through-current, without requiring attention.

11.3 OLTC Driving Mechanism

On-load tap changers shall be provided with an electrically operated driving mechanism which complies with the requirements of Section 14. The motor drive mechanism shall be capable of operation over the ambient air temperature range of -25°C to +55°C.

The tap change mechanism shall be designed such that when a tap change has been initiated, it will be completed independently of the operation of the voltage control relays and switches. If a failure of the auxiliary supply during tap change or any other contingency would result in that movement not being completed, an approved means shall be provided to safeguard the transformer and its auxiliary equipment.

Limit switches shall be provided to prevent over-running of the tap changing mechanism. These shall be directly connected in the operating motor circuit. In addition, mechanical stops shall be fitted to prevent over-running of the mechanism under any conditions. These stops shall withstand the full torque of the driving mechanism without damage to the tap change equipment.

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

Manual operation of the tap changer shall require clockwise rotation to raise the tap position number.

Tap changer motors shall comply with the requirements of Section 14. Thermal devices or other approved means shall be provided to protect the drive mechanism motor and its control circuit.

The tap changer mechanism enclosure shall be to protection class IP54 according to BS5490 and shall be protected against condensation by suitable approved means. The internal and external surfaces of the motor drive mechanism box shall be finished with a paint protective system complying with the requirements of Section 10.

A permanently legible lubrication chart shall be provided and fitted inside the tap changer mechanism box.

11.4 Off-Circuit Changers

Where specified in Schedule D of Requirements, off-circuit tap changing facility shall be by means of an externally operated self-positioning tapping switch. All phases of the tapping switch shall be operated by one handwheel which shall be positively located and padlockable at each tapping switch "on-tap" position. Operation of the tapping switch shall require clockwise rotation to raise the tap position number.

An indication plate shall be fitted to show clearly the tap position number at which the transformer is operating. Switch position number one shall correspond to the maximum plus tapping.

Shaft extensions, level gear boxes etc. to operate the off-circuit tapping selectors from ground level, are not permitted.

11.5 Voltage Control

Transformer manual and electrical control shall be in accordance with the requirements of Section 14.

12 Terminal Arrangements and Connections

12.1 General Requirements

Where stated in Appendix A, Schedule D of Requirements, transformers are to be terminated with either outdoor type bushing insulators, or unfilled type cable enclosures, which shall be complete with all necessary fittings.

All equipment shall withstand the tests specified in Section 15. Outdoor bushings shall be provided with adjustable co-ordinating gaps. Where stated in Appendix A, Schedule D of Requirements, accommodation for current transformers shall be provided in the bushing turrets.

Transformers having bushing terminations and separately mounted cooler banks, shall be arranged to permit either initially, or at a later date under a separate contract, the installation of a sound attenuation enclosure without modification to, or movement of, the transformer and cooler.

12.2 Terminal Bushings

12.2.1 Particular Requirements

Except where otherwise specified, the 33kV and 11kV side of the transformers shall be terminated with bushings. All bushings shall comply with IEC60137 and the minimum creepage distance for outdoor bushings shall be not less than 31mm/kV.

The required voltage characteristics are as shown in Table 8 below:

Table 8 – Voltage Characteristics

	VOLTAGE (KV)		
Rated voltage between phases	132	33	11
Highest voltage for equipment	145	36	12
Lightning impulse withstand voltage	650	200	110
Power frequency voltage withstand (dry)	275	75	45*
Power frequency voltage withstand (wet)	275	75	35

(* To cater for applied voltage test on transformers having graded insulation)

Bushings shall be capable of carrying the maximum current obtainable including overload consideration from any winding to which they may be connected.

Where accommodation is required on bushings for current transformers, this and co-ordinating gap setting shall be as follows:

(a) Each 132kV HV bushing insulator shall be suitable for accommodating up to three protection type current transformers. One of the HV bushings will also be required to accommodate the current transformer for operation of the winding temperature indicator in addition to the protection current transformers. These bushings shall be fitted with adjustable arcing horns to achieve a minimum gap setting of 660mm (range 655mm to 710mm).

(b) 132kV HV neutral bushing shall be mounted vertically on the tank and shall be rated at not less than 11kV 630A for all ratings of transformer.

(c) LV bushings insulators for use on 33kV windings shall be of the pull through design rated to comply with the required voltage characteristics in Table 8 and shall be specified if required to accommodate protection current transformers. These bushings shall be fitted with fixed arcing horns having a gap of 315mm.

HV and LV line bushings shall be mounted in extended turrets to allow fitting a sound attenuation enclosure. It shall also be possible to remove any bushing without disturbing the current transformers. Attention shall be paid to site conditions, particularly in respect of the clearances between the HV and LV open terminal connections.

12.2.2 Construction

Drawings of bushings showing the dimensions, terminals, terminal arrangements, shed profiles and current transformer accommodation shall be submitted with the tender. Bushings shall be designed such that they can be mounted in and removed from turrets with current transformers fully occupying the space indicated.

Bushings for windings having U_m >36kV shall be of the condenser type having either Epoxy Resin Impregnated Paper (ERIP) or Oil Impregnated Paper (OIP) core insulation, and of an Approved design.

Cast iron is not to be used for any part of the equipment which is in tension or which is subject to impact stresses. The application of bolts and nuts shall comply with the requirements of Section 6.11.

Aluminium alloys used for castings shall comply with BS1490, Grade LM6-M or LM8-M and for fabrication with BS1470, Grade5083. Flanges shall be of a shape which will not trap air.

Completed bushings shall be capable of supporting a maximum vertical load (compression) of 2250N.

The construction shall prevent current, other than capacitance current, passing through fixings for gasketed joints.

A minimum of two flexible connections shall be made between all electrically live internal parts, for potential equalisation, unless such parts form a solid connection to each other by virtue of their construction and assembly. The cross sectional area of each flexible connection shall be more than 0.32 mm^2.

A central, rigid, conductor shall be provided with each bushing by the bushing manufacturer. The rigid conductor shall be adequately supported and prevented from twisting during assembly and in service.

The connection point for the winding shall be external to the bushing body and comply with the detail given on the appropriate drawing.

Stress shields required at the end of the bushing shall be an integral part of the bushing assembly.

Facilities to release air trapped during assembly, with the minimum dismantling of component parts, shall be provided. Air release plugs, if used, shall be of an approved design.

Oil-filled bushings shall have an expansion space above the oil; this space shall be filled with either dry air or dry nitrogen. The volume of the space shall be a minimum of 10% of the total oil volume at 15°C. It shall not be possible to drain the bushing of its oil filling when in service.

Bushings weighing more than 25kg shall be provided with lifting facilities, eg tapped holes in the flange to take eye-bolts or shackles to hold slings.

Precautions shall be taken to exclude moisture or other contamination from insulation (particularly air in OIP) during transformer manufacture, transport and site erection. The bushing manufacturer shall provide written instructions for transport and erection.

12.2.3 Temperature Limits

The temperature limits commonly used under the operating conditions for OIP and ERIP core insulation, as specified in IEC 60137, shall apply.

The operational temperatures for ambient and immersion media as stated in IEC 60137 for outdoor bushings complying to Class 1, with the following exception:

Exception – For bushings intended for use in an insulation medium other than air at atmospheric pressure, it shall be assumed that the immersion medium operates within a temperature profile having:

- A maximum of 100°C
- A maximum daily average of 90°C
- A maximum annual average of 80°C

12.2.4 Porcelains and Associated Gaskets

All porcelain insulators shall be designed to facilitate cleaning. Porcelain shall be sound, free from defects and thoroughly vitrified. The glaze shall be of a uniform shade of dark brown approximately to BS 381C, Colour 412, and shall cover completely all exposed parts except where ground. The glaze shall comply with the requirements of BS 4963; any blemishes permitted shall be unfilled and left exposed.

Outdoor porcelain and associated fittings shall be unaffected by grease coatings and atmospheric conditions due to weather, proximity to the coast, fumes, ozone, acids, alkalis and dust, normally encountered in service. They shall also withstand rapid changes of air temperature between -25°C and +40°C under service conditions.

Weather-sheilds made from multi-piece porcelains must have all porcelain parts from the same manufacturer, and the positions of the joint(s) and the jointing method having written Approval from Electricity North West prior to manufacture.

Porcelain shall not engage directly with hard metal and, where necessary, gaskets complying with Section 6 and Section 10 shall be interposed between the porcelain and the metal. All porcelain clamping surfaces in contact with gaskets shall be ground to the requirements of BS 4963, incorporate radiuses or chamfered corners to prevent splintering, and be free from glaze.

Fixing materials shall not chemically react with the metal parts or cause fracture by expansion in service. Cemented surfaces shall be sealed and prevent the collection of water.

Each porcelain part shall bear the date of manufacture together with a manufacturer's identification mark to assist in the representative selection of batches for the purpose of the sample tests stated in Section 15. These marks shall be printed (not impressed) before firing and be clearly legible and visible after assembly of fittings.

Porcelains shall be obtained from Approved manufacturers. Where it is proposed to supply porcelains of a manufacture differing from that used for the type tests, written agreement to their use shall be obtained from Electricity North West prior to ordering.

12.2.5 Polymeric Bushings and Associated Gaskets

Electricity will accept Polymeric bushings subject to them meeting the minimum ratings and standards as detailed in Section 12.2. Tenderers shall submit full Bushing details with their Tender for Approval by Electricity North West's Plant Policy Manager.

12.2.6 Paint and Other Protection

The surface of the oil immersed end of ERIP insulated bushings shall be finished with an approved non-hygroscopic, non-tracking, varnish.

Where required, oil containers and mounting flanges shall have a paint protective system in accordance with Section 10.

12.2.7 Mounting of Bushings

Bushing insulators shall be mounted on the tank in a manner such that the external connections can be taken away clear of all obstacles. Neutral bushings shall be mounted in a position from which a connection can be taken to a neutral current transformer mounted on a bracket secured to the transformer tank.

The clearances from phase to earth must not be less than those stated in Section 6.6.

All bolt threads are to be greased before erection.

12.3 Cable Boxes

12.3.1 Particular Requirements

Where specified in Appendix A, Schedule D, the 33kV and 11kV sides of the transformers shall be terminated with cable boxes of the unfilled enclosure type, suitable for terminating up to three 630mm2 single core cables per phase in the 33kV cable box, four 400mm^2 single core cables in the 11kV cable box and one 400mm^2 single core cable in the neutral connection cable box. Electricity North West will supply the cables, cable glands and dry type cable terminations, details of which shall be provided during the contract stage.

Cable boxes and clearances shall comply with BS 6435 and shall be of adequate proportions so that they can be opened for inspection without disturbing the gland plate or incoming cables. A split type aluminium cable gland plate with 10mm diameter pilot holes for the glands shall be provided.

Environmental protection shall comply with the requirements of BS 5490, IP 33 classification and Section 10.12 for the finish of internal and external surfaces. Anti-condensation paint is not required for internal surfaces of unfilled enclosures.

12.3.2 Ratings

When carrying continuous rated current or any other specified loading, the air temperature of the unfilled enclosure shall not exceed 70°C, with the cable conductors at a temperature of 90°C and the external ambient at 40°C, the effects of solar gain shall be taken into consideration.

12.3.3 Construction

Cable boxes shall be designed for ease of access for jointing and connecting the cables. Suitable means shall be provided for clamping the armour wires of the cables.

Cable boxes shall:-

(a) Accommodate the fittings for cable termination, including stress-cones or other stress control devices.

(b) In the event of an internal breakdown, they shall:-

- Not disintegrate.
- Control emission of arc products safely (particularly with regards to personnel) and without penetration into the main tank.

Terminals shall be marked in a clear and permanent manner, in accordance with Section 10.

Fixing studs/bolts for cover plates and flanges shall:

(a) Be more than M10,

(b) Be spaced less than 75mm between centres,

(c) Not penetrate the casing. Where blind tapped holes are employed, studs shall be used; set screws and bolts are not permitted.

Flanges shall have:

(a) A thickness more than 4mm,

(b) More than 12mm between the inner edge of the flange and the hole for the securing studs.

Cover plates shall:

(a) Be separate and removable,

(b) Have a thickness of more than 5mm,

(c) Not exceed 25kg in weight.

Gaskets shall be supplied, made in one piece from oil resisting synthetic rubber bonded cork, having:

(a) An uncompressed thickness >5mm,

(b) An effective width on the inside of the fixing studs/bolts of more than 12mm.

(c) A medium hardness of 70±10IRHD, as defined BS 903, Part A26; separate compression devices shall not be used.

Aluminium alloys used for castings shall comply with BS 1490, Grade LM6-M and, for fabrication, with BS 1470, Grade 5083. Any departure from this requirement shall be subject to specific Approval.

Cast resin bushing assemblies shall comply with the following requirements:

(a) Less than 12kV working voltage - BS 2562.

(b) More than12kV and less than 36kV working voltage - to the Approval of Electricity North West.

Where condenser bushings are specified, they shall be in accordance with BS 2562, Figure.15.

To facilitate connection between the bushing end-cap and the associated cable, bushing assemblies shall be suitable to accept one of the following:

(a) Hot-pressed or cast sockets, generally in accordance with BS 91, Table 1.

(b) Compression sockets to suit the rating of the equipment; these will be provided by Electricity North West.

(c) Flexible connections and connectors in accordance with Electricity North West requirements.

(d) When specified, tubular lug-sockets, in accordance with BS 91, Table 2B, or other specified sockets.

Each cable shall be provided with an individual removable gland plate. Gland plates for single-core cables shall be manufactured from non-magnetic material. Glands for single-core cables shall be on the same axis as the cable connector.

12.3.4Venting, Drainage and Earthing

Cable boxes shall incorporate:

(a) Two 6mm holes at the rear for breathing,

(b) Two 12mm holes at the base for drainage.

In addition to the requirements of IP33 classification, the protection shall prevent the insertion of any object liable to cause a dangerous occurrence (the use of gauze is not acceptable).

(c) An accessible earth terminal, near the base. This terminal shall comprise a screwed rod of phosphor bronze or high tensile brass having a minimum size of M12 x 65mm long, passing through the shell and secured on each side by a plain washer and one full nut. it shall also be provided with two plain washers and two locknuts, both inside and outside the enclosure.

12.3.5 Disconnecting Chambers

Where specified in Appendix A, Schedule D of Requirements, an oil-filled cable disconnecting chamber with removable links shall be provided for testing purposes. Barriers shall be provided on both sides of the disconnecting chamber to prevent ingress of the oil used for filling the chamber into the cable box or the transformer. It shall not be necessary to remove all of the oil in the chamber itself when making the necessary testing connections.

The disconnecting chamber shall have a removable cover and be fitted with an air release plug at its highest point. The oil in the chamber shall be separate from the oil in the main tank being supplied through a separate pipe attached to the body of the chamber and fitted with an isolating valve from the transformer side of the gas and oil actuated relay in the transformer feedpipe. Means shall be incorporated in the construction of the bushings between the transformer and the disconnecting chamber to prevent rotation of the bushing stems when removing or replacing the links. The provision of palm terminations would satisfy this requirement.

The links shall be of a design to prevent inadequate clearance and with links removed the clearances provided shall be adequate to permit site testing of the transformers to IEC 60076 and testing of the cables after installation in accordance with BS 6480.

An earthing terminal shall be provided in each disconnecting chamber to which the connections from the transformer winding can be earthed during cable testing.

12.4 Current Transformers

Where stated in Appendix A, Schedule D of Requirements, the contractor will be required to supply current transformers, in the HV and LV bushing turrets. It shall include also all necessary wiring to spring loaded terminal blocks at the transformer marshalling kiosk.

A current transformer shall be mounted in the HV neutral connection. The CT is for high voltage restricted earth fault differential protection. The current transformer shall be weatherproof, mounted externally to the transformer tank and accessible for protection testing. The transformer neutral connection shall be connected to the current transformer. The characteristics of the HV neutral CT shall be matched to the measured characteristics of the HV phase CTs.

HV bushing current transformers shall be fitted with a primary test lead to provide an access point for primary testing of the HV CTs. All test windings shall have a minimum CSA of 10mm2 to allow sufficient current to be injected during commissioning and shall be wired to the transformer marshalling kiosk.

A current transformer (CT) shall be provided for the compounding equipment and associated with the yellow phase.

Full CT specification and location diagrams are shown in Appendix A Schedule A and will be confirmed at the time of order by Electricity North West Grid and Primary Design Department.

13 Cooling Plant

13.1 General Requirements

Radiators and cooling banks shall be galvanised and painted and designed to avoid pockets in which water can collect. They shall be capable of withstanding the pressure tests specified for the transformer main tank.

The clearance between any oil or other pipework and live parts shall be not less than the minimum clearances stated in Section 6.6.

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Vibration of the cooling plant shall not cause problems in service.

All cooling plant fans, motor housings and fan blades including all their components shall be of a suitable design for Coastal locations this should include a C5M finish (or better) or plastic in construction. All bearings and drive shafts shall be suitable for Coastal locations in the UK and shall not seize in a saline atmosphere.

13.2 Radiators

The minimum thickness of radiator panels shall be 1mm. Tank attached radiators shall be detachable and provided with flanges for the inlet and outlet connections. Valves of an approved type shall be provided at each point of connection to the transformer tank. Plugs shall be fitted at the top of each radiator for air release and at the bottom for oil draining.

Where a transformer is provided with cable end boxes, the arrangement of radiators shall give unrestricted access for the cables when rising vertically from below.

13.3 Cooling Banks

Where required, the transformer shall be provided with a suitable free standing bank of radiators. In this case, the radiators shall be divided into two 50% cooling banks with separate headers and one common oil conservator.

As a minimum requirement, each cooler bank shall be provided with:

(a) A valve at each point of connection to the tank.

(b) A valve at each point of connection to radiators.

(c) A 50mm gate valve at the top.

(d) A 50mm gate valve at lowest point of each interconnecting oil pipe.

(e) A thermometer pocket, fitted with captive screw cap in the inlet and outlet oil pipes.

(f) Air release and drain plugs on each radiator.

The omission of any, or the provision of, alternative arrangements to the above requirements will not be accepted unless Approved in writing by Electricity North West before manufacture.

13.4 Oil Pipes and Flanges

All oil pipework necessary for the connecting of each transformer to its conservator, cooling banks and oil pumps etc. shall be supplied.

The oil piping shall be of an Approved material with machined flanged joints. Cast iron shall not be used.

Where necessary, an approved expansion piece shall be provided in each pipe connection between the transformer and each oil cooler bank.

It shall be possible to drain any section of pipework independently of the rest and drain valves or plugs shall be provided as necessary to meet this requirement.

13.5 Oil Pumps

Forced oil coolers shall be provided with fully waterproof, motor driven, oil circulating pumps of the totally submerged type, suitable for continuous operation of oil at temperatures from -10°C to +105°C.

Each oil circulating pump and its driving motor shall be mounted together in a common casing, without exposed shafts or couplings. Plugs for air release and oil drainage shall be provided. Indications shall be provided to show the direction of pump rotation by incorporating a window in the pump motor casing. A terminal housing for electrical connections shall be provided. This shall be capable of being removed without oil leakage from the pump motor casing.

The design of forced oil circulation pumps shall be such as to permit the removal of the pump for maintenance and repairs without lowering the oil in the transformer or in the oil cooling plant.

Oil pumps shall be capable of dealing with the maximum output and head of oil which may occur in service and with the varying load due changes in viscosity of the oil.

13.6 Air Blowers

Fans for forced air cooling shall be suitable for continuous operation out-of-doors. They shall also be capable of withstanding the stress imposed when brought up to speed by the direct-on-line starting.

Fans shall be mounted under the radiators and shall force air vertically upwards.

It shall be possible to remove each fan complete with its motor without disturbing or dismantling the cooler structure framework or associated pipework.

Fan assemblies shall be designed to prevent ingress of water to the motor bearings when in service.

Galvanised wire guards with mesh not exceeding 12.5mm shall be provided to prevent fouling and accidental contact with the fan blades. Guards shall also be provided over all moving parts. Guards shall be designed such that blades and other moving parts cannot be touched by test fingers to IEC 60529.

13.7 Motors

Electric motors shall be in accordance with IEC 60034-1 and, unless otherwise specified, shall have cooling type ICC1 suitable for continuous operation and direct-on-line starting. When used for driving on-load tap change equipment, a short-time (15 minute) rating may be used.

Motors shall be capable of operating continuously at rated output at any frequency between 47Hz and 51Hz and at any voltage within +10% and -6% of the nominal 230V value. Motors shall be designed to operate for a period of not less than five minutes at a voltage of 25% below the nominal value and at normal frequency without injurious overheating.

Each motor shall be protected by a miniature circuit-breaker or fuses with thermal overcurrent protection.

The starting current at full voltage is not to exceed six times the rated full load current of the motor.

All terminals shall be suitable for their particular duty and enclosed in weatherproof boxes.

13.8 Cooler Control

The cooler control schemes shall meet the requirements specified in Section 14.3.

14 Electrical Control and Marshalling

14.1 General Particulars

Equipment for local manual and electrical operation of the cooling and tap change equipment shall be provided in an outdoor marshalling kiosk complying with the requirements of this Section. Electrical interfaces for the remote control of the tap changing equipment shall also be supplied in-line with the requirements of this section and also as specified in Appendix A, Schedule D.

All electrical equipment shall have the following degrees of protection classified in IEC 60529:

- IP54 for outdoor control cubicle and marshalling kiosk
- IP54 for auxiliary switches and associated terminals
- IP65 for outdoor instruments
- IP54 for outdoor motors
- IP41 for indoor control cubicles.

14.2 Common Requirements

The provision and installation of all wiring for the electrical equipment covered by this Section shall form part of the Contract Works.

The provision and installation of all wiring for the control gear accommodated in the marshalling kiosk together with all necessary cable boxes, terminations and all wiring and cabling between the marshalling kiosk and the motors shall be included.

All contacts and other parts which may require renewal, adjustment or inspection shall be readily accessible.

All hand operated electrical control switches shall be clearly labelled and inscribed, as applicable, in accordance with Electricity North West requirements, to indicate the function of the apparatus with which they are associated.

Contacts and current carrying parts associated with motor circuits shall be capable of making, breaking and carrying, as applicable, the starting and stalled current of the motor(s).

The requirements for electrical control and alarms shall be as specified in Appendix A, Schedule D and to Electricity North West standard circuit diagrams 900230-001, 900230-002, 900230-003, 900200-004, 900230-005 and 900219-009.

14.3 Electrical Control of Cooling Plant

The AC cooling supply to the marshalling kiosk shall be used to derive both cooling motor supplies and cooling control scheme supplies. The supply shall be isolatable via an ON / OFF Cooler Supply Isolation switch (CSI), mounted in the marshalling kiosk associated with the cooling plant. The OFF position for switches shall be at 12 o'clock and lockable, with clockwise rotation to ON.

The supply side of the cooling supply isolation switch shall be monitored by a Cooling Supply Supervision Relay (CSSR) which shall be provided with a volt free alarm output contact which shall operate in the event of loss of any 1 or all 3 phases of the incoming cooling supply. The contact shall be arranged to be normally open and close under alarm conditions (i.e. fail safe).

Transformers shall be provided with facilities for selection of AUTOMATIC or MANUAL control of the cooling plant. These control facilities shall be provided by a multi-position cooler control switch (CCS), mounted in the marshalling kiosk associated with the cooling plant. The cooler control switch shall provide the following manual test facilities, as necessary, for the installed cooling arrangement: -

ONAF

- Each fan or group of fans
- All fans (sequenced starting)

OFAF

- Each fan or group of fans
- Each pump
- All fans and pumps (sequenced starting)

The winding temperature indicators, both HV and LV, shall control the operation of the cooling plant motors automatically when the associated cooler control switch is set for AUTOMATIC. The cooler control switch shall be mounted with its AUTOMATIC position arranged at 12 o'clock. The winding temperature indicators shall typically be arranged to start and stop the cooling system when the following winding temperatures are reached, however the transformer manufacturer shall advise of alternative temperature limits to ensure the most efficient long term operation of the transformer based its design.

The cooling shall:

Start at 75°C

Stop at 50°C

Transformers with ONAF cooling arrangements, the cooling control equipment shall be provided with a Sequence Start Relay (SSR) to prevent the starting of more than one bank of fan motors at the same time when the cooling control switch is selected to AUTOMATIC or FANS mode.

Transformers with OFAF cooling arrangements, the cooling fan motor control equipment shall be provided with a Sequence Start Relay (SSR) to prevent the starting of more than bank of fan motors at the same time when the cooling control switch is selected to AUTOMATIC or FANS AND PUMPS mode. Also, where more than one cooling circulating pump is used, it shall only be possible to start and stop the pump motors in a timed sequence when the cooling control switch is selected to AUTOMATIC or FANS AND PUMPS. This is to prevent sudden changes in oil pressure which may affect other auxiliary devices on the transformer.

Where the cooling arrangement contains more than one group of fan or pump motors, the control circuit shall be arranged to permit the isolation of each control circuit for maintenance purposes.

The control arrangements shall provide an alarm output in the event of any one cooling fan or cooling pump motor failure. This shall preferably be achieved by monitoring of currents drawn by the cooling equipment via interposing CT's.

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.

Each motor or group of motors shall be provided with a three-pole electrically operated contactors (FMC and PMC) and control gear of approved design for starting and stopping manually.

Each fan and oil circulating pump motor circuit shall include a three phase overload and single phasing protection relay (FMPR or PMPR), fitted with hand reset and trip indication facilities and having a dust protecting case, mounted in the marshalling kiosk. This relay shall be capable of carrying the motor starting current without tripping when its trip setting is 115% of rated full load current of the motor.

The coolers and their control arrangements shall be such that failure of one part of the cooling equipment will not result in the loss of more than 50% of the total forced cooling capacity.

All motor contactors and their associated control apparatus shall function correctly when supplied at any frequency within the range 47Hz to 51Hz, for the following voltages and durations:

(a) Any value between 85% and 115% of nominal voltage - continuously.

(b) At 75% of nominal voltage - for 10 minutes.

The motor contactors shall comply with the requirements of BS EN 60470.

Each motor circuit or, as applicable, group of fan motor circuits, shall be provided with back-up protection of the motor protection relays by suitably rated fuses mounted in the marshalling kiosk.

Where forced cooling using multiple small single-phase motors is employed, the motors in each cooling bank shall be grouped so as to form a balanced three-phase load.

Where motors are operated in groups, the group protection shall be arranged so that it will operate satisfactorily in the event of a fault occurring in a single motor.

The control arrangements shall be designed to prevent the starting of motors totalling more than 15kW simultaneously either manually or automatically.

14.4 Electrical Control of On-Load Tap Change Equipment

14.4.1 General

All on-load tap change equipment shall be provided with facilities for local and remote electrical control. The various forms of electrical control covered by this Section shall be in accordance with Electricity North West standard drawings as detailed in Section 14.2.

The electrical control circuits for each primary unit shall operate at 110V a.c., single phase, derived from a Control Circuit Transformer, which shall comply with the requirement of BS 3535, having a ratio of 230/55-0-55 volts, with the centre point of the secondary winding earthed through a bolted link. The incoming connections to the transformer shall be supplied with a fuse and a neutral link. The outgoing connections shall be supplied with a fuse in each pole. This transformer, with its fuses and links, shall be mounted in the marshalling kiosk.

All motor contactors and their associated control apparatus and indicating devices shall function correctly with the operating supply voltages at any value between 85% and 115% of nominal. The motor contactors and their associated control apparatus shall also be capable of holding in and functioning satisfactorily for a period of ten minutes if the operating supply voltages fall to 75% of nominal. Both these operating conditions shall apply for a frequency range of 47Hz to 51Hz. The motor contactors shall comply with the requirements of BS EN 60470.

It shall not be possible to operate the tap changer electric motor drive when the manual operating handle is inserted. To achieve this, a handle interlock device, integral with the manual operating gear, shall isolate the motor supply when the manual operating handle is inserted but before it engages the mechanical drive.

The electrical control shall be provided with a Directional Sequence Switch (DSS) integral with the Driving Mechanism (DM) to ensure that when a tap change operation has commenced it shall be completed independently of the operation of control switches or relays. If failure of the operating supply should occur during a tap change operation, the driving mechanism shall complete its operation when the supply is restored.

Directional Raise and Lower end stop Limit Switches (DRLS and DLLS), to prevent operation of the driving mechanism beyond the end positions, shall isolate the motor supply and the motor control circuit. The arrangement of these limit switches shall permit electrical operation in the opposite direction; these switches shall automatically reclose when the mechanism moves from such an end position.

Facilities shall be provided to isolate the incoming a.c. tapchanger supply at each marshalling kiosk by means of a two position ON/OFF Local Selector Switch (LSS). This switch shall be mounted with its OFF position arranged at 12 o'clock and shall be capable of being padlocked in the OFF position.

A two position Local/Remote selector switch shall be provided at the tap changer marshalling kiosk and shall complete the control functions as detailed in section 14.4.2.

14.4.2 Local/Remote Control

Circuits and arrangements for local and remote control of on-load tap change equipment shall comply, as applicable, with Electricity North West standard schematic diagrams 900230-005 and 900219-009.

Facilities shall be provided such that when operating in either local or remote control position the tap-changer position number can be raised or lowered. The local control switches shall be clearly inscribed to indicate their purpose; typical examples are: "RAISE TAP POSITION NUMBER" and "LOWER TAP POSITION NUMBER".

The controller at the marshalling kiosk shall be operative only when its associated LOCAL/REMOTE local selector switch at the marshalling kiosk is set to LOCAL. Under this condition, all other control points shall be inoperative.

The controller at the remote control panel shall be operative only when its associated LOCAL /REMOTE local selector switch at the marshalling kiosk is set to REMOTE. Under these conditions, all other control points shall be inoperative.

Electrical operation initiated by any controller shall cause one tap movement only unless the controller is released between successive changes.

14.4.3 Remote Automatic Voltage Control

Remote automatic voltage control is outside the scope of this works. The interfaces shall be provided in accordance with Electricity North West standard drawings as detailed in Section 14.2.

The Tenderer shall also provide an option for the automatic voltage control scheme to be fitted within the Transformer Marshalling kiosk in line with Electricity North West drawing 900219/009 and 900230/005.

14.4.4 Voltage Regulating Device CT

A current transformer (CT) shall be for the compounding equipment and associated with the yellow phase.

Full CT specification and location diagrams are shown in Appendix A Schedule A and will be confirmed at the time of order by Electricity North West Grid and Primary Design Department.

14.4.5 Remote Tap Position Indicators

Facilities shall be provided within the tap change panel to provide separate remote indications of tap position for both the Automatic Voltage Control relay and the Electricity North West Telecontrol system as detailed on the Electricity North West standard drawings 900230-002 and 900230-004.

The moving contact arm(s) of multi position switches required for Tap Position Indication shall rotate in a clockwise direction, viewed from their fixed contact faces, when raising tap position numbers.

14.5 Temperature Indicators

14.5.1 General

The requirements for oil and winding temperature measurements, including sensor bulb pockets and their positioning, and the provisions for alarm, trip and cooler control switches and their interconnection, are specified for the transformer as appropriate on the Electricity North West standard drawings 900230-002 and 900230-004.

Current shall not be carried through terminal boards by studs or screws (except for the WTI heater link terminal panel).

All digital devices shall have a scale ranging from 30°C to 150°C. They shall be easily reset.

14.5.2 Oil Temperature Indicators (OTI)

The indicator shall provide a remote temperature indication in the form of an output suitable for connection to an Electricity North West Network Management System, typically 0-10mA as detailed on the Electricity North West standard drawings 900230-002 and 900230-004.

14.5.3 Winding Temperature Indicators (WTIs)

Winding Temperature Indicators shall simulate the hottest spot temperature of the transformer windings and shall preferably be of the digital type capable of covering a temperature from 30°C to 150°C. The type and model shall be approved for use by Electricity North West and shall be mounted in the marshalling kiosk.

To simulate indication of the hottest spot temperature of the winding the device shall include a current transformer associated with one phase only and a heating device designed to operate continuously at 130% of transformer CMR current and for 30 minutes at 150% of CMR current, associated with a sensing bulb installed in an oil tight pocket in the transformer top oil.

Each WTI shall be supplied from a CT having its primary energised from the relevant winding via a test module complete with terminals, links and a moving iron ammeter. The test module shall be shielded by a removable, transparent, flame retardant cover and shall be mounted in the marshalling kiosk.

The test module shall allow: -

(a) The output of the heating device CT to be checked.

(b) The WTI's to be used as oil temperature indicators by short-circuiting the CT secondary and disconnecting the heating device.

(c) Injection testing of current into the heating device to check the calibration.

(d) Testing the current transformer.

The linking arrangement for each function shall be clearly identified on the test module diagram plate.

The CT supplying the WTI shall meet the following specification: -

(a) Ratio of rated current on nominal tap position / 5A.

(b) Capable of operating at 150% rated current continuously with excursions to 200% rated current for 15 minutes.

Details of the calibration and setting of the WTI shall be provided to Electricity North West.

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 tripping contacts shall be adjustable to close between 100°C and 150°C and to re-open when the temperature has fallen by not more than 10°C.

The alarm contacts and the contacts used to control the cooling plant motors shall be adjustable to close between 50°C and 100°C and to re-open when the temperature has fallen by a desired amount between 10°C and 15°C.

All contacts of the WTI's shall be suitably rated for the control scheme which they are incorporated within.

Where digital WTI's are provided they shall be equipped with a the following features :-

(a) Fail safe self monitoring feature with suitable volt free alarm contacts which close on failure.

(b) Shall not raise a trip output in the event of a failure mode situation.

All Digital WTI indicators shall be supplied from the substation 110V DC battery system to ensure that the alarm and tripping outputs are maintained in the event of an AC cooler supply failure.

14.5.4 Remote Indication of Winding Temperature

An analogue remote indication of winding temperature shall be provided in accordance with the temperature measurement requirements as appropriate and the Electricity North West Standard drawings 900230-002 and 900230-004. The output shall be 0-10mA for connection to the Electricity North West Network Management System.

14.6 Oil Level Indicators

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).

14.7 Transformer and Tap Changer Alarm and Trip Outputs

The auxiliary devices on the transformer and its associated equipment shall provide the following outputs at the marshalling kiosk for connection to the Electricity North West protection, control and alarms schemes: -

AUXILIARY DEVICE	SIGNAL	PROTECTION TRIP	ALARM
Transformer Buchholz Relay	Operated	x	x
Tap changer Oil Surge Relay	Operated	x	x
Transformer Pressure Relief Device	Operated		x
Auxiliary Transformer Buchholz Relay	Operated	x	x
Auxiliary Transformer Pressure Relief Device	Operated		x
Transformer Winding Temperature Relay (HV)	135°C Reached*	x	
Transformer Winding Temperature Relay (LV)	135°C Reached*	x	
Transformer Winding Temperature Relay (HV)	110°C Reached*		x
Transformer Winding Temperature Relay (LV)	110°C Reached*		x
Transformer Oil Level	Low		x
Tap Changer Oil Level	Low		x
Tap Changer Incomplete Relay	Operated		x
Tap Changer Motor Protection Device	Operated		x
Transformer Regenerative Breather	Failed		x
Tap Changer Regenerative Breather	Failed		x

* Transformer manufacturer shall advise of alternative temperature limits to ensure the most efficient long term operation of the transformer based its design.

14.8 Marshalling Kiosks

14.8.1 General Requirements

All marshalling kiosks shall preferably 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.

For free-standing kiosks, two welded lifting lugs shall be provided at diagonally opposite corners.

Paint protection systems shall comply with the requirements of Section 10.

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.

14.8.2 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.

14.8.3 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.

14.8.4 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).

(c) 230V a.c. light fittings shall be provided within all marshalling kiosks. The light fittings shall be controlled by a door switches which automatically turn the light fittings on / off when the marshalling kiosk doors are opened / closed respectively.

The above circuit shall be supplied from the 'Auxiliary Supplies' incoming 230v, 1ph, a.c. supply.

The regenerative breathers installed on the transformer shall be supplied from 'Breather Supplies' incoming 230v, 1ph, a.c. supply.

The transducers installed within the marshalling kiosk shall be supplied from 'Transducer Supplies' incoming 230v, 1ph, a.c. supply.

Where low voltage connections are taken into marshalling kiosks, “400 VOLT DANGER” notices shall be affixed to the outsides of the doors of the appropriate compartments.

Labels shall be provided for all apparatus mounted inside and outside marshalling kiosks.

An isolation link shall be provided within the marshalling kiosk for connection of the sump pump alarm output, which will be supplied and installed by others.

14.9 Connections and Wiring

14.9.1 General Requirements

Insulated wires shall comply with BS 6231or equivalent IEC. Wire sizes shall be the responsibility of the Contractor, however all CT wiring shall be a minimum of 2.5mm^2 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.

14.9.2 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/cubicle, 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.

14.9.3 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^2) 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^2). All pilot wiring shall be a minimum size of 2.5mm^2 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^2 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^2 (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.

15 Tests

15.1 General Requirements

Tests for transformers shall be performed in accordance with the requirements set out in this section, to the satisfaction of Electricity North West. Type Tests and Special Tests shall be at the option of Electricity North West. Electricity North West may agree to the omission of type tests in part or in whole upon submission of details of type tests which have been carried out previously on identical or essentially similar equipment.

Other general requirements for testing are as follows:

Tests as listed in Sections 15.5, 15.6, 15.7, 15.8 and 15.9 shall be performed in order to determine that the material and apparatus comply with the Specification and to provide the necessary operating data; all correction factors used in determining the test results shall be to the Approval of Electricity North West and shall be detailed on the test certificates.

Tests shall be arranged to represent the working conditions as closely as possible. Unless otherwise stated, all electrical tests shall be carried out at a frequency of 50Hz and at normal room temperature. The voltage waveform of the supply shall be approximately sinusoidal.

The requirements of this section are not to be taken as a Test Programme. Test Programmes and place of testing shall be agreed between Electricity North West and Contractor prior to the commencement of testing. Not less than ten days notice of all tests shall be given to Electricity North West in order that Electricity North

West may be represented. As many tests, as in the opinion of Electricity North West are possible, shall be arranged together. Four copies of the Contractor's records of all tests shall be supplied to Electricity North West; these records may form part of other test records.

Instruments shall be suitable for the intended measurement and be within twelve months of calibration by an approved laboratory. Re-calibration, if necessary, shall be at the expense of the Contractor.

Should either failure occur or non-compliance with the Specification become apparent, testing shall be discontinued and not recommenced without the agreement of Electricity North West. The Contractor shall make available to Electricity North West all information, test data and evidence relating to the failure/cause of non-compliance, and also make available all facilities for examination of the Contract Works. The Contractor shall repair the failure (or resolve the non-compliance) and shall replace any part of the Contract Works which may have been damaged or contaminated.

The Contract Works shall neither be subjected to additional tests nor used for testing other equipment without the prior written permission of Electricity North West.

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 Electricity North West representatives are witnessing the type tests.

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

An electronic copy of the test results in PDF format shall be forwarded to the Electricity North West Policy & Standards Section (for the attention of the Plant Policy Manager).

All corrections to the test results shall be detailed on the test certificates and shall be to the Approval of Electricity North West.

15.2 Tests at Manufacturer's Work

15.2.1 General

Works tests shall include all routine electrical, mechanical and hydraulic tests in accordance with the relevant IEC or British Standard except where departures from and modifications to those standards are embodied in this Specification. For plant not covered by any IEC or British Standard or other standard specifically mentioned in this specification, such tests as are relevant shall be agreed with Electricity North West.

Should the plant or any portion fail under test to give the required performance, further tests which are considered necessary by Electricity North West shall be carried out by the Contractor and the whole costs of the repeated tests borne by the Contractor. This also applies to tests carried out at the Sub-Contractor's works.

After satisfactory completion of the tests at the Works, the plant shall be submitted for Electricity North West' Approval during dismantling preparatory to despatch. No item of plant is to be despatched to site until Electricity North West has given Approval in writing.

15.2.2 Material Tests

The Contractor shall provide test pieces as required by Electricity North West to enable it to approve the quality of the material supplied under this Contract. Such test pieces shall be prepared and supplied free of charge and any cost of the tests shall be borne by the Contractor.

If any test piece fails to comply with the requirements of the appropriate specifications for the material in question, Electricity North West may reject the whole of the material represented by that test piece; the Contractor's designers and metallurgists will be consulted before any material is so rejected.

In the event of Electricity North West being furnished with certified particulars of tests which have been carried out for the Contractor by the suppliers of materials, it may, at its own discretion, dispense with the previously mentioned test entirely.

15.2.3 Test Certificates

Triplicate sets of all principle test records, test certificates and performance curves shall be supplied for all tests carried out in accordance with the provisions of this Contract. These test records, certificates and performance curves shall be supplied for all tests, whether or not they have been witnessed by Electricity North West. The information given in such test certificates and curves shall be sufficient to identify the material or equipment to which the certificate refers.

15.3 Tests after Delivery

15.3.1 General

Site tests and commissioning tests shall be carried out by the Contractor under the supervision of Electricity North West. Test equipment shall be provided by the Contractor including any special equipment necessary.

15.3.2 General Test Requirements

15.3.2.1 Procedure

A programme of tests shall be agreed between the Contractor and Electricity North West.

Testing shall be carried out during normal working hours as far as is practicable. Tests which involve existing apparatus and outages may be carried out outside normal working hours. The Contractor shall give sufficient notice to allow for the necessary outage arrangements to be made in conformity with the testing programme.

The Contractor shall advise Electricity North West in writing at the time of commencement of site erection of the site supplies which will be required for the operation of the test equipment, to enable Electricity North West to arrange accordingly or to agree alternative arrangements should this be necessary.

The Contractor shall provide the requisite experienced test personnel and all relevant test equipment, unless otherwise agreed by Electricity North West.

The Contractor shall record the results of the tests clearly, in an approved form and with clear reference to the equipment and items to which they refer, so that the record can be used as the basis for maintenance tests during the working life of the equipment. The required number of site test result records shall be provided by the Contractor to Electricity North West as soon as possible after completion of the tests.

No tests as agreed under the programme of tests shall be waived except upon the instruction or agreement of Electricity North West in writing.

15.3.2.2 Standards and Requirements

A brief description of all tests and testing procedures shall be provided before tests commence and the method of testing, unless otherwise specified in the Schedules, shall be agreed with Electricity North West.

Details of the test equipment and instruments used shall be noted in the test sheets in cases where the instrument or equipment characteristics can have a bearing on the test results.

The Contractor's test equipment shall be of satisfactory quality and condition and, where necessary, shall be appropriately calibrated by an approved authority or standard at the Contractor's expense.

15.4 Rejection of Plant

If any item fails to comply with the requirements of this specification in any respect whatsoever at any stage of manufacture, test, erection or on completion at Site, Electricity North West may reject the item, or defective component thereof, whichever Electricity North West considers necessary, and after adjustment or modification as directed by Electricity North West, the Contractor shall submit the item for further inspection and/or test.

In the event of a defect on any item being of such a nature that the requirements of this specification cannot be fulfilled by adjustment or modification, such item is to be replaced by the Contractor, at his own expense, to the entire satisfaction of Electricity North West.

15.5 132kV/Lower Voltage Transformer – Summary of Tests

Type Tests and Routine Tests are to be carried out at the Manufacturers Works (unless an alternative place of testing is specified or approved).

RT	Routine Tests - to be performed on each transformer
TT	Type Tests - to be performed as required by the Electricity North West Plant Policy Manager (Extra costs to be entered in Schedule H)
1	RT - Degree of Polymerisation (DP)
2	RT - Dissolved Gas Analysis (DGA)
3	RT - Winding Resistance
4	RT - Vector Group

5	RT - No-Load loss & No Load current Voltage Ratio
6	RT - Load loss & Impedance
7	RT - Sound Pressure Level (Transformer Tank Only)
8	RT - Sound Pressure Level (Cooler Bank Only fully erected in intended arrangement)
9	RT - Voltage Ratio
10	TT - Zero Sequence Impedance
11	TT - Temperature Rise
12	TT - DGA (Repeat only if Temperature Rise Test carried out)
13	RT - Separate Source Voltage
14	RT - Lightning Impulse Voltage
15	RT - Insulation Resistance
16	RT - Induced Overvoltage
17	RT - Partial Discharge measurements, coupled with Induced Overvoltage test above
18	RT - Magnetic Circuit and Associated Insulation Separate Source Voltage
19	RT - Tapchanger Operation
20	RT - Oil Samples (DGA Repeat)
21	RT - Sweep Frequency Response Analysis

NOTE:

Tests 3 to 10 may be carried out in any convenient sequence.

Tests 11 to 17 shall be carried out in the order specified above.

Tests 18 and 19 may be carried out at any convenient opportunity during the above sequence.

Tests 20 and 21 shall be performed after all other tests have been completed.

15.6 132kV/Lower Voltage Transformer – Details of Tests during Manufacture

All transformers submitted for testing shall be substantially complete with all relevant fittings, accessories, etc., that are included in the Contract Works. Where oil is referred to it shall be in accordance with IEC 60296 (BS 148).

The following tests shall be carried out on all transformers when completely assembled and substantially as in service:

(a) Degree of Polymerisation (DP) - RT

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.

(b) Dissolved Gas Analysis (DGA) - RT

Duplicate samples shall be taken from the top & bottom of the tank, within 24 hours prior to the commencement of the temperature rise and induced over voltage tests, for DGA. In addition, samples shall be taken to determine the withstand voltage. If requested oil samples shall be made available to Electricity North West for additional testing.

Precautions shall be taken to prevent contamination by the atmosphere the samples for DGA may be analysed after the completion of the dielectric tests

(c) Winding Resistance - RT

The Resistance of each winding shall be measured for each tapping position with results corrected to 75°C.

(d) Vector Group - RT

The vector groups shall be determined by comparison of voltmeter readings measured between the appropriate terminals.

(e) No Load Loss and Magnetising Current - RT

The no load loss and magnetising current shall be measured at 90%, 100% and 110% of rated voltage on the principal tap.

(f) Load Loss and Impedance - RT

The load losses and impedance shall be measured on maximum, principal, mean and minimum tapping positions at not less than 50% of the current corresponding to CMR.

(g) Sound Pressure Level (Transformer Tank Only) - RT

Measurements shall be taken round transformer tank only generally in accordance with IEC 60076-10.

(h) Sound Pressure Level (Cooler Bank Only) - RT

Measurement shall be taken round cooling bank only generally in accordance with IEC 60076-10.

(i) Voltage Ratio - RT

This shall be measured on each phase for all tap position.

(j) Zero Sequence Impedance - TT

Zero sequence impedance to be carried out in accordance with IEC 60076-1.

(k) Temperature Rise - TT

(a) Temperature Rise Tests shall be performed in accordance with IEC 60076 except where varied by the following. Unless otherwise specified by Electricity North West, the loading method shall be in accordance with IEC 60076-2.

Three tests shall be performed:

- At CMR with forced cooling in operation on extreme minus tap position.
- At CMR with forced cooling in operation on extreme plus tap position.
- At 50% CMR, ONAN cooled on the extreme minus tap position.

(b) The top oil temperature rise and average winding temperature rises shall be determined for each of the above tests. The temperature rise of all windings shall be determined by change of resistance. The temperature rises so determined shall not exceed the limits specified in IEC 60076-2. With the transformer operating at CMR on any tapping position the temperature rise on any part of the tank shall not exceed 65°C.

(c) The price for these tests shall be included in Schedule H Optional Work.

NOTE: In addition to the above requirements stated in (a) above, the following dispensation is given. Where the tapping range is achieved by the reversing method and at one extreme tapping position the maximum current coincides with the maximum winding resistance condition, the test at the other extreme tapping position may be omitted.

(l) Oil Samples (Report) - TT

Further oil samples shall be taken for DGA as in Section 15.6(b) immediately after the completion of all temperature rise test, for comparison.

(m) Separate Source Voltage - RT

(n) Lightning Impulse Voltage - RT

(a) The test shall be carried out in accordance with IEC 60076-3 by direct application of the impulse voltage to each line terminal in turn. The test circuit, including all earthing arrangements, current and voltage recordings, and sweep times of oscillographic records, shall be to the Approval of the Electricity North West Plant Policy Manager.

(b) The tests shall be performed on the two extreme tappings and the principal tapping, one tapping for each of the three individual phases of a three phase transformer, as per IEC 60076-2 clause 6.

(c) The test sequence at the specified voltage level.

1 - Reduced full wave application (between 50% and 75%)

1 - 100% Full wave application

1 – Reduced Chopped wave application

2 - 115% Chopped wave applications

2 - 100% Full wave applications

1 - Reduced full wave applications (at the same level as for the initial application)

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(d) For each voltage application, oscillographic records shall be taken of the applied voltage and of the current at the neutral end of the winding under test or for a delta connected winding, at the two terminals not under test, at least two current records shall be taken. All records shall be of a standard acceptable to the Electricity North West Plant Policy Manager or nominated deputy witnessing the tests.

(e) There shall be no evidence of complete or incipient failure as indicated by audible indications from within the transformer or by changes in the voltage and/or current records, apart from intended amplitude changes.

(o) Insulation Resistance

Insulation resistance measurements shall be made on each winding with respect to the other windings and earthed metal, at 2.5 kV dc. The average oil temperature at the time of these measurements shall be recorded.

(p) Induced Overvoltage and Applied Voltage - RT

These tests shall be carried out in accordance with IEC 60076-3 at the specified voltage levels.

The induced overvoltage test shall be arranged so that in addition to the requirements of IEC 60076, the voltage appearing between all terminals, windings, sections and turns of windings and connections of the phase under test is at least twice normal working voltage for any tapping position.

The secondary circuits of all current transformers shall be tested at 2kV rms for 1 minute to earth, and between separate circuits.

(q) Partial Discharge Measurements - RT

Partial discharge measurements shall be made at the HV terminals of each phase of the transformer during the induced overvoltage routine test 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 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 the 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 voltage to earth shall not exceed 300 pC 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.

(r) Magnetic Circuits and Associated Insulation - Applied Voltage - RT

Immediately prior to despatch, the magnetic circuit and associated insulations covering

(a) Any "insulated breaks" for the prevention of circulating currents,

(b) Any insulations of such structural steelwork to tank,

(c) The insulation of the magnetic structure itself, shall withstand to earth and to each other a 2kV rms, or 3kV dc applied voltage test of one minute duration.

(s) Tapchanger Operation - RT

Tapchanger Operation to be carried out in accordance with IEC 60076

(t) Oil Samples (Repeat) - RT

Further samples shall be taken for DGA as in Section 15.6(b) immediately after the completion of all dielectric tests, for comparison.

(u) Sweep Frequency Response Analysis (SFRA) - RT

A SFRA test on the transformer shall be carried out after completion of all the type and routine tests. 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 lowest tap position to ensure that all of the winding is included in the test and all terminals shall be free of earth. The results shall be displayed graphically and a spreadsheet containing the raw data shall also be supplied to the Electricity North West Asset Policy & Standards Department for the attention of the Electricity North West Plant Policy Manager.

15.7 132kV/Lower voltage Transformer – Site Commissioning Tests

Such tests as are required by Electricity North West to prove compliance with the specification independently of any tests which may have already been carried out at the manufacturer's works.

(a) 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 & Standards Section for the attention of the Plant Policy Manager.

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

(b) Insulation Test

Insulation tests on small wiring shall be carried out at site

(c) Magnetic Circuit and Associated Insulation

A 2kV rms or 3kV dc applied voltage test of one minute duration to the magnetic circuit and associated insulation shall be carried out.

(d) Insulation Resistance

The pre-delivery insulation resistance tests shall be repeated.

(e) 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.

(f) Gas and Oil Relay

An operation test by injection shall be carried out.

(g) Forced Cooling

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

(h) Tapchanger

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

(i) DGA

A DGA test shall be completed on the Transformer and tapchanger following full installation.

15.8 Earthing/Auxiliary Transformer – Summary of Tests

Tests during manufacture shall be carried out in the order specified below unless otherwise agreed with Electricity North West in the test programme.

RT	Routine Test - To be performed on each transformer in accordance with IEC 60076 as listed below.
TT	Type Test - To be performed as required by the Electricity North West Plant Policy Manager in accordance with IEC 60076. Extra costs to be entered in Schedule H optional work.
TS	Tests on Site - To be performed on each transformer.
1	RT - Winding Resistance
2	RT - Vector Group
3	RT - Voltage Ratio
4	RT - No Load Loss & No Load Current
5	RT - Load Loss & Impedance
6	RT - Zero sequence Impedance (Interconnected star winding)
7	TT - Sound Pressure Level
8	TT - Temperature Rise
9	RT - Induced Overvoltage

10	RT - Separate Source Voltage
11	TT - Lightning Impulse Withstand Voltage including 100% Chopped Wave
12	RT - Insulation Resistance
13	RT - Magnetic Circuit and Associated Insulation - Separate Source Voltage
14	TS - Site Commissioning Tests

15.9 Earthing/Auxiliary Transformer – Details of Tests during Manufacture

The specified type and routine tests shall be generally as described in the appropriate parts of Section 15.6.

15.10 Earthing/Auxiliary Transformer – Site Commissioning Tests

Such tests as required by the Electricity North West Plant Policy Manager to prove compliance with the Specification independently of any tests which may have been carried out at the Manufacturer's Works, including insulation resistance test on small wiring carried out at site and a 2kV rms or 3kV dc applied voltage test of one minute duration to the magnetic circuit and associated insulation.

15.11 Test Certificates and Records to be Supplied

Routine test certificates from the main suppliers should satisfy all sections of this Specification for each of the following items:

- Main transformer
- Earthing transformer
- Earthing reactor
- Magnetic circuits
- Windings
- Cable boxes
- Noise
- Tanks
- Radiators

- Cooler control
- Tap control
- WTI calibrations
- Marshalling kiosk
- Control wiring

Several sections may be reported on a common certificate.

The following test/data cards from sub-contractors should be forwarded: -

- Bushings
- Cable boxes
- Pressure relief device
- Radiators
- Pumps
- Fans
- Motors
- Tapchanger
- Winding temperature indicator
- Gas and oil relay

Confirmation should be available of satisfactory tests on the following: -

- Valves
- Paint
- Breathers
- Oil gauges
- Radiators
- Rating plate

When type tests are required, the main supplier shall supply certificates relating to tests on:

- Main transformer
- Earthing transformer
- Magnetic circuits
- Noise

Confirmation of satisfactory type test by sub-contractors may be called for relating to:-

- Bushings
- Pressure relief devices
- Valves
- Paint
- Breather
- Oil gauge
- Radiators
- Rating plates
- Pumps
- Fans
- Motors
- Tapchanger
- Winding temperature indicator
- Gas and oil relay

16 Drawings

Before the work is put in hand, dimensioned drawings and diagrams showing all details of the plant and materials to be used shall be submitted to Electricity North West for Approval.

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. All

drawings, schematics and wiring diagrams shall comply with UK ESI convention and be produced in conventional format up to a maximum A1 paper size.

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 Electricity North West that the drawing is in its final form. Drawings, other than those requiring Approval agreed between the Contractor and Electricity North West as being appropriate to the Contract, shall be supplied in duplicate. The above drawings shall be in the form of white paper prints. They shall also be accompanied by equivalent AutoCAD.dwg format files on a CDROM.

For the final Contract records, the Contractor shall supply:

(a) A contract drawing list giving the number, title and revision of each drawing.

(b) One copy of each drawing and the drawing list on a CDROM, AutoCAD.dwg compatible.

The contract drawing list shall be submitted by the Contractor for Approval by Electricity North West, who will indicate thereon the 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 Electricity North West.

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

NOTE: The drawings which shall be submitted with the Tender are detailed in Appendix A, Schedule F

(a) The following Drawings as applicable, are to be supplied within three calendar months of contract award: -

- Definite foundation plan drawing and provisional outline drawing for the complete transformer, earthing transformer, reactor.
- General arrangement of cable entry boxes and disconnecting chamber (as applicable).
- General arrangement of Marshalling Kiosk or Cubicle.
- General arrangement drawing of Standby Control panel if to be supplied as part of the Contract Works.
- 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).
- 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).
- Diagram(s) of connections of all loose apparatus supplied as part of the Contract Works for mounting and wiring on Panel(s) under separate Contract(s).

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

- Define outline drawing for complete transformer, earthing transformer and reactor.
- Sectional arrangement Drawing(s) of the windings, method of coil bracing, core magnetic (leakage of flux) shield construction and core earthing, and any directed oil flow arrangement.
- Name, rating and diagram plate and diagram of connections of transformer and associated equipment showing the relative position of leads taken out of the tank.
- Schematic diagram of tap-change control circuits and cooler control circuits including tap changer driving mechanism, marshalling kiosk and standby control panels, as applicable.
- Details and diagram connections of winding temperature alarm, trip and cooler control arrangements.
- Detailed drawing of oil coolers.
- Valve function plate.
- Drawing(s) showing any special features likely to need special attention during inspection, testing, maintenance or repair.
- Outline drawing showing the transformer accommodated on the truck for transport to site.

17 Assembly, Operating and Maintenance Instructions

When the general arrangements and details of the transformers and reactors have been finalised and before the specified completion date shown in Appendix A, Schedule B, Item 4, the Contractor shall submit Assembly, Operating and Maintenance Instructions and Diagrams for Approval by Electricity North West 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 Appendix A, Schedule D of Requirements. A further copy in pdf format shall be submitted to Electricity North West.

The details shall cover the main plant and all associated ancillary equipment as supplied under the Contract. It will not be sufficient to incorporate manufacturers' standard brochures as part of the text unless they refer particularly to the equipment supplied and are free of extraneous matter.

18 Models and Samples

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

19 Documents Referenced

DOCUMENTS REFERENCED	
Electricity Supply Quality and Continuity Regulations 2002	
Health and Safety at Work Act 1974	
Construction Design and Management Regulations 2007	
Electricity at Work Regulations 1989	
Control of Substances Hazardous to Health Regulations 2002	
Health and Safety Manual Handling Operation Regulations 1992	
Factories Act 1961	
IEC 60034-1	Rotating electrical machines. Rating and performance
IEC 60076	Power transformers
IEC 60076-1	Power transformers: General
IEC 60076-2	Power transformers. Temperature rise
IEC 60076-3	Power transformers. Insulation levels, dielectric tests and external clearances in air
IEC 60076-5	Power transformers. Ability to withstand short circuit
IEC 60076-10	Power transformers. Determination of sound levels
IEC 60137	Bushings for alternating voltages above 1000V

IEC 60214	On-load tap changers
IEC 60269	Cartridge fuses for voltages up to and including 1000V a.c. and 1500V d.c.
IEC 60296	Unused mineral insulating oils for transformers and switchgear
IEC 60354	Guide to loading of oil immersed power transformers
IEC 60404	Magnetic materials
IEC 60529	Specification for degrees of protection provided by enclosures (IP code)
IEC 60898	Specification for circuit-breakers for overcurrent protection for household and similar installations
ISO 9001	Quality systems
BS EN 10029	Tolerances on dimensions, shape and mass for hot rolled steel plates 3mm thick or above
BS EN 12163	Copper and copper alloys. Rod for free machining purposes
BS EN 12944-2	Paints and varnishes. Corrosion protection of steel structures by protection paint systems. Classification of environments
BS EN 14001	Environmental management systems
BS EN 60270	High voltage test techniques. Partial discharge measurements.
BS EN 60470	High voltage alternating current contactors and contactor-based motor starters
BS 88	Cartridge fuses for voltages up to and including 1000V a.c. and 1500V d.c.
BS 0091	Electric cable soldering sockets

BS 148	Specification for unused and reclaimed mineral insulating oils for transformers and switchgear
BS 381c	Colours for identification, coding and special purposes
BS 970	Wrought steels for mechanical and allied engineering purposes
BS 1432	Copper for electrical purposes: high conductivity copper rectangular conductors with drawn or rolled edges
BS 1433	Copper for electrical purposes: rod and bar
BS 1470	Wrought aluminium and aluminium alloys for general engineering purposes - drawn tube
BS 1490	Aluminium and aluminium alloy ingots and castings for general engineering purposes
BS 2562	Cable boxes for transformers and reactors
BS 2569	Sprayed metal coatings
BS 2757	Method for determining the thermal classification of electrical insulation
BS 3643	ISO metric screw threads
BS 3692	ISO metric precision hexagon bolts, screws and nuts. Specification
BS 3693	Recommendations for design of scales and indexes on analogue indicating instruments
BS 4190	ISO metric black hexagon bolts, screws and nuts. Specification
BS 4828	Guide to partial discharge measurements
BS 4963	Specification for tests on hollow insulators for use in high voltage electrical equipment

BS 5490	Specification for classification of degrees of protection provided by enclosures
BS 5825	Specification for low voltage switchgear and controlgear for industrial use.
BS 6231	Specification for PVC-insulated cables for switchgear and controlgear wiring
BS 6399-2	Code of practice for wind loads
BS 6435	Specification for unfilled enclosures for the dry termination of HV cables for transformers and reactors
BS 6480	Specification for impregnated paper-insulated lead or lead alloy sheathed electric cables of rated voltages up to and including 33000 V
BS 7354	Code of practice for design of high voltage open-terminal stations
BS 7626	Specification for current transformers
ENA TS 50-18	Design and application of ancillary equipment

20 Keywords

Tapchanger; Transformer; 132kV; 33kV.

Appendix A – Schedules of Requirements, Particulars and Guarantees

A.1 Foreword

These Schedules of Requirements, General Particulars and Guarantees form a part of the Specification.

These Schedules do not purport to include all the necessary provisions of a Contract.

Except where otherwise specified or implied herein, transformers shall comply with the requirements, as applicable, of the latest amendments of the Standards of the International Electrotechnical Commission (IEC) or British Standards (BS) where specified and in particular the standards listed in Section 19 of this Specification.

No departures from the Specification except those shown in the Schedule J of Departures shall be made without the written Approval of Electricity North West.

Schedule A – General Particulars of Definite Work

(Relevant Details to be Completed by Electricity North West)

1	Section(s) for purposes of payments and taking over	See commercial contract
2	Substation Name	
3	Number of 132kV/Lower Voltage Transformers required	
4	Continuous maximum rating	
	(a) Rating MVA	
	(b) Power Factor	
	(c) Voltage kV	
5	Minimum continuous ONAN rating MVA	
6	Rated higher voltage between phases kV	
7	Rated lower voltage between phases kV (not applicable to reactors)	
8	Whether a standby voltage control panel is required	Yes/No
9	Number of Earthing/Auxiliary Transformers required	
10	Type and Rating of Earthing Transformer and Neutral Earthing System -	Low Reactance - 30s, 1000A, Resistance Earthed
11	Continuous maximum rating kVA	
12	Rated higher voltage between phases kV	
13	Rated lower voltage between phases (no load kV)	0.400/0.230, three-phase, four wire

14	Purchaser's Nomenclature	
	(a) Main Unit	GT1
	(b) Earthing/Auxiliary Transformer	EAT1
15	CT Details	As indicated in diagram overleaf

Example Diagram of CT Details for 90MVA, 132/33kV Transformer

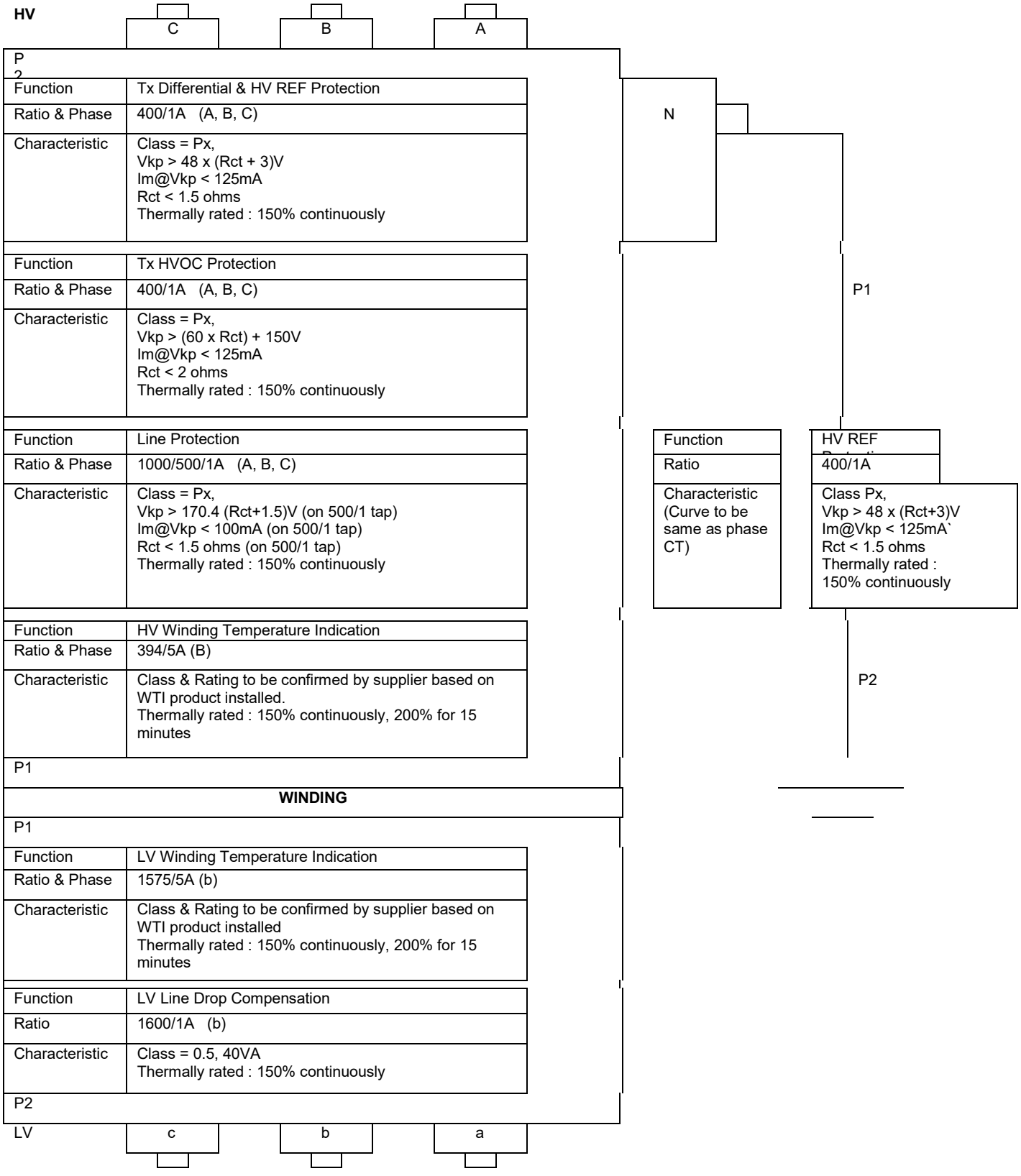


Diagram of CT Details for 60MVA, 132/33kV Transformer

HV

C B A

P2

Function	Tx Differential & HV REF Protection
Ratio & Phase	400/1A (A, B, C)
Characteristic	Class = Px, Vkp > 32 x (Rct + 3)V Im@Vkp < 125mA Rct < 1.5 ohms Thermally rated : 150% continuously

N

Function	Tx HVOC Protection
Ratio & Phase	300/1A (A, B, C)
Characteristic	Class = Px, Vkp > (60 x Rct) + 150V Im@Vkp < 160mA Rct < 1.5 ohms Thermally rated : 150% continuously

P1

Function	Line Protection
Ratio & Phase	1000/500/1A (A, B, C)
Characteristic	Class = Px, Vkp > 170.4 (Rct+1.5)V (on 500/1 tap) Im@Vkp < 100mA (on 500/1 tap) Rct < 1.5 ohms (on 500/1 tap) Thermally rated : 150% continuously

Function	HV Winding Temperature Indication
Ratio & Phase	263/5A (B)
Characteristic	Class & Rating to be confirmed by supplier based on WTI product installed Thermally rated : 150% continuously, 200% for 15 minutes

P1

WINDING

P1

Function	LV Winding Temperature Indication
Ratio & Phase	1050/5A (b)
Characteristic	Class & Rating to be confirmed by supplier based on WTI product installed Thermally rated : 150% continuously, 200% for 15 minutes

Function	LV Line Drop Compensation
Ratio	1200/1A (b)
Characteristic	Class = 0.5, 40VA Thermally rated : 150% continuously

P2

LV

c b a

Function	HV REF Protection
Ratio	400/1A
Characteristic (Curve to be same as phase CT)	Class Px, Vkp > 32 x (Rct+3)V Im@Vkp < 125mA Rct < 1.5 ohms Thermally rated: 150% continuously

P1

P2

Diagram of CT Details for 30MVA, 132/11kV Transformer

HV

C B A

P2

Function	Tx Differential & HV REF Protection
Ratio & Phase	200/1A (A, B, C)
Characteristic	Class = Px, Vkp > 32 x (Rct + 3)V Im@Vkp < 250mA Rct < 0.75 ohms Thermally rated : 150% continuously

Function	Tx HVOC Protection
Ratio & Phase	150/1A (A, B, C)
Characteristic	Class = Px, Vkp > (60 x Rct) + 150V Im@Vkp < 330mA Rct < 0.75 ohms Thermally rated : 150% continuously

Function	Line Protection
Ratio & Phase	1000/500/1A (A, B, C)
Characteristic	Class = Px, Vkp > 170.4 (Rct+1.5)V (on 500/1 tap) Im@Vkp < 100mA (on 500/1 tap) Rct < 1.5 ohms (on 500/1 tap) Thermally rated : 150% continuously

Function	HV Winding Temperature Indication
Ratio & Phase	132/5A (B)
Characteristic	Class & Rating to be confirmed by supplier based on WTI product installed Thermally rated : 150% continuously, 200% for 15 minutes

P1

WINDING

P1

Function	LV Winding Temperature Indication
Ratio & Phase	1575/5A (b)
Characteristic	Class & Rating to be confirmed by supplier based on WTI product installed Thermally rated : 150% continuously, 200% for 15 minutes

Function	LV Line Drop Compensation
Ratio	1600/1A (b)
Characteristic	Class = 0.5, 40VA Thermally rated : 150% continuously

P2

LV

c b a

N

P1

Function	HV REF Protection
Ratio	200/1A
Characteristic (Curve to be same as phase CT)	Class Px, Vkp > 32 x (Rct + 3)V Im@Vkp < 250mA Rct < 0.75 ohms Thermally rated : 150% continuously

P2

(details to be confirmed by Electricity north West BEFORE MANUFACTURE)

Schedule B – Commencement Date and Dates of Readiness for Inspection, Testing, Delivery, Access to Site and Completion Definite Work

(to be completed by Tenderer)

FOR ELECTRICITY NORTH WEST'S PROGRAMME SEE COMMERCIAL CONTRACT

Commencement Date:…….

Section(s) for purposes of payments and taking over Site Station. Times are calculated from Commencement Date and are given in **calendar months**.

	TIME FROM COMMENCEMENT	NUMBER OF CALENDAR MONTHS
1	Within which detailed drawings shall be submitted for Approval.	
2	Within which the material shall be ready for inspection and testing.	
3	Within which the Contractor will require access to the site.	
4	Within which the material shall be delivered to site.	
5	Within which the works shall be completed, tested and ready for continuous use.	

Completion date:…….

Schedule C.1 – Manufacturers and Places of Manufacture, Testing and Inspection 132kV/Lower Voltage Transformer

(Relevant Details to be Completed by Tenderer)

ITEM	MANUFACTURER'S DRAWING NUMBER AND/OR TYPE DESIGNATION	MANUFACTURER	PLACE OF MANUFACTURE	PLACE OF TESTING AND/OR INSPECTION
Transformer Complete				
On-load Tap-Change equipment				
On load Tap-changer porcelain				
HV Bushings				
LV Bushings				
Neutral Bushings				
Insulating Cylinders				
Core Plate				
Copper/Aluminium				
Steel Tanks				
Radiators				

Oil Pumps				
Oil Pump Motors				
Oil Flow Indicators				
Fans				
Fan Motors				
Gaskets for Oil Tight Joints				
Pressure Relief Device				
Regenerative Breather				
Gas & Oil Actuated Relay(s)				
Marshalling Kiosk				
Temperature Indicating Devices				
Motor Control Equipment				
Alarm Devices				
Standby Control Panel				

AVR Relays				
Material for Anti-vibration Mountings				

Any deviation from this Schedule shall be notified in writing as soon as possible for Electricity North West' Approval.

Any deviation or failure during manufacturing and tests shall be notified by the Contractor to Electricity North West.

Schedule C.2 – Manufacturers and Places of Manufacture, Testing and Inspection Earthing/Auxiliary Transformer

(Relevant Details to be Completed by Tenderer)

ITEM	MANUFACTURER'S DRAWING NUMBER AND/OR TYPE DESIGNATION	MANUFACTURER	PLACE OF MANUFACTURE	PLACE OF TESTING AND/OR INSPECTION
Earth/Aux. Transformer Complete				
HV Bushings				
LV Bushings				
Neutral Bushings				
Insulating Cylinders				
Core Plate				
Copper/Aluminium				
Steel Tanks				
Radiators				
Oil				

Oil Valves				
Gaskets for oil Tight Joints				
Pressure Relief Device				
Regenerative Breather				
Gas and Oil Actuated Relay(s)				
Marshalling Kiosk				
Temperature Indicating Devices				
Transformer Fuse-switch				

Any deviation from this Schedule shall be notified in writing as soon as possible for Electricity North West' Approval.

Any deviation or failure during manufacturing and tests shall be notified by the Contractor to Electricity North West.

Schedule D – Requirements for 132kV/Lower Voltage Transformers - Part 1 - Control, Operation, Indications, Alarms and Trips

(to be completed by Tenderer)

For ……..

The requirements for control, operation, indications, alarms and trips are detailed in the following Electricity North West drawings:
Electricity North West Drawing No.
900230-001
900230-002
900230-003
900230-004
900230-005

Loose Control, Operation, Indication, Alarm and Trip apparatus for mounting and wiring under a separate contract shall be supplied to: (to be completed by Electricity North West).

Schedule D – Requirements for 132kV/Lower Voltage Transformers – Part 2

(to be completed by Electricity North West)

For …….

Item No.	Description		
	Rating and Performance		
1	Continuous Maximum Rating (CMR) at rated voltage	MVA	
2	Continuous ONAN rating with mixed cooling	MVA	
3	No-load voltage ratio at nominal tap	kV	
4	Winding Connections:		
	(a) HV windings		
	(b) LV windings		
	(c) IEC Vector Group symbols		
	(d) Whether links are required for alternative vector group		Yes/No
5	Impedance voltage at 75°C and CMR (to be completed for impedance on normal tapping or envelope impedances as appropriate)		See Fig D1
6	Short Circuit capacity:		
	(a) Available at HV terminals	MVA	
	(b) Available at LV terminals	MVA	
	Voltage Control		
7	Method of variation of voltage radio		On load

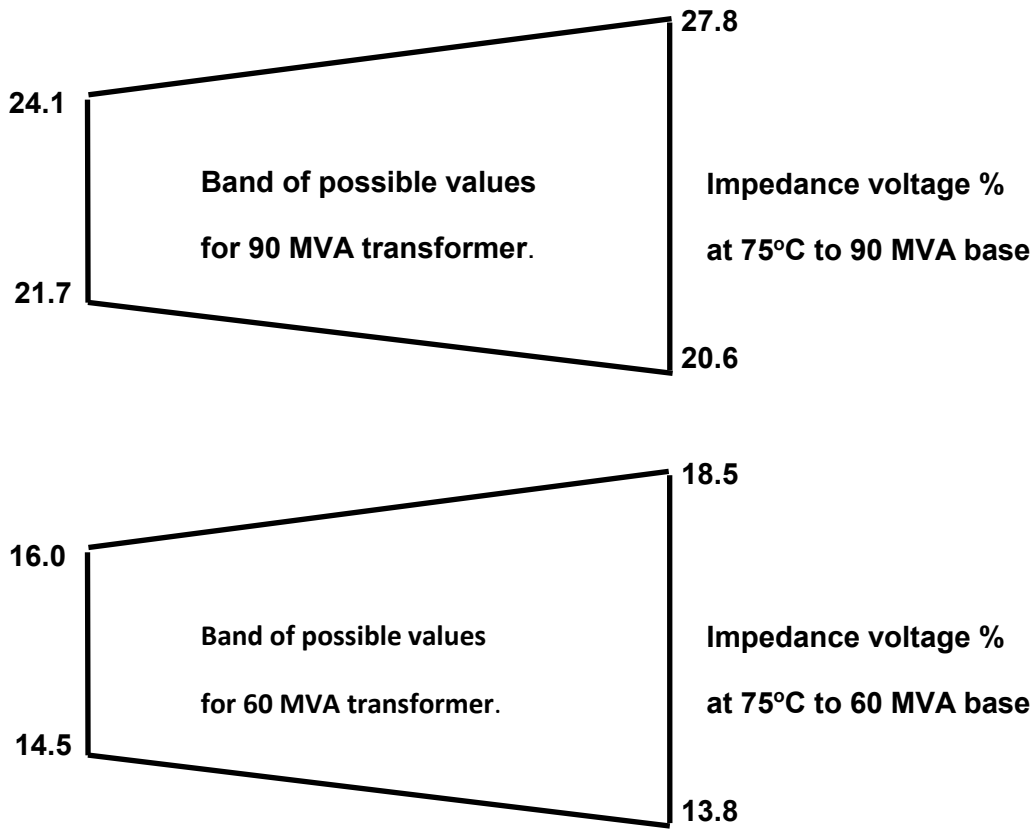
8	Total range of variation of voltage ratio (Expressed as a percentage of ..... with ..... constant):	
	Plus per cent	
	Minus per cent	
9	Size of step %	
10	Whether control by direct wire or selective system required at remote control point	Yes/No
11	Automatic voltage control:	
	(a) Whether required	Yes/No
	(b) Whether group parallel control is required	Yes/No
12	Space available for line drop compensation current transformer in LV switchgear	Yes/No
	(a) Inside diameter mm	
	(b) Outside diameter mm	
	(c) Axial length including clamps mm	
13	Whether load shedding facilities are required, either by direct wire or selective system at remote control point	Yes/No
14	Number of Marshalling kiosk (cubicle) compartments	
15	Marshalling kiosk (cubicle) switch-sockets:	240V a.c.
	(a) Type	
	(b) Voltage	
16	Marshalling kiosk (cubicle) telephone jacks required:	Yes/No
	(a) Type	
	Terminations	

17	Terminals:	
	(a) Bushing insulators or cable boxes for line terminals:	
	(1) HV	
	(2) LV	
	(b) Bushing insulators or cable boxes for neutral terminals:	
	(1) HV	
	(2) LV	
18	Co-ordinating arc gaps, on tank or outrigger	
19	Cable Box Details:	
	(a) Higher voltage:	
	Number of poles	
	(2) Number of cables per phase	
	(3) Type of cable	
	(4) Sectional area of conductor mm²	
	(5) Diameter over metal sheathing mm	
	(6) Diameter over armouring	
	(7) Special particulars, if any (e.g. whether gland or island layer insulation is required).	
	(8) Whether cables enter box from below or from above	
	(9) Filling medium for cable box	
	(b) Higher voltage neutral point:	
	(1) Number of poles	
	(2) Number of cables per phase	

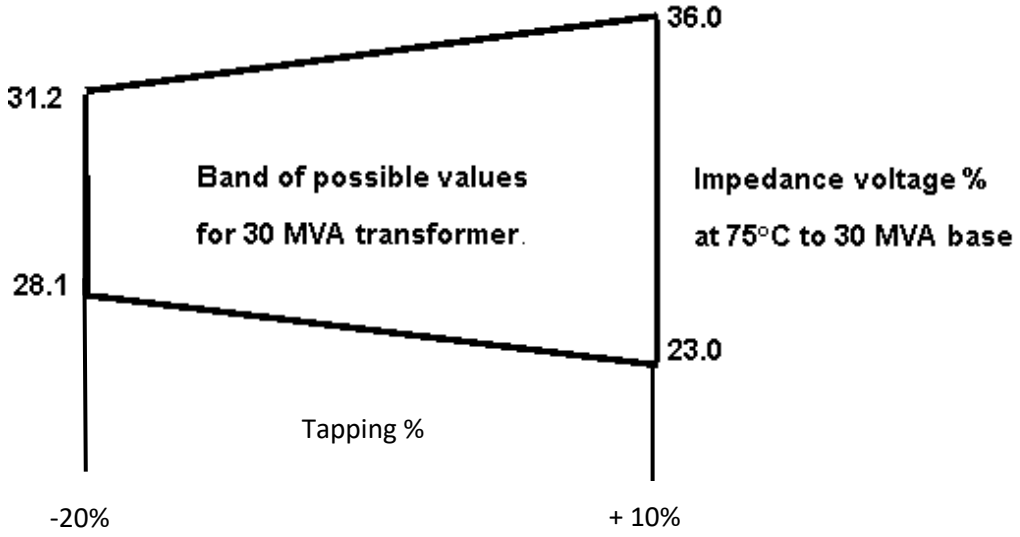
	(3) Type of cable	
	(4) Sectional area of conductor mm²	
	(5) Diameter over metal sheathing mm	
	(6) Diameter over armouring mm	
	(7) Special particulars, if any(e.g. whether gland or island layer insulation is required).	
	(8) Whether cables enter box from below or from above	
	(9) Filling medium for cable box	
20	Whether CT accommodation is required on bushing insulators:	
	(a) HV	Yes/No
	(b) LV	Yes/No
	Cooling	
21	Cooling designation	
22	Arrangement of coolers:	
	(a) Tank attached	Yes/No
	(b) Separate free-standing	Yes/No
23	Whether valves for oil filtering require flexible hose adaptors	Yes/No
24	Size of flexible hose adaptor	50mm
	General	
25	Whether anti-vibration pads are required	Yes/No
26	Whether a noise enclosure is required from the outset	Yes/No
27	Number of copies of Operating and Maintenance Instructions required per station (site)	One draft, two final per station

28	Transformer Management System Required	Yes/No

Figure D1 – Envelope of Impedance Characteristics



The 90 and 60 MVA base units are 132/33kV units only.



The 30 MVA base unit is 132/11kV units only.

Schedule D – Requirements for Earthing/Auxiliary Transformers – Part 3

(to be completed by Electricity North West)

For …….

ITEM NO	DESCRIPTION	
	Rating and Performance	
1	Method of Neutral Earthing transformer combined with liquid earthing resistor supplied by Electricity North West	Yes/No
2	Continuous Maximum Rating (CMR) at rated voltage kVA	200
3	No-load voltage ratio at normal tap kV	
4	Winding Connections:	
	(a) HV windings	
	(b) LV windings	
	(c) IEC 76-4 (BS 171/4) Vector Group symbols	
	(d) Whether links are required for alternative vector group	Yes/No
5	Impedance voltage at 75°C and CMR (to be completed for impedance on normal tapping)	See Fig D1
6	Terminals:	
	(a) Bushing insulators or cable boxes for line terminals:	
	(1) HV	
	(1) LV	
	(b) Bushing insulators or cable boxes for neutral terminals:	

	(1) HV	
	(2) LV	
7	Cable Box Details:	
	(a) Higher voltage:	
	(1) Number of poles	
	(2) Number of cables per phase	
	(3) Type of cable	
	(4) Sectional area of conductor mm²	
	(5) Diameter over metal sheathing mm	
	(6) Diameter over armouring mm	
	(7) Special particulars, if any (e.g. whether gland or island layer insulation is required).	
	(8) Whether cables enter box from below or from above	
	(9) Filling medium for cable box	
	(b) Higher voltage neutral point:	
	(1) Number of poles	
	(2) Number of cables per phase	
	(3) Type of cable	
	(4) Sectional area of conductor mm²	
	(5) Diameter over metal sheathing mm	
	(6) Diameter over armouring mm	
	(7) Special particulars, if any (e.g. whether gland or island layer insulation is required).	

	(8) Whether cables enter box from below or from above	
	(9) Filling medium for cable box	
8	(c) Lower voltage:	
	(1) Number of poles	
	(2) Number of cables per phase	
	(3) Type of cable	
	(4) Sectional area of conductor mm²	
	(5) Diameter over metal sheathing mm	
	(6) Diameter over armouring mm	
	(7) Special particulars, if any (e.g. whether gland or island layer insulation is required).	
	(8) Whether cables enter box from below or from above	
	(9) Filling medium for cable box	
	(d) Lower voltage neutral point:	
	(1) Number of poles	
	(2) Number of cables per phase	
	(3) Type of cable	
	(4) Sectional area of conductor mm²	
	(5) Diameter over metal sheathing mm	
	(6) Diameter over armouring mm	
	(7) Special particulars, if any (e.g. whether gland or island layer insulation is required).	
	(8) Whether cables enter box from below or from above	

	(9) Filling medium for cable box	
9	Cooling designation	Yes/No
10	Arrangement of coolers: Tank attached	Yes/No
11	Whether valves for oil filtering require flexible hose adpators	Yes/No
12	Size of flexible hose adaptors	25mm
	General	
12	Whether anti-vibration pads are required	Yes/No
13	Whether a noise enclosure is required from the outset	Yes/No
14	Number of copies of Operating and Maintenance Instructions required per station (site)	One draft, two final per station

Schedule E – Technical Particulars and Guarantees – Part 1

(to be completed by Tenderer)

FOR 132kV/LOWER BOLTAGE TRANSFORMERS

ITEM NO	DESCRIPTION		
	Magnetic Circuit		
1	Core Construction:		
	(a) Taped/banded/bolted limbs		
	(b) Taped/banded/bolted yokes		
	(c) Taping/banding material (as applicable)		
	(d) Number of limbs		
	(e) Number of limbs wound		
2	Insulation of:		
	(a) Core bolts		
	(b) Core bolt washers		
	(c) Side plates		
	(d) Core laminations		
3	Flux density in iron:		
	Nominal value at normal voltage, frequency and normal tap:		
	(a) Wound limbs	tesla	
	(b) Yokes	tesla	
	(c) Unwound limbs	tesla	
	(d) Shields	tesla	

	Maximum value at nominal voltage, minimum frequency and minimum tap		
	(a) Wound limbs	tesla	
	(b) Yokes	tesla	
	(c) Unwound limbs	tesla	
	(d) Shields	tesla	
4	Whether tank or other flux shields are incorporated		Yes/No
	Windings		
5	Types and arrangement of:		
	(a) HV windings		
	(b) LV windings		
	(c) Tapping windings (as applicable)		
	(d) Winding arrangement, i.e. core/...../...../		
	(e) Tertiary Winding		
6	Arrangement of tappings (linear, coarse/fine, reversing)		
7	Conductor material for:		
	(a) HV windings		
	(b) LV windings		
	(c) Tapping windings		
8	Conductor insulation:		
	(a) HV windings		
	(b) LV windings		
	(c) Tapping windings		

9	Oil circulation (i.e. natural/partially directed/directed):		
	(a) To windings		
	(1) HV windings		
	(1) LV windings		
	(2) Tapping windings		
	(b) Through windings		
	(1) HV windings		
	(2) LV windings		
	(3) Tapping windings		
10	Short circuit capability:		
	(a) Potential axial thrust for worst fault condition of each winding:		
	(1) HV windings	Tonne	
	(2) LV windings	Tonne	
	(3) Tapping windings	Tonne	
11	(b) Coil clamping short circuit withstand capacity		
	(1) HV windings	Tonne	
	(2) LV windings	Tonne	
	(3) Tapping windings	Tonne	
12	Current density in windings (at normal tapping position):		
	(a) HV windings (CMR)	A/mm²	
	(b) LV windings (CMR)	A/mm²	
	(c) Tapping windings (as applicable) (CMR)	A/mm²	

	Performance Characteristics			
13	No-load loss at normal ratio (excluding cooling plant loss)		kW	
14	Cooling plant loss		kW	
15	Load losses at CMR and 75°C			
	(a)	On normal tapping: HV/LV	kW	
	(b)	On tapping for maximum loss - Tap position number HV/LV	kW	
16	Impedance voltage at 75°C and CMR			
	(a)	Impedance on normal tapping: HV/LV		
	(b)	Minimum impedance on minimum tapping - Tap position number HV/LV		
	(c)	Maximum impedance on minimum tapping: HV/LV	%	
	(d)	Minimum impedance on maximum tapping - Tap position number		
	(e)	Maximum impedance on maximum tapping: HV/LV	%	
17	Demonstrable zero phase sequence impedance at 75°C and on normal tapping, referred to HV side, at 10% full load current in each phase winding: HV/LV ohms per phase			
18	Calculated zero phase sequence impedance at 75°C and on normal tapping, referred to HV side, assuming rated voltage (single phase) applied between line terminals and neutral:			
	(a)	Z Ω per phase (approx.)		
	(b)	Z Ω per phase (approx.)		
	(c)	Z Ω per phase (approx.)		
	(d)	Z Ω per phase (approx.)		
19	Hottest spot winding temperature on most onerous tap position. (Average ambient air temperature 30°C or water temperature at 20°C) Position No.			
	(a)	At CMR		

	(1) HV	°C	
	(2) LV	°C	
20	Maximum observable oil temperature (Average ambient air temperature 30°C)		
	(a) At CMR		
	(1) Top oil	°C	
	(2) At inlet to cooler	°C	
	(3) At outlet to cooler	°C	
	(b) At ONAN - top oil		
	(c) With HV at CMR. LV loaded 0.9 pf lagging and tertiary loaded 60 MVAr lagging - top oil	°C	
21	Proportion of sum of iron and copper losses at CMR which will be supplied during temperature rise test	%	
22	Calculated winding capacitance:		
	(a) Approximate series capacitance of each phase winding:		
	(1) HV	pF	
	(2) LV	pF	
	(b) Approximate shunt capacitance of each phase winding with core and tank earthed:		
	(1) HV to earth with LV windings unearthed	pF	
	(2) LV to earth with HV windings unearthed	pF	
	(c) Approximate capacitance HV to LV phase winding with LV winding unearthed	pF	
23	(a) Guaranteed sound power level (ONAN)	dBA	
	(b) Guaranteed sound power level (with cooling in operation)	dBA	
	Tank and Cooler		

24	Tank material		
25	Thickness of tank:		
	(a) Sides	mm	
	(b) Base	mm	
	(c) Cover	mm	
26	Thickness of radiator plates and/or cooling tubes	mm	
27	Total oil required (including cooling system)	litre	
28	Volume of oil to be removed:		
	(a) to gain access to core earthing link	litre	
	(b) to effect in situ change of HV bushing	litre	
	(c) to effect in situ change of LV bushing	litre	
	(d) to effect in situ maintenance of one oil cooler	litre	
29	Total volume of conservator(s)	litre	
30	Volume of oil in (each) conservator between highest and lowest visible levels	litre	
31	Height of oil at maximum level in the conservator(s) above pad level	m	
32	Total number of oil pumps		
33	Output of each oil pump under service conditions:		
	(a) quantity	litre/s	
	(b) head	metres head of oil (approx.)	
34	Continuous rating of each oil pump motor	Shaft kW	
35	Starting current of each oil pump motor	A	
36	Total number of fans		

37	Rated normal output of each fan:		
	(a) quantity	metres³/sec	
	(b) head	mm, water gauge (approx.)	
38	Nominal diameter of fans	mm	
39	Speed of fans	rpm	
40	Continuous rating of each fan motor	Shaft kW	
41	Starting current of each fan motor	A	
42	Filling medium for transport		
43	Total weight as installed in service, including cooling plant, all fittings and oil		
	(a) quotation estimate	Tonne	
	(b) final design calculation	Tonne	
44	Weight arranged for transport:		
	(a) excluding vehicle	Tonne	
	(b) including vehicle (to be completed for transformers weighing in excess of 200 Tonne)	Tonne	
45	Weight of each individual coolers, complete with oil	Tonne	
46	Weight of each bushing insulator:		
	(a) HV	kg	
	(b) LV	kg	
	(c) Neutral	kg	
47	Weight of regenerative breather	kg	

Schedule E – Technical Particulars and Guarantees – Part 2

(to be completed by Tenderer)

For Earthing/Auxiliary Transformers

ITEM NO	DESCRIPTION	
	Magnetic Circuit	
1	Core Construction:	
	(a) Taped/banded/bolted limbs	
	(b) Taped/banded/bolted yokes	
	(c) Taping/banding material (as applicable)	
	(d) Number of limbs	
	(e) Number of limbs wound	
2	Insulation of:	
	(a) Core bolts	
	(b) Core bolt washers	
	(c) Side plates	
	(d) Core laminations	
3	Flux density in iron - Nominal value at normal voltage, frequency and normal tap:	
	(a) Wound limbs tesla	
	(b) Yokes tesla	
	(c) Unwound limbs tesla	
	(d) Shields tesla	
	Windings	

4	Types and arrangements of:	
	(a) HV windings	
	(b) LV windings	
	(c) Winding arrangement, i.e. core/ / /	
5	Conductor material for:	
	(a) HV windings	
	(b) LV windings	
6	Conductor insulation:	
	(a) HV windings (b) LV windings	
7	Current density in the interconnected star winding with:	
	(a) The specified earth fault current (30 second rating) A/mm²	
	(b) The resultant earth fault current with no external impedance in circuit (3 second rating) A/mm²	
8	Current density in windings (at normal tapping position):	
	(a) HV windings (CMR) A/mm²	
	(b) LV windings (CMR) A/mm²	
	Performance Characteristics	
9	No-load loss at normal ratio kW	
10	Load losses at CMR and 75°C HV/LV kW	
11	Impedance voltage at 75°C and CMR: HV/LV %	
12	Demonstrable zero phase sequence impedance at 75°C and on normal tapping, referred to HV side, at 10% full load current in each phase winding:	

	(a)	HV/LV	Ω per phase	
	(b)	HV-N (Earthing Transformers only)	Ω per phase	
13	Calculated zero phase sequence impedance at 75°C and on normal tapping referred to HV side, assuming rated voltage (single phase) applied between line terminals and neutral:			
	(a)	ZH	Ω per phase (approx.)	
	(b)	ZL	Ω per phase (approx.)	
	(c)	ZT/N	Ω per phase (approx.)	
	(d)	ZH + ZL	Ω per phase (approx.)	
14	Proportion of sum of iron and copper losses at CMR which will be supplied during temperature rise test		%	
15	Guaranteed sound level ("A" weighting)		dB	
	Tank and Cooler			
16	Tank material			
17	Thickness of tank:			
	(a)	Sides	mm	
	(b)	Base	mm	
	(c)	Cover	mm	
18	Thickness of radiator plates and/or cooling tubes		mm	
19	Total oil required (including cooling system)		litre	
20	Volume of oil to be removed:			
	(a)	to gain access to core earthing link	litre	
	(b)	to effect in situ change of HV bushing	litre	
	(c)	to effect in situ change of LV bushing	litre	

21	Total volume of conservator(s)	litre	
22	Volume of oil in conservator between highest and lowest visible levels litre		
23	Filling medium for transport		
24	Total weight as installed in service, including all fittings and oil		
	(a) quotation estimate	Tonne	
	(b) final design calculation	Tonne	
25	Weight arranged for transport:		
	(a) excluding vehicle	Tonne	
26	Weight of each bushing indicator:		
	(a) HV	kg	
	(b) LV	kg	
	(c) Neutral	kg	
27	Weight of regenerative breather	kg	
	Neutral Coupler		
28	Insulation Level		
29	Cooling		
30	Rated Power		
31	Rated Voltage		
32	Rated Continuous Current		
33	Rated Continuous Neutral Current		
34	Winding Connections: (a) HV winding		

	(b) LV Winding	
35	Zero sequence impedance per phase	
36	Total Oil required	
37	Filling medium for transport	
38	Total weight as installed in service	
39	Total weight for transport	

Schedule E – Technical Particulars and Guarantees – Part 3

Quality of Materials

(relevant details to be completed by Tenderer)

MATERIAL	SPECIFICATION OF ANALYSIS
Aluminium Alloys:	
(a) Castings for current-carrying parts	
(b) Other purposes	
Gaskets for oil-tight joints	

Schedule F – Drawings

(to be completed by Tenderer)

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

DESCRIPTION	TENDERER'S DRG. NO.
(a) A preliminary outline giving side and elevation and plan of the tank including tapchanger, terminals/cable boxes and controlling equipment. The principal dimensions shall be given and parts to be removed for transport shall be indicated. NOTE: The outline drawing shall indicate the worst case civil interfaces which cannot be exceeded during the contract.	
(b) A preliminary diagram plate and rating plate.	

Schedule G – Prices and Quantities for Definite Works

(to be completed by Tenderer)

The Prices (other than the provisional sums) entered below (items 13 to 16) include the whole of the definite work specified in the Specification.

1	Section(s) for purposes of payment(s) and taking over		
2	Substation Name		
3	Number of 132kV/Lower Voltage Transformers required		
4	Continuous maximum rating	MVA	
5	Rated higher voltage between phases	kV	
6	Rated lower voltage between phases	kV	
7	Number of Earthing/Auxiliary Transformers required Type: Earthing transformer with resistance earthed system		
8	Continuous maximum rating	kVA	
9	Rated higher voltage between phases	kV	
10	Rated lower voltage between phases (no load)	kV	0.400/0.230 Three phase four wire
11	Number of Neutral Earthing Reactor required		
12	Rated voltage	kV	
13	(a) Price of each 3 phase 132kV/Lower Voltage transformer (Temperature rise test and impulse tests to be quoted as an extra in Schedule H)	£	
	Loss Evaluation (Each 132kV/Lower Voltage transformer):		
	(b) Schedule D No load loss kWx£	£	
	(c) Schedule D Load loss kWx£	£	

14	Total evaluated cost (a+b+c)	£	
15	Price of each Earthing/Auxiliary Transformer	£	
16	Total evaluated cost of Section	£	
17	Price for delivery and off-loading each transformer	£	
18	Price for installation and commissioning each transformer	£	

Schedule H – Prices for Work at the Option of Electricity North West

(relevant details to be completed by Tenderer)

ITEM	DESCRIPTION	PRICE OF EACH ITEM £
1	Extra for:	
	(a) For temperature rise tests per transformer	
	(b) For impulse tests per transformer	
	(c) For each additional shot, impulse test	
	(d) For discharge test	
2	Extra for:	
	(a) Supply and fitting of anti-vibration pads (transformers only)	To be included
	(b) Noise enclosure if required from outset	
3	Extra for Tap Change Control Equipment	
	(a) For standby Control Panel complete	
	(b) For supply of Loose Equipment only.	

Schedule I – Access Facilities to the Site

(to be completed by Electricity North West)

1	Section	
2	Substation Name	
3	Ordnance Survey 132kV/Lower Voltage reference	
4	Whether direct road access is available to the site	Yes/No
5	Approximate distance from the site to the nearest road	
6	Whether rail transport is required	Yes/No
7	Whether there is a railway siding near to the site	Yes/No
8	Nearest railway goods station and approximate 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 – Proposed Departures from this Specification

(relevant details to be completed by Tenderer)

REF.	PROPOSED DEPARTURES FROM THE REQUIREMENTS OF THIS SPECIFICATION	DETAILS OF ALTERNATIVE PROPOSALS

Schedule K – List of Special Tools and Equipment to be Provided

(relevant details to be completed by Tenderer)

ITEM NO	DESCRIPTION

Appendix B – Conformance Declaration

SECTION-BY-SECTION CONFORMANCE WITH SPECIFICATION

The manufacturer shall declare conformance or otherwise, section by section, 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:

Name:

Company:

Signature:

SECTION-BY-SECTION CONFORMANCE			
Section	**Section Topic**	**Conformance Declaration Code**	**Remarks * (must be completed if code is not C1)**
4.1	Product not to be Changed		
4.2	Electricity North West Technical Approval		
4.3	Quality Assurance		
4.4	Formulation		
4.5	Identification Markings		
4.6	Product Conformity		
5	Requirements for Type and Routine Testing		
6.1	Standards		
6.2	Compliance With Specification		
6.3	Safety		
6.4	Environmental Conditions		
6.5	System Conditions		
6.6	Electrical Clearances		
6.7	Terminal Points of Contract		
6.8	Design of Equipment		

6.9	Rating of Ancillaries		
6.10	Quality of Material		
6.11	Fasteners and Fittings		
6.12	Interchangeability		
6.13	Insulating Oil		
6.14	Tests		
6.15	Transformer Management Systems		
7.1.1	Windings		
7.1.2	General		
7.1.3	Cooling		
7.1.4	Parallel Operation		
7.2	Ratings and Loadings		
7.3	Voltage Ratio and Taps		
7.4	Winding Connections and Vector Group		
7.5	Losses and Evaluation of Losses		
7.6	Impedances		
7.7	Duty under Fault Conditions		
7.8	Magnetic Circuit		

7.9	Flux Density		
7.10	Vibration		
7.11	Noise		
7.12	Terminal Connections		
7.13	Tanks and Coolers		
7.14	Voltage Control		
8.1	General		
8.2	Electrical Characteristics		
8.3	Short Time Current Rating		
8.4	Tanks and Fittings		
8.5	Lower Voltage Windings		
8.6	Multicore Cable Connections		
8.7	EAT / AT Noise		
9.1	General		
9.2.1	General Requirements		
9.2.2	Laminations		
9.2.3	Structural Framework		
9.2.4	Core Bands		

9.2.5	Flux Density		
9.3.1	General Requirements		
9.3.2	Winding		
9.3.3	Connections		
9.3.4	Terminal Markings		
9.4.1	General Requirements		
9.4.2	Earthing of Core Clamping Structure		
9.4.3	Earthing of Magnetic Circuits		
9.4.4	Earthing of Coil Clamping Ring		
9.4.5	Size of Earthing Connection		
9.5	Drying Out		
10.1	Safety and Clearances		
10.2	Transformer Tanks		
10.3	Conservator Tanks and Breathers		
10.4	Earthing Connections		
10.5	Pressure Relief Devices		
10.6	Joints and Gaskets		

10.7	Valves and Plugs		
10.8	Oil Level Indicators		
10.9	Winding Temperature Indicators		
10.10	Gas and Oil Actuated Relays		
10.11	Rating, Diagram and Valve Plates		
10.12	Cleaning and Painting		
10.13	Surge Arrestors		
11.1	General Requirements		
11.2	On-load Tap Changers (OLTC)		
11.3	OLTC Driving Mechanism		
11.4	Off-Circuit Tap Changers		
11.5	Voltage Control		
12.1	General Requirements		
12.2.1	Particular Requirements		
12.2.2	Construction		
12.2.3	Temperature Limits		
12.2.4	Porcelains and Associated Gaskets		

12.2.5	Polymeric Bushings and Associated Gaskets		
12.2.6	Paint and Other Protection		
12.2.7	Mounting of Bushings		
12.3.1	Particular Requirements		
12.3.2	Ratings		
12.3.3	Construction		
12.3.4	Venting, Drainage and Earthing		
12.3.5	Disconnecting Chambers		
12.4	Current Transformers		
13.1	General Requirements		
13.2	Radiators		
13.3	Cooling Banks		
13.4	Oil Pipes and Flanges		
13.5	Oil Pumps		
13.6	Air Blowers		
13.7	Motors		
13.8	Cooler Control		
14.1	General Particulars		

14.2	Common Requirements		
14.3	Electrical Control of Cooling Plant		
14.4.1	General		
14.4.2	Local/Remote Control		
14.4.3	Automatic Voltage Control		
14.4.4	Voltage Regulating Device CT		
14.4.5	Remote Tap Position Indications		
14.5.1	General		
14.5.2	Oil Temperature Indicators		
14.5.3	Winding Temperature Indicators		
14.5.4	Remote Indication of Winding Temperature		
14.6	Oil Level Indicators		
14.7	Transformer and Tap Changer Alarm and Trip Outputs		
14.8.1	General Requirements		
14.8.2	Earthing		
14.8.3	Ventilation and Heating		

14.8.4	Fittings - General		
14.9.1	General Requirements		
14.9.2	Interconnecting Cables		
14.9.3	Small Wiring		
15.1	General Requirements		
15.2.1	General		
15.2.2	Material Tests		
15.2.3	Test Certificates		
15.3.1	General		
15.3.2	General Test Requirements		
15.4	Rejection of Plant		
15.5	132kV/Lower Voltage Transformer - Summary of Tests		
15.6	132kV/Lower Voltage Transformer - Details of tests during manufacture		
15.7	132kV/Lower Voltage Transformer - Site commissioning tests		
15.8	Earthing/Auxiliary Transformer - Summary of Tests		

15.9	Earthing/Auxiliary Transformer - Details of tests during manufacture		
15.10	Earthing/Auxiliary Transformer - Site commissioning tests		
15.11	Test certificates and records to be supplied		
16	Drawings		
17	Assembly, Operating and Maintenance Instructions		
18	Models and Samples		
Schedule B	Commencement date and Dates of Readiness for Inspection, Testing, Delivery, Access to Site and Completion Definite Work		
Schedule C1	Manufacturers and Places of Manufacture, Testing and Inspection – 132kV/Lower Voltage Transformer		
Schedule C2	Manufacturers and Places of Manufacture, Testing and Inspection – Earthing/Auxiliary Transformer		
Schedule E Part 1	Technical Particulars and Guarantees for 132kV/Lower Voltage Transformers		

Schedule E Part 2	Technical Particulars and Guarantees for Earthing/Auxiliary Transformers		
Schedule E Part 3	Quality of Materials		
Schedule F	Drawings		
Schedule G	Prices and Quantities for Definite Works		
Schedule H	Prices for Works at the Option of Electricity North West		
Schedule J	Proposed Departures from this Specification		
Schedule K	List of Special Tools and Equipment to be Provided		

Additional Notes: