WESTERN POWER DISTRIBUTION

Serving the Midlands, South West and Wales

Company Directive

ENGINEERING SPECIFICATION
EE SPEC: 8/8

Relating to Emergency Rated System Transformers - 66/11.5kV and 33/11.5kV Delta/Star and Star/Star connected

Policy Summary
This specification covers Western Power Distribution's requirements for 7.5/15MVA, 12/24MVA and 20/40MVA delta/star and star/star continuous emergency rated system transformers. It is based on ENA Technical Specification 35-2 Issue 6 - June 2014 and must be read in conjunction with that document.

Author: Andrew Reynolds

Implementation Date: February 2017

Approved by

Policy Manager

Date: 23 February 2017

IMPLEMENTATION PLAN

Introduction
This document defines the 66/11.5kV and 33/11.5kV CER Primary Transformers used within WPD and provides a standard with which the Purchasing Section can go out to tender with.

Main Changes
The document has been updated to include the use of inhibited insulating oil.

Impact of Changes
The impact of changes affects the Procurement Team, Primary System Design, Engineering Design and Major Projects.

Implementation Actions
Implementation is immediate.

Implementation Timetable
This policy can be implemented with immediate effect.

Document Revision & Review Table		
Date	**Comments**	**Author**
Feb 2017	• Inclusion of inhibited insulating oil • Spelling changes and grammar	Andrew Reynolds
May 2015	• Inclusion of new standard schemes, Ashridge WTI instrument and removal of some contradictory terms • Inclusion of new ENATS 35-2 issue 6 2014 • Inclusion of Eco design regulation 2009/125/EC • Update to latest ENATS 35-2 numbering	Andrew Reynolds
04/01/2013	• Inclusion of revision table, update of drawing references and inclusion of new Appendix 1 and 1A, inclusion of WPD Midlands transformers	Andrew Reynolds

CONTENTS

1.0 SCOPE

This specification covers the technical requirements for three-phase, oil immersed, 66/11.5kV , 33/11.5kV and 33/11.5/6.9kV dual ratio, 50Hz, emergency rated system transformers for use on systems having the 11.5kV neutral earthed directly or through resistance, reactance or arc suppression coil at one or more points.

2.0 FOREWORDS

All equipment supplied under this specification will meet the technical requirements of ENA Technical Specification 35-2, Issue 6, 2014 - Emergency Rated System Transformers 66/20.5kV, 66/11.5kV and 33/11.5kV Delta/Star and Star/Star Connected.

Additional clauses contained within this specification are in addition to the requirements of the standards outlined in ENA Technical Specification 35-2. Where there is any conflict between ENA Technical Specification 35-2 and this document, then this specification shall take precedence.

Manufacturers should consider carefully the implications of arc suppression coil earthing of both 33kV and 11.5kV systems on the insulation requirements of the equipment supplied.

The transformer and its ancillaries shall be designed such that it can continue in operation in times of flood when water levels could reach 1m above the plinth level. All parts below this level shall be sealed to allow submersion. Items which are not suitable for submersion shall be located above this level. Any items that are below the 1m level that are not suitable for submersion shall be listed in Appendix 4 together with the reason for the non-compliance and the extent of damage and rectification needed following subsidence of the flood.

Clause numbers in this specification correspond to clause numbers in ENA Technical Specification 35-2.

3.0 DEFINITIONS

Clause 3 of ENA Technical Specification 35-2 applies.

4.0 SERVICE CONDITIONS

4.2 Normal Service Conditions

The requirements of IEC 60076-1, Clause 4.2 shall apply only at the ONAN rating.
The emergency rated condition (CER) shall be based on an ambient air temperature of 5 degrees C unless specified otherwise by the purchaser in the schedule of requirements.

5.0 RATINGS

Clause 4 of ENA Technical Specification 35-2 applies with the addition of -

- Dual ratio transformers for which the voltage ratio at no-load, on the principal tap, shall be 33000/11500/6900 V.

For 66//11.5kV transformers the voltage ratio at no load on the principal tap shall be 66000/11 500V.

Table 1
Standard Values of Rated Power

ONAN Rated Power in accordance with IEC60076-1 (MVA)	Emergency Rated Power CER (MVA)	Emergency Rated Secondary Current (A)	Switchgear Nominal Rated Current (A)[1]
7.5	15	753	800
12	24	1205	1250
20	40	2008	2000
Note 1: The purchaser shall ensure that the switchgear on the 11kV side is adequately rated for the transformer secondary current.			

An extra two rows shall be added to Table 1 to give the Switchgear Nominal Rated Current (A) for when a dual ratio transformer is running on the 33000/6900 V ratio as below:-

ONAN Rated Power in accordance with IEC60076-1 (MVA)	Emergency Rated Power CER (MVA)	Emergency Rated Secondary Current (A)	Switchgear Nominal Rated Current (A)[1]
7.5	15	1255	1250
12	24	2008	2000
Note 1: The purchaser shall ensure that the switchgear on the 6.9kV side is adequately rated for the transformer secondary current.			

Transformer ratings larger than 24 MVA emergency rating will not be required for 33/11.5/6.9 kV transformers.

Options are given in Appendix 1 (33/11.5kV) or Appendix 1A (66/11.5kV)

5.1.2 Preferred values of rated power

In addition to Clause 5 of ENA Technical Specification 35-2, the manufacturer shall supply with the tender the following graphs

- CER vs. ambient temperature.
- ONAN rating vs ambient temperature.
- CMR vs ambient temperature.

6.0 REQUIREMENTS FOR TRANSFORMERS HAVING A TAPPED WINDING

Clause 6 of ENA Technical Specification 35-2 applies. Options are given in Appendix 1. (33/11.5kV) or Appendix 1A (66/11.5kV)

Unless a multi-start tapping winding is employed, all tappings should be made on the outside winding face. Tappings brought out between turns or discs are not acceptable.

6.4 - **Tappings**

For 66/11.5kV transformers the tapping range shall be +9% to -15% in 16 steps of 1.5%.

For 33/11.5kV transformers the tapping range shall be ±8 x 1.25% (+/- 10%)

6.5 - **Short circuit impedance**

Unless otherwise specified in Appendix 1A, the short circuit impedance of 66/11.5kV transformers shall be designed to be 95 to 98% (on 100MVA base) at nominal tap, 95 to 98% at tap17 and 105 to 107% at tap 1

6.6 - **Load loss and temperature rise**

The requirements of ENATS 35-2 clause 6.6 shall apply.

Temperature rise test shall be carried out in accordance with Clause 11.1.3 of ENA technical spec 35-2.

Transformers offered by manufacturers are required to satisfy the eco-design regulations 2009/125/EC and to conform to the requirements associated with Commission Regulation 548/201 with regard to small, medium and large power transformers.

The energy performance of a transformer at its equivalent CMR rating shall comply with the maximum allowed values of load losses and no load losses or peak efficiency index (PEI) for Tier 1 stated in the appropriate tables of Annex 1 of the eco-design regulations.

7.0 CONNECTION AND PHASE DISPLACEMENT SYMBOLS FOR 3 PHASE TRANSFORMERS

Clause 7of ENA Technical Specification 35-2 applies. Options are given in Appendix 1 (33/11.5kV) or Appendix 1A (66/11.5kV).

8.0 RATING PLATES

Clause 8 of ENA Technical Specification 35-2 applies.

Rated power shall be shown on the rating plate as below.

Ambient Temp (degrees C)	Rated Power (MVA)		
	ONAN	CER	CMR
5	AA	BA	CA
10	AB	BB	CB
20	AC	BC	CC
30	AD	BD	CD
40	AE	BE	CE

9.0 SAFETY, ENVIRONMENTAL AND OTHER REQUIREMENTS

Clause 9 of ENA Technical Specification 35-2 applies.

All windings shall be of copper.

The maximum flux density in any part of the core or shields shall not exceed 1.65T (tesla).

The line-to-neutral output voltage wave of Star/Star connected transformers shall not introduce more than 0.5% third harmonic component when the transformer is excited at 33kV or 66kV (as relevant) on the normal tapping.

The transformer, coolers, tapchanger and ancillaries shall be designed so that water collection points/traps are avoided.

The transformers shall be designed to withstand without damage external short circuits as specified in BS EN 60076-5, taking the 33kV short circuit apparent power of the system (clause 3.2.2.4) as 1000 MVA and that for the 66kV system as 3000 MVA unless otherwise specified. The duration of the short circuit (clause 4.1.3) shall be 3 seconds.

9.3 Oil preservation system

The oil preservation system shall be free breathing with a maintenance free desiccant (silica gel) or self dehydrating breather as determined by the manufacturer. Details of the system used shall be provided at time of tender for approval. Although the device is maintenance free it shall be positioned so that it is accessible from ground level for repair/maintenance and situated 1m from the ground to prevent damage during times of flooding.

9.4 Insulating oil

The manufacturer will provide oil in accordance with IEC 60296 high grade inhibited oil.

The oil offered shall have the following stand out properties.

Property	Test Method	Value
Dielectric Dissipation Factor at 90 ºC and 20 ºC	IEC 60247	Less than 0.0025
Flash Point (ºC)	ISO 2719 ASTM D93	>170
Total Sulphur Content (ppm)	IP 373 ISO14596	Non-detectable (less than 1 ppm)
Breakdown Voltage (kV)	IEC 60156	>50kV (Untreated)
Breakdown Voltage (kV)	IEC 60156	>70kV (Treated)
Corrosive Sulphur	DIN 51353 or ASTM D1275B	Non corrosive
PCB (ppm)	IEC 61619	Non-detectable (less than 1 ppm)
Water Content (ppm)	IEC 60814	<15

The oil used needs to be identified at time of tender and on the name plate for future reference.

10.0 TOLERANCES

Clause 10 of ENA Technical Specification 35-2 applies.

11.0 TESTS

Clause 11 of ENA Technical Specification 35-2 applies.

For 33kV and 66kV rated transformers, the Insulation Levels in Table 2 shall apply

Table 2
Insulation Levels

Highest voltage for equipment Um (r.m.s.) kV	Nominal system voltage (kV)	Rated lightning impulse voltage (LI) kV (peak)	50Hz withstand voltage kV (r.m.s)
12	11	95	28
36	33	170	70
72	66	325	140

The following additional tests are also required:-

11.1.2 Routine Tests

i. Measurement of positive sequence impedance at every tapping position
ii. Correct functioning of the tap-changer and driving mechanism
iii. SFRA shall be carried out in the factory before shipping and as the first test on site once the transformer has been landed on its plinth.
iv. For all star star connected transformers zero sequence impedance tests shall be carried out on all units

11.1.3 Type Tests

Where a tank attached radiator design is offered the OFAF type tests shall be undertaken twice, once with the radiator panels attached to the tank and once with the radiators configured in a separate bank.

11.1.4 Special Tests

The cost for a short circuit test in accordance with BS EN 60076-5 shall be provided at the time of tender, when a decision shall be made as to whether the test is required.

11.6 Measurement of zero-sequence impedance

On star/star transformers, measurements of zero-sequence impedance shall be taken with the current specified in Table 5 of ENA Technical Specification 35-2 in the LV neutral and the HV winding open circuited. The zero-sequence impedance in ohms/phase shall lie within the limits in table 3.

Table 3
Zero Phase Sequence Impedance

Emergency Rated Power (MVA)	Zero Phase Sequence Impedance (ohms/phase)	LV Neutral Current (A)
15	8 to 12	400
24	6 to 10	600
40	3 to 8	1000

11.14 Determination of Sound Levels

The ONAN Sound Power Levels given in Clause 11.14 Table 4 of ENA Technical Specification 35-2 shall apply, but cooler sound power levels (dBA), shall each be reduced by 3dBA from the ENA Technical Specification 35-2 figures to new Western Power Distribution figures listed in Table 4.

Table 4
Maximum Noise Level

Rated Emergency Power (MVA)	ONAN Rating Sound Power Level (dBA)	CER Rating Sound Power Level (dBA)	WPD CER Rating Sound Power Level (dBA)
15	63	81	78
24	65	83	80
40	68	85	82

11.15 Frequency Response Analysis

FRA shall be carried out on the transformer before leaving the manufacturer's works and repeated again at site following assembly. The instrumentation leads, etc. shall be arranged so that the conditions of test on site are as close as possible to the conditions of test in the manufacturer's works.

11.18 Site Tests

The site tests (a) to (n) listed in Clause 11.18 of ENA Technical Specification 35-2 and the flowing tests shall be carried out by the manufacturer at the time of commissioning.

1. Core Earth Test
2. For all CT's
    a. DC resistance
    b. Flick test
    c. Magnetisation Curves

The cost of providing the FRA tests shall be included in the overall price, but identified separately at the time of tender.

12.0 ELECTROMAGNETIC COMPATIBILITY (EMC)

Clause 11 of ENA Technical Specification 35-2 applies.

14.0 TRANSFORMER DETAILS

Clause 14 of ENA Technical Specification 35-2 applies.

14.4 Limiting Dimensions

14.3.1 Separate Cooler Bank Arrangement - as ENA Technical Specification 35-2 applies.

14.7 Tank Attached Cooler Arrangement

An arrangement having flanged tank attached radiators, which is designed to permit simple conversion, either at time of initial installation or at a later date, to a separate radiator bank arrangement using the existing components save for additional pipework, expansion joints and supports.

This arrangement shall meet all requirements of this specification including the requirements of Clause 14.3.1 of ENA Technical Specification 35-2 when configured as a separate radiator bank arrangement.

Flanges between radiator panels and the tank shall be equipped with valves.

The same pump(s), radiator panels and conservator shall be used when converting to separate radiator bank arrangement, noting height, hydraulic and thermal issues.

The Contractor must have fully designed the conversion arrangement and type tested it they must provide full manufacturing, arrangement and assembly drawings to permit WPD to undertake later conversion without further need for reference to the Contractor.

14.8 Plinth

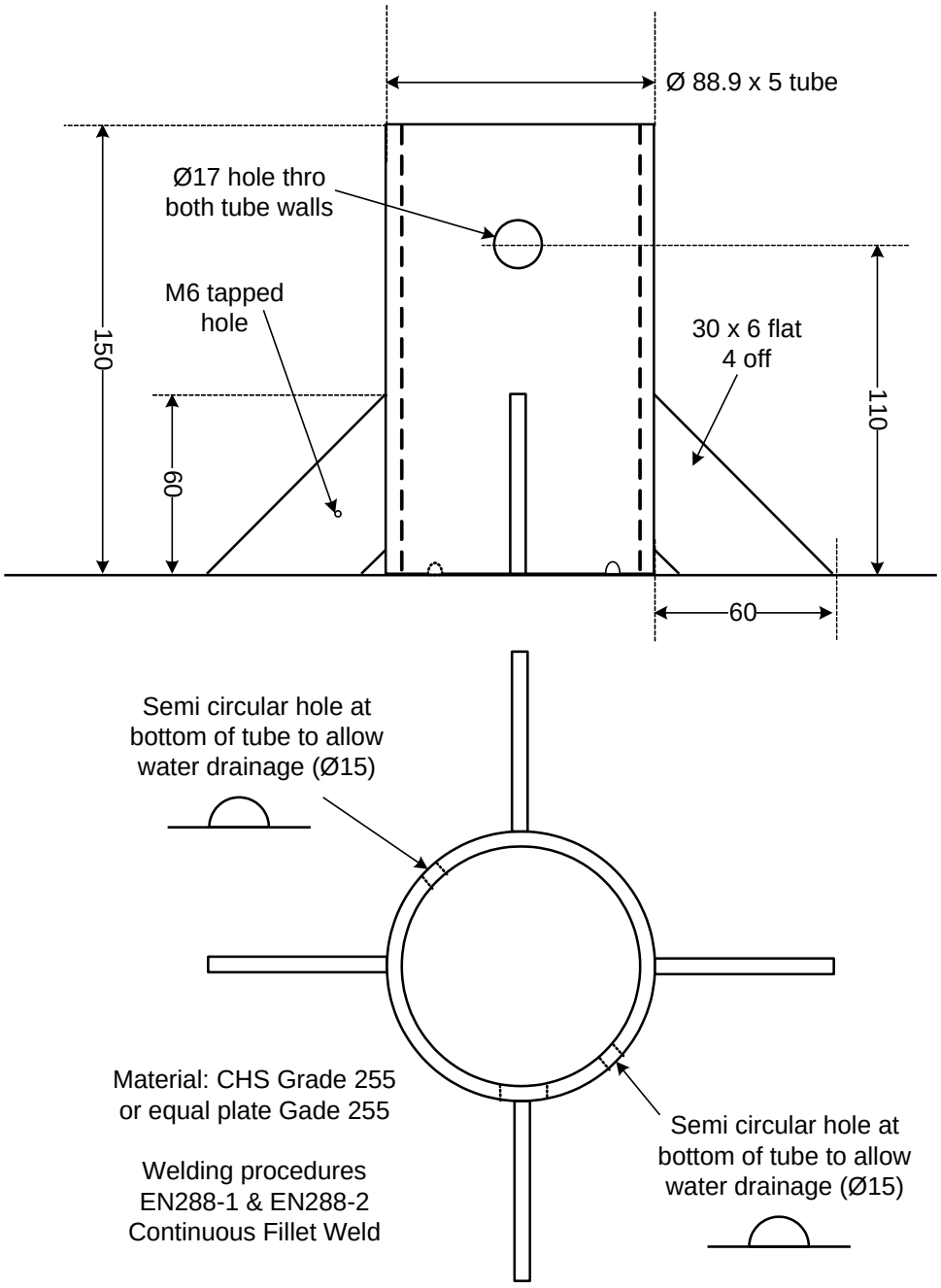
The transformer and cooler footprint shall be at least 50mm from the edge of the plinth.

15.0 CONSTRUCTION DETAILS

Clause 15 of ENA Technical Specification 35-2 applies.

15.1 Tanks and Covers

A socket for insertion of a work positioning restraining post (RidgeGear SSP Sub-Station fall arrest post) shall be provided as near the centre of the transformer lid as practicable. This shall be as detailed in the Figure below.



15.3 Terminals

15.3.1 The HV connection shall be either:-

Three outdoor bushings in accordance with IEC 60137 and Table 5 of ENA Technical Specification 35-2 mounted on turrets. For 66kV rated transformers the following requirements apply for Table 5.

Table 8
Outdoor bushing details

Voltage (kV)	Live Metal to Earth Flashover distance (mm)	Air end creepage distance(mm)	Stem diameter (mm)	Stem length (mm)
72.5	700	1820	20 or 30	125

Accommodation for two sets of protective current transformers to BS EN 60044-1,

Set 1 15VA 5P10, ratio 300/1 for 15MVA, 400/1 for 24MVA, 800/1 for 40MVA
Set 2 nearest the windings 800/1 class PX

For transformers with tank attached or separate cooler bank arrangements the CT's may be located in the main tank top oil, provided they are readily accessible for replacement via an access cover. The necessary accommodation space, 66kV or 33kV insulation and suitable external terminals must always be provided, independent of whether the CT's themselves are supplied by the manufacturer.

The volume of oil that needs to be removed to change the CT's shall be given in Appendix 3.

The supply of two sets of current transformers as specified above shall be included in the offer. The manufacturer shall supply a full specification including physical dimensions of all CTs installed.

Limiting dimensions for each current transformer are:

Inside Diameter	75 mm minimum
Outside Diameter	230 mm maximum
Length	55 mm maximum

Protective current transformers provided shall be wired to terminal blocks in the control cubicle.

The HV bushings shall be wired to allow for Neutral Voltage Displacement protection. This needs to be wired back to the control kiosk. The same arrangement needs to be made available for separable connectors and the LV terminations.

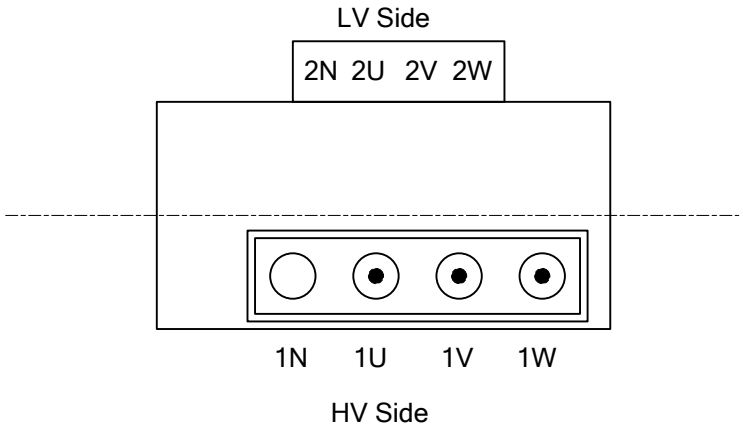
Surge diverter brackets shall be provided. The bracket should have a 14mm diameter hole to accommodate a surge diverter with a single bolt fixing and suitable to accommodate a surge diverter with a length of up to 600mm (33kV) when the busbar connection is horizontal. For 66kV assume use of ABB PEXLIM Q XV02 housing (736mm) when the busbar connection is horizontal. Or alternatively for 66kV assume use of TE Energy PCA 3-72 housing (1085mm) when busbar connection is horizontal

The surge diverter brackets shall be fitted to accommodate busbars being connected from the HV side of the transformer, however it shall be possible to fit the surge diverter brackets on the opposite side of the bushing to accommodate the HV busbars being landed from the LV side across the top of the transformer.

Facility shall be available to fit a single arc gap of 305mm on each 33kV bushing and 540mm on each 66kV bushing, but as it is intended to use surge diverters these shall not be fitted.

The layout of the LV cable box and HV bushings shall be as shown below.

The HV bushings shall not be on the same physical side of the transformer as the LV separable connectors.



It is accepted that when bushings are replaced with cable boxes and any associated disconnecting chambers, some component parts may need to be changed, but these should be kept to a minimum.

Or

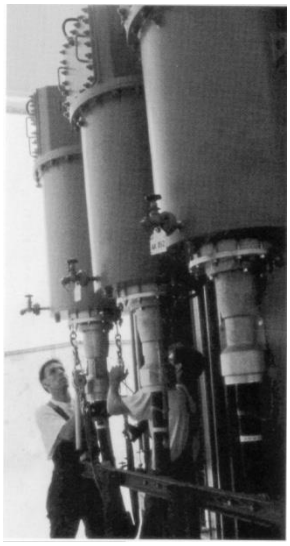
Cable connected transformers having a voltage rating of 66 kV, shall have their cables terminated using inner cone Pfisterer Size 4 separable connectors the separable connectors shall have individual phase chambers.

Where inner cone separable connectors are fitted to transformers rated 20MVA and above, a disconnecting chamber shall be provided. Both inner cone separable connector chambers and disconnecting chambers shall be of phase isolated design.

The inner cone separable connector chambers shall be filled with insulating oil complying with the requirements of BS 148 (2009). The oil level shall be maintained from the main conservator by means of a connecting pipe of 25 mm diameter to the highest point in the chamber. This connection shall be controlled by a suitable valve, and shall ensure that any gas leaving the chamber will pass through the gas and oil actuated relay specified. A barrier shall be provided on both sides of the disconnecting chamber to prevent oil used for filling the chamber from entering the cable box or from communicating with the oil in the transformer, other than through the equalising pipework to the conservator. It shall be necessary to remove only part of the oil in the chamber itself when making the necessary testing connections.

An approved drain/filter valve shall be provided at the lowest point and a filter valve shall be fitted at the top of the chamber.

Each chamber shall have two Pfisterer size 4 inner cone separable connectors; one connector shall be installed in the upward direction and the other in the downward direction, see pictures below for typical layout. The incoming cable entries shall be vertical from below; the upper inner cone connector shall be voltage-proof sealed with a dummy connector.



The inner cone separable connector chambers shall have flanged joints with gaskets and provided with bolted access covers. Gaskets shall be below oil level at a temperature of minus 10°C.

The inner cone separable connector chambers and associated disconnecting chambers shall permit either the transformer or the cable to be subjected to the high voltage test specified in their own Contract documents. The upper inner cone connector provides for mounting a temporary bushing for this purpose. Subject to the approval of the Purchaser, it will be permissible to use such a bushing for factory tests on the transformer in lieu of the cable.

When required by the Purchaser, inner cone separable connectors and their associated chambers shall be tested in accordance with the relevant clauses of IEC 60840 and DIN VDE 0276 05.

The inner cone separable connectors, bushings and their mounting arrangements shall withstand the thermal and dynamic effects of short-circuit currents of the associated transformer, as specified in IEC 60076.

The inner cone separable connector chambers shall, in addition to their own specified requirements and the specified ‘when laid and jointed’ test requirements for the associated cables, be capable of withstanding for 60 minutes, between phases and between phases to earth, the following test voltage: -

Either: -

(i) 1.7Uo kV, ac generated by series resonance at or about 50Hz the actual test frequency will depend on the length and CSA of the cable.

Where U_o = the power frequency voltage between phase and earth.

Or

(ii) An AC voltage test at power frequency. This test shall be for 5 minutes with the phase-to-phase voltage (U) applied between the conductor and the metallic screen.

Note: - During these tests, the links between the transformer/reactor and cable connections will be withdrawn and the windings earthed.

A supporting bracket shall be provided on the side of the transformer to support the HV cables and pre-drilled to mount Ellis Patent twin bolt fixing Atlas cable cleats. The Ellis Patent Atlas cable cleats shall be commensurate for the correct size of cable required for the transformer in question. Unless otherwise agreed, this bracket shall be mounted no more than 1 metre below the gland plate. The bracket shall be positioned in such a way that when the Atlas cable cleats are fitted, the cables shall pass through the centre of the cleat and enter straight into the base of the inner cone separable connector housing. The Ellis Patent, Atlas cable cleats will not be supplied with the transformer.

Cabling and jointing within the inner cone separable connector chambers will be carried out under a separate contract.

Cable connected transformers having a voltage rating of 33 kV, shall have their cables terminated using outer cone, bolted, interface C separable connector bushings to EN 50181, rated 36kV 1250A continuous (Euromold type M400 AR-4, see drawing SD 567 E, unless otherwise agreed in writing at time of tender) mounted on the vertical face of the tank wall to permit cable connection from below. Alternative makes may be offered but shall not be provided unless accepted in writing by WPD. A weather shield shall be provided over these bushings, having sufficient clearance to house one separable connector type M440 TB/G, for the respective cable size, with dead end plug and cap, plus an additional 100 mm air clearance. The weather shield shall provide for access to unplug the separable connectors by removal of the front face of the weather shield and such bottom mounted parts as necessary. These removable components shall be fitted with handles as required and no single part shall weigh more than 25kg. Materials surrounding the single core cable entries shall be nonferrous to avoid eddy current heating effects and shall avoid a shorted turn being created by the tank wall. If the weather shield is unsuitable to carry the weight of a person weighing 150kg, suitable warning labels shall be applied to the front and top.

The phase markings shall be as detailed in Clause 13.3 with the HV and LV connections on the same side of the tank.

A supporting bracket shall be provided on the side of the transformer to support the 33kV cables and pre-drilled to mount Ellis Patent twin bolt fixing Atlas cable cleats type AR2-A13. Unless otherwise agreed, this bracket shall be mounted no more than 1 metre below the bushing. The bracket is likely to need bracing to either the tank wall or to the ground, it is preferred that the bracing be to the tank wall. The bracket shall be positioned such that when the Atlas cable cleats are fitted, the cables shall pass through the centre of the cleat and enter straight into the base of the connector housing. The Ellis Patent, Atlas cable cleats will not be supplied with the transformer.

A bolt on oil filled disconnecting chamber shall be provided as detailed in Clause 15.3 of ENA Technical Specification 35-2.

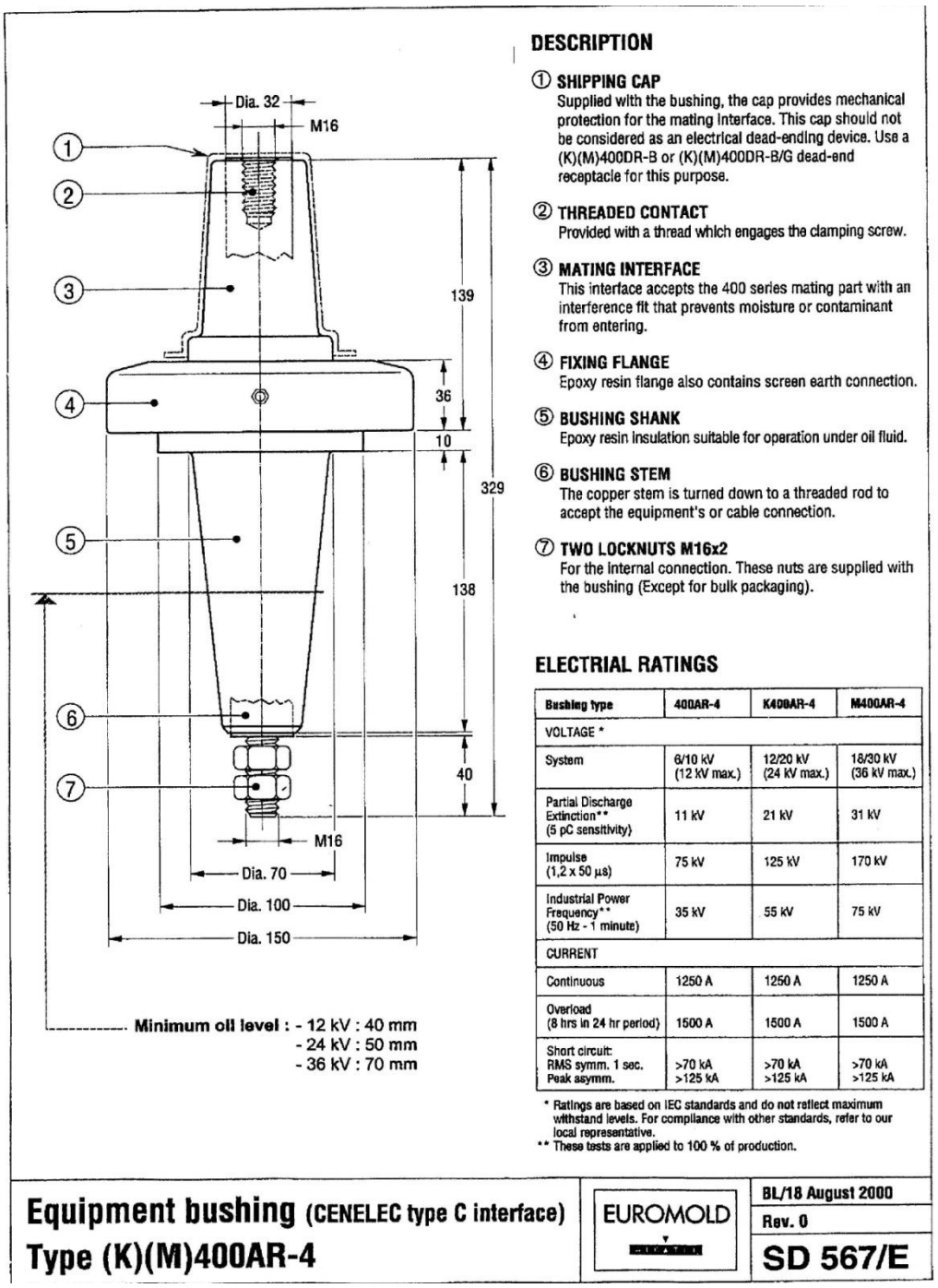
Two sets of current transformers as detailed in 15.3.1 of this specification, mounted on suitable bushings to facilitate replacement, and easily accessible through a suitable access plate in the tank lid shall be provided.

Protective current transformers provided shall be wired to terminal blocks in the control cubicle.

The HV bushings or terminals shall include a capacitor tap for neutral voltage displacement protection purposes. The capacitance shall be as follows

66kV outdoor bushings 260pF
33kV outdoor bushings 76pF
C Type Euromold bushings 28pF

To match the NVD relay, these arrangements shall be wired to a terminal within the MK ready for WPD to connect to this shall form on board NVD protection as specified in the schedule of requirements.



15.3.5 HV Neutral

The 66kV and 33kV neutral point of each Star/Star connected transformer shall be made readily available. A flange to BS2562 facing 'C' with its major axis horizontal shall be provided on the tank to accept one of the following.

i. A blanking plate
ii. An outdoor bushing in accordance with IEC 60137 and Table 5 of this specification and ENA Technical Specification 35-2

A bracket shall be provided near the base of the bushing to enable WPD to fit a surge diverter.

Facility shall be available to fit a single arc gap of 305mm for 33kV transformers and 540mm for 66kV transformers, but as it is intended to use surge diverters this shall not be fitted.

15.3.6 LV Terminations

15 and 24 MVA - Four separable connector bushings Euromold type M400 AR-4, 1250A mounted on the vertical face of the tank wall to permit cable connection from below. A weather shield shall be provided over these bushings, having sufficient clearance to house two separable connectors type M440 TB/G with one connecting plug and a dead end plug and cap plus an additional 100 mm air clearance.

40 MVA transformers - 9 + 1 separable connector bushings Euromold type M400 AR-4, 1250A mounted on the vertical face of the tank wall to permit cable connection from below. A weather shield shall be provided over these bushings, having sufficient clearance to house one separable connectors type K440 TB/G with one connecting plug and a dead end plug and cap plus an additional 100 mm air clearance.

Alternative makes of separable connectors may be offered, but shall not be provided unless accepted in writing by WPD.

If specified in Appendix 1 (33/11.5kV) or Appendix 1A (66/11.5kV) - Schedule of Requirements, an oil filled disconnecting chamber shall be provided as detailed in Clause 13.3 of ENA Technical Specification 35-2 to disconnect the 11/6.6 kV windings from the outgoing cable.

A supporting bracket shall be provided on the side of the transformer to support the 11kV cables and pre-drilled to mount Ellis Patent twin bolt fixing Atlas cable cleats type AR2-A13. Unless otherwise agreed, this bracket shall be mounted no more than 1 metre below the bushing. The bracket is likely to need bracing to either the tank wall or to the ground, it is preferred that the bracing be to the tank wall. The bracket shall be positioned such that when the Atlas cable cleats are fitted, the cables shall pass through the centre of the cleat and enter straight into the base of the connector housing. The Ellis Patent, Atlas cable cleats will not be supplied with the transformer.

The weather shield shall provide for access to unplug the separable connectors by removal of the front face of the weather shield and such bottom mounted parts as necessary. These removable components shall be fitted with handles as required and no single part shall weigh more than 25kg. Materials surrounding the single core cable entries shall be nonferrous to avoid eddy current heating effects and shall avoid a shorted turn being created by the tank wall. If the weather shield is unsuitable to carry the weight of a person weighing 150kg, suitable warning labels shall be applied to the front and top.

It is a requirement to construct a bund wall around the transformer to contain an oil spillage. In constructing a bund it is necessary to fix ducts around all cables to above the height of the bund wall (up to 600 mm). It shall be possible to terminate and fit cables onto the bushings with this duct in place.

15.3.7 LV Neutral

A bracket, suitable for supporting a weatherproof outdoor neutral current transformer fitted around the neutral cable, is required vertically below the neutral cable connector.

15.3.8 Unit Auxiliary Transformer

When specified in Appendix 1 (33/11.5kV) or Appendix 1A (66/11.5kV), an auxiliary transformer shall be supplied. It shall be oil filled, 50kVA, 11,000 / 415V, 3 phase, 50Hz, 4.75% impedance, Dyn11 and as specified in Clause 15.3.58of ENA Technical Specification 35-2. The auxiliary transformer shall be supplied via full range fuses that are situated in a chamber separate from the main transformer tank.

The LV terminations of the auxiliary transformer shall be isolatable via a ganged switchfuse and have clearance from the bottom of the switchfuse termination to the gland plate of 200mm for 50kVA and 300mm for the 100kVA option. The operating handle must be lockable in the on and off position.

When no auxiliary transformer is specified the flange arrangement specified in Clause 15.3.8 of ENA Technical Specification 35-2 shall be provided, but fitted with a blanking plate.

15.4 On-load Tap-changer

Clause 15.4 of ENA Technical Specification 35-2 applies.
The tap-changer shall be capable of bi-directional power flow for its full rating.

The possibility of overrunning the mechanism at each end of the voltage range shall be prevented by means of limit switches and mechanical stops.

A mechanically operated indicator shall show the number of the tap position in use. The numbering of the tap position shall be such that an increase in number corresponds to an increase in voltage of the lower voltage side of the transformer.

When the tapchanger is switched to local operation, automatic or supervisory operation shall be inhibited.

Equipment shall be designed for minimum maintenance. Diagnostic testing and inspection shall be required at intervals of not less than six years. In any event, the switches and oil of the diverter switch and selector switch compartments shall be capable of withstanding 50,000 operations at maximum rated through current without requiring attention.

The manufacturer shall advise at time of Tender the maintenance requirements for the tapchanger offered, including current costs of parts and an estimate of man hours.

For transformers with separate radiator banks and an external flange mounted tapchanger, the tapchanger shall be positioned on one of the longest sides of the tank and not on either end, so access to the tapchanger shall not be inhibited by oil pipes to the radiators, independent of which way the transformer is handed.

The de-hydrating breather shall be accessible from ground level to facilitate maintenance.

Tapchanger control shall be to WPD schematics

SPC11TCC2 shall apply to WPD Midlands and WPD South West

SPC11TCC1 shall apply for WPD South Wales.

15.5 Clearances to exposed conductors

Clause 15.5 of ENA Technical Specification 35-2 applies except in paragraph (ii) 2580mm shall be substituted in place of 2400mm,

For 66kV transformers the following requirements apply for Table 10 External Air Clearances.

Table 10
External Air Clearances

Highest voltage for equipment	**72.5kV (mm)**	**36kV (mm)**
Between live metal including neutral, and earth	700	500
Between live metal of different phases and phase to neutral	780	430
From live metal to any oil pipe work including conservator	700	500

15.6.1 Conservator

In addition to the requirements of Clause 15.6.1 of ENA Technical Specification 35-2 the conservator shall have a minimum volume of 10% of the total transformer and cooler oil content.

15.6.2 Cooling Plant

In addition to the requirements of Clause 15.6.2 of ENA Technical Specification 35-2 a valve shall be provided between the pump and bottom header of the cooler bank to facilitate the removal of the pump.

Drain plugs shall be fitted for draining each section of the cooler.

Air release plugs shall be provided where necessary to facilitate oil fillings.

15.6.3 Gas and oil actuated Relays

For checking the operation and continuity of the electrical contacts each relay shall be provided with an internal injection nozzle associated with a test cock (to be operated standing at ground level and with facilities for locking in the closed position) to take a flexible pipe connection for air and oil injection.

Gas and oil actuated relays with magnetic reed contacts are not permitted.

15.6.4 Pressure Relief Device

The pressure relief device shall be unaffected by the starting or stopping of the pump.

The device shall be flange mounted, preferably on the side of the tank. If it is not possible to mount the device on the side of the tank, and it is mounted on the cover means shall be provided to prevent any gas collection in the chamber under the valve disc.

The outer end of the pipework shall be protected from ingress of vermin etc by a fine mesh grid, but the mesh shall not facilitate the formation of ice or paint spray to seal the outlet.

An approved, sealed, normally open, weatherproof trip switch shall be provided, cabled to the marshalling cubicle. Means shall be provided whereby the switch reset button or arm can be operated without removing the outer pipework.

15.6.5 Winding Temperature Indicator

ENATS 35-2 clause 15.6.5 applies.

Each transformer shall be provided with an approved device indicating the maximum winding temperature) a winding temperature indicator and associated current transformer. The winding temperature indicator shall be of an electronic design for example the Ashridge 852 Plus.

Means shall be provided, external to the winding temperature indicator case, for checking the operation and setting of the contacts Means shall be provided with facilities to prevent unauthorized interference. The temperature indicator shall have a range of 30°C to 150°C. The design of the indicators, the components contained therein, any capillaries and their connections, other associated equipment and the mounting arrangements shall be such that the equipment will not sustain damage or mal-operation due to vibration in service. Anti-vibration mountings shall preferably be integral with the indicator case.

The indicator shall have three sets of independently adjustable contacts having the following purpose and characteristics:

(i) Cooler Control

Adjustable setting 50°C to 100°C (5°C maximum steps)

Adjustable differential 15°C to 30°C

(ii) Alarm

Adjustable setting 80°C to 150°C (5°C maximum steps)

Fixed differential of not more than 10°C

(iii) Trip

Adjustable setting 80°C to 150°C (5°C maximum steps)

Fixed differential of not more than 10°C

Dial type indicators shall have contacts that are adjustable to a scale and that are accessible on removal of the cover.

The winding temperature indicator shall be arranged to replicate the "hottest" winding.

15.6.6 Current Transformers

All CT's shall be provided with a 40 amp primary injection test loop. The test loops shall be terminated in a terminal box either mounted on the turret (if outdoor bushing are used), or on the tank side.

The voltage compounding current transformer shall be rated at not less than 15VA Class 0.5S.

All CT's must be positioned such that they can be readily replaced through an inspection plate with the transformer oil level still above the windings.

15.6.7 Other Fittings

(v) The oil sampling device shall be between 200 and 300mm above plinth height. Details of this device are to be supplied at the time of tender.

(vii) In addition to the requirement of Clause 15.6.7 (vii) identical earthing tags shall be provided on the main tank, as close as possible to, and below, each surge diverter mounting point (HV side only).

Facility shall be provided to support 50mm x 4mm copper earth tape horizontally between the 3 earth tags mentioned above and vertically from this horizontal run to ground level at a point on the tank as close to the central tag as possible. For security reasons (copper theft) it shall be possible to securely bolt the earth tape to the transformer using stainless M12 shear head bolts at a maximum spacing of 300mm.

The earthing tags shall have a blanking plate fitted over them before painting, which can easily be removed, on site, leaving a clean face for connection of the earth.

(xii) The transformer lid shall be bonded to the main tank with 200mm² copper at a point as close as possible to the central earth tag mentioned above.

Ladder tie off points shall be provided where there is a need to access the lid or other lid mounted apparatus.

15.7 Marshalling and/or Control Box

The marshalling and/or Control box can be mounted on either the cooler supporting frame work or the tank wall.

The top of any marshalling / control box shall be less than 2.2m above ground level. Attention is drawn to the requirement given in Clause 2 of this specification for equipment being able to withstand flood water to 1m above plinth level.

Terminal boards shall preferably be Klippon type RSF1 except for telecontrols which shall be type SAKR. If space is a premium consideration shall be given to the use of RSF3 terminals, but all AC supplies shall be RSF1. All terminations shall be made off with hook blade crimps and all wiring shall be Steel Wire Armoured double insulated cable.

A RCD controlled 13A socket (MK Masterseal or equivalent) shall be fitted to the outside of the Marshalling/Control box.

Cooler Control circuitry shall be as WPD schematics

SPC 201 for WPD Midlands and WPD South West,

PSD0890 for WPD South Wales.

Telecontrol voltage shall be as follows

WPD Midlands and South West new build substations shall be 48V.
WPD South Wales shall be 24V.

There will be existing sites that will need the voltage to be advised at the time of order.

16.0 DOCUMENTATION

Clause 16 of ENA Technical Specification 35-2 applies.

16.1 Format of electronic drawing shall be Autocad DWG.

All Detailed Project/Contract Specific Drawings including the physical Transformer GA drawing drawings shall be supplied within 2 months and no longer than 3 months of receipt of order. Indicative layout drawings shall be issued within 1 month to enable WPD to commence civil works.

All drawings shall be approved by WPD before manufacture commences. WPD approval shall take no longer than 2 weeks after drawings are sent to the relevant design engineer.

After construction and commissioning the manufacturer shall incorporate any alterations in these drawings, which have occurred during site work and these shall be completed within 2 months of the completion of site works.

A copy of the transformer test certificate shall also be provided in .pdf format.

17.0 PROGRAMME AND PROGRESS INFORMATION

The manufacturer shall provide within one month of the date of WPD's order a detailed manufacturing programme for each transformer. These copies shall be sent to the WPD nominated Engineer. The programme shall include delivery date to site, erection, commissioning test and handover dates. This programme shall then be updated on the first working day of each month and an update provided to the Engineer named. In the event of changes to the programme, detail should be provided on the reason for the change verbally and backed up in writing.

18.0 DELIVERY AND ERECTION

18.1 The manufacturer shall deliver the transformer to site, off load, carry out all site erection onto prepared foundations, and undertake all site tests specified in Clause 11.13 of this specification. Site erection staff shall be proficient in English. Two copies of all site test results shall be provided to WPD prior to handover.

18.2 All the above work will be carried out in co-operation with the WPD’s staff.

APPENDIX 1

EXAMPLE OF SCHEDULE OF REQUIREMENTS FOR EMERGENCY RATED SYSTEM TRANSFORMERS: 33/11.5KV SEE PURCHASING CATALOGUE FOR CURRENT VERSION OF APPENDIX 1 FOR USE AND FLOW CHART ON PROCESS OF COMPLETING AND LIST OF SHOPS CODES

(To be completed by Purchaser) * Purchaser to delete as appropriate

Item	Clause	Description	
1	1.2.2	Ambient temperature for Emergency Rating °C	* 5
2	4.1	Rated power at Emergency Rating MVA HV Nominal Voltage kV LV Nominal Voltage kV	15 / 24 / 40 33 33 or 11.5 11.5/6.9
	5.4	Tap range	* ±8 x 1.25% (+/- 10%) +4 x 1.43% / -12 x 1.43% (+5.72% - 17.16%)
4	5.4	Category of Tapping Voltage Variation Where CbVV is selected, provide tap position for changeover between CFVV and VFVV Tap Number	*CFVV
5	5.5	Impedance envelope for 7.5/15MVA Impedance envelope for 12/24MVA Impedance envelope for 20/40MVA	*1 (a) / 2 (a) 1 (b) / 1 (c) / 2 (b) 1 (d) / 2 (d)
6	5.6	Loss Capitalization Values (i) No-load Loss £/kW (ii) Load Loss at 50% CER rating £/kW OR Maximum Guaranteed Losses in accordance with 5.6 (i) No-load Loss W (ii) Load Loss at 50% CER rating W	 £4000 £350
7	6	Vector group (add phase displacement number)	* Dyn11 YNyn0
8	6	Vector Links required If yes, alternative vector group	*No
9	8.1	Neutral conductor and terminal intended to carry load	No
10	8.3	Generator transformer load rejection per 8.3	* No
11	10.1.1	FRA test required at works and on site	* Yes Cost to be advised at time of tender
12	10.1.3	Short circuit test required	* No Cost to be advised at time of tender

Item	Clause	Description	
13	12.4.1	Separate cooler bank required	* Yes / No
	12.4.3	Compact Cooler Arrangement	* Yes / No
		Height limitation mm	* 4880 / 4270
		Valve & blanking plates required at alternative oil inlet	* Yes
14	12.4.2	Anti-vibration mountings required (Main TX)	* Yes
15	12.5	Auxiliary supply voltage	* 400 V 3 ph / 230 V 1ph
16	13.2	Finish colour required	Dark Admiralty Grey unless otherwise approved
17	13.3	Position of cable boxes	* Yes / No
18	13.3.1	HV terminal arrangement	* (iv) / (v)
		NVD capacitor taps required	* Yes / No
		NVD capacitance if required pF	* C Type bushings 28pF
			Outdoor bushings 76pF* No
		Surge arresters required	* Yes / No
		Brackets for surge arresters required	
19	13.3.2	HVN terminal arrangement	* (i) / (ii)
20	13.3.3	LV Terminal arrangement	*separable connectors – see Clause 13.3.3 for details
		Number and size of single core cables to be terminated	
		LV cable link disconnecting chamber required	*Yes / No
21	13.3.4	LVN terminal arrangement	* (ii)
		Number and size of single core cable to be terminated	* No – Mounting bracket only required
		LVN current transformer(s) required	
		Details of LVN current transformer(s)	
22	13.3.5	Auxiliary Transformer required	* Yes / No
23	13.4.1	Max / min tap position indicator required	* No
24	13.6.5	Winding temperature indicator or sensor	* Indicator / Sensor
		Output required from sensor	
		Winding temperature indicator type	* Dial / Electronic
		Second WTI or sensor required	* No
		Electronic WTI d.c. supply voltageMinimum (V)	
		Maximum (V)	
25	13.6.6	Second voltage compounding CT required	* No, but space for a second one shall be provided.

APPENDIX 1A

EXAMPLE OF SCHEDULE OF REQUIREMENTS FOR EMERGENCY RATED SYSTEM TRANSFORMERS: 66/11.5KV <u>PLEASE SEE PURCHASING CATALOGUE</u> FOR UP TO DATE VERSION OF APPENDIX 1A

(To be completed by Purchaser) * Purchaser to delete as appropriate

Item	Clause	Description	
1	1.2.2	Ambient temperature for Emergency Rating °C	* 5
2	4.1	Rated power at Emergency Rating MVA HV Nominal Voltage kV LV Nominal Voltage kV	15 / 24 / 40 66 11.5
	5.4	Tap range	+9% to -15% 16 steps of 1.5% Other tapping ranges will be considered
4	5.4	Category of Tapping Voltage Variation Where CbVV is selected, provide tap position for changeover between CFVV and VFVV Tap Number	CFVV
5	5.5	Impedance envelope for 12/24MVA Other ratings - Impedance envelope for other ratings -see clause 5.5 unless otherwise stated here	85 – 90% (100MVA base) on nominal tap “clause (5.5) / other
6	5.6	Loss Capitalization Values (i) No-load Loss £/kW (ii) Load Loss at 50% CER rating £/kW OR Maximum Guaranteed Losses in accordance with 5.6 (i) No-load Loss W (ii) Load Loss at 50% CER rating W	 £4000 £500
7	6	Vector group (add phase displacement number)	* Dyn11 YNyn0
8	6	Vector Links required If yes, alternative vector group	No
9	8.1	Neutral conductor and terminal intended to carry load	No
10	8.3	Generator transformer load rejection per 8.3	No
11	10.1.1	FRA test required at works and on site	Yes Cost to be advised at time of tender

Item	Clause	Description	
12	10.1.3	Short circuit test required	No but cost to be advised at time of tender
13	12.4.1	Separate cooler bank required	* Yes / No
	12.4.3	Compact Cooler Arrangement	* Yes / No
		Height limitation mm	* 4880 / 4270
		Valve & blanking plates required at alternative oil inlet	Yes
14	12.4.2	Anti-vibration mountings required (Main TX)	Yes
15	12.5	Auxiliary supply voltage	400 V 3 ph / 230 V 1ph
16	13.2	Finish colour required	Dark Admiralty Grey unless otherwise approved
17	13.3	Position of cable boxes	Same side of tank
18	13.3.1	HV terminal arrangement	(iv) / (v)
		NVD capacitor taps required	Yes / No
		NVD capacitance if required pF	260pF
		Surge arresters required	No
		Brackets for surge arresters required	Yes
19	13.3.2	HVN terminal arrangement	* (i) / (ii)
20	13.3.3	LV Terminal arrangement	* Separable connectors – see Clause 13.3.3 for details
		Number and size of single core cables to be terminated	
		LV cable link disconnecting chamber required	*Yes / No
21	13.3.4	LVN terminal arrangement	* (i) / (ii)
		Number and size of single core cable to be terminated	
		LVN current transformer(s) required	No – Mounting bracket only required
		Details of LVN current transformer(s)	
22	13.3.5	Auxiliary Transformer required	* Yes / No
23	13.4.1	Max / min tap position indicator required	No
24	13.6.5	Winding temperature indicator or sensor	Indicator / Sensor
		Output required from sensor	
		Winding temperature indicator type	* Dial / Electric
		Second WTI or sensor required	No
		Electronic WTI d.c. supply voltage Minimum (V)	
		Maximum (V)	
25	13.6.6	Second voltage compounding CT required	No, but space for a second one shall be provided.

APPENDIX 2

MANUFACTURERS AND PLACES OF MANUFACTURE, TESTING AND INSPECTION

(To be completed by Tenderer)

MANUFACTURERS AND PLACES OF MANUFACTURE, TESTING AND INSPECTION *(To be completed by Tenderer)* **Item**	**Manufacturer's Drawing Number and/or Type Designation**	**Manufacturer**	**Place of Manufacture**	**Place of Testing and/or Inspection**
Transformers Complete				
On-load Tap-change Equipment				
HV Bushings				
LV Bushings				
Neutral Bushings				
Radiators				
Pipework Expansion Devices				
Oil Valves				
Oil Pumps				
Oil Pump Motors				
Fans				
Fan Motors				
Dehydrating Breather				
Gas and Oil Actuated Relay(s)				
Outdoor Marshalling or Composite Cubicle				
Indoor Control Cubicle				
Temperature Indicating Devices				
Auxiliary Transformer				
Material for Anti-vibration Mounting				
Noise Enclosure				
Test Equipment / Company used for FRA tests				
Any deviation from this Schedule shall be notified in writing as soon as possible for the Purchaser's approval				

APPENDIX 3

TECHNICAL SCHEDULE

(To be completed by Tenderer)

Item	Description			7.5/15 Star Star	7.5/15 Delta Star	12/24 Star Star	12/24 Delta Star	12/24 Delta Star Dual Ratio	20/40 Delta Star	20/40 Star Star
	MAGNETIC CIRCUIT									
1.	Core									
	(a)	Maximum flux density (Tesla)								
		Construction of core								
	(b)	Taped/banded/bolted limbs								
	(c)	Taped/banded/bolted yokes								
	(d)	Taping/banding material (as applicable)								
2.	Insulation of:									
	(a)	Core bolts								
	(b)	Core bolt washers								
	(c)	Side plates								
	(d)	Core laminations								
	WINDINGS									
3.	Types and arrangements of:									
	(a)	HV windings								
	(b)	LV windings								
	(c)	Tapping windings (as applicable)								
	(d)	Winding arrangement ie Core/...../...../...../.....								
4.	Conductor Insulation:									
	(a)	HV windings								
	(b)	LV windings								
	(c)	Tapping windings (as applicable)								
5.	Oil circulation (eg neutral/partially directed/directed):									
	(a)	To windings -								
		(i)	HV windings							
		(ii)	LV windings							
		(iii)	Tapping windings (as applicable)							
	(b)	Through windings -								
		(i)	HV windings							
		(ii)	LV windings							
		(iii)	Tapping windings (as applicable)							
6.	Short circuit capability:									
	(a)	Potential axial thrust for worst fault condition of each winding-								
		(i)	HV windings, tonnes							
		(ii)	LV windings, tonnes							
		(iii)	Tapping windings (as applicable) tonnes							

Item	Description				7.5/15 Star Star	7.5/15 Delta Star	12/24 Star Star	12/24 Delta Star	12/24 Delta Star Dual Ratio	20/40 Delta Star	20/40 Star Star
6.	Short circuit capability (Cont'd):										
	(b)	Coil clamping short circuit withstand capacity -									
		(i)	HV windings	tonnes							
		(ii)	LV windings	tonnes							
		(iii)	Tapping windings (as applicable)	tonnes							
7.	Current density in windings (at normal tapping position):										
	(a)	HV windings (ER)		A/mm²							
	(b)	LV windings (ER)		A/mm²							
	(c)	Tapping windings (as applicable) (ER)		A/mm²							
	PERFORMANCE CHARACTERISTICS										
8.	Rated power OFAF at 20ºC ambient and hot spot temperature of 98ºC			MVA							
9.	Hotspot temperature ONAN at 20ºC ambient			ºC							
10.	No load loss at normal tap (excluding cooling plant loss)			kW							
11.	Cooling plant loss			kW							
12.	Load losses:										
	(a)	ONAN rating, 75ºC, normal tapping		kW							
	(b)	CER at 115ºC, extreme negative tapping		kW							
13.	Transformer Sound Power Level dBA Cooler Sound Power Level dBA										
14.	TANK AND COOLER THICKNESS										
	(a)	Tank Sides		mm							
	(b)	Tank Base		mm							
	(c)	Tank Cover		mm							
	(d)	Radiator plates									
15.	Total oil required (including cooling system)			litres							

APPENDIX 3 (Cont'd)

Item	Description		7.5/15 Star Star	7.5/15 Delta Star	12/24 Star Star	12/24 Delta Star	12/24 Delta Star Dual Ratio	20/40 Delta Star	20/40 Star Star
16.	Volume of oil to be removed:								
	(a) To gain access to core earthing link	litres							
	(b) To effect in-situ change of hv bushing	litres							
	(c) To change CT's	litres							
17.	Total volume of conservator(s)	litres							
18.	Volume of oil in conservator between highest and lowest visible levels	litres							
19.	Continuous rating of oil pump motor	shaft kW							
20.	Starting current of oil pump motor	amp							
21.	Total number of fans								
22.	Nominal diameter of fans	mm							
23.	Speed of fans	rev/min							
24.	Continuous rating of each fan motor	shaft kW							
25.	Starting current of each fan motor	amp							
	GENERAL								
26.	Filling medium for transport								
27.	Total weight as installed in service, including cooler plant, all fittings and oil	tonnes							
28.	Weight of cooler, complete with oil, conservator etc.	tonnes							
	TAPCHANGER								
29.	Maintenance requirements - (eg years/operations) describe:								
30.	Vol of oil to be removed for tapchanger maintenance	litres							
31.	Cost of parts required for tapchanger maintenance - Itemised list.	£							
32.	PAINT SYSTEM								
	Provide detail of paint system including details of 'on-site' repair system								

APPENDIX 4

Clause 2.0 calls for the transformer and its ancillaries to be designed such that it can continue in operation in times of flood when water levels reach 1m above plinth level. Any exceptions to this shall be listed below:-

Item on Transformer not suitable for submersion and below the 1m level	**Reason for non-compliance**	**Height of flood to which Item will survive**	**Likely damage and repair necessary after the flood has subsided**

APPENDIX A

SUPERSEDED DOCUMENTATION

This document supersedes EE SPEC: 8/7 dated May 2015 which should now be withdrawn.

APPENDIX B

ASSOCIATED DOCUMENTATION

ENA Technical Specification 35-2 Issue 6 - 2014
Eco design regulation 2009/125/EC
IEC 60296

A hyperlink to that document is provided below for use by WPD staff.
ENA Technical Specification 35-2, Issue 6, 2014 - Emergency Rated System Transformers 66/20.5kV, 66/11.5kV and 33/11.5kV Delta/Star and Star/Star Connected.

It should be noted that this document is copyright and shall not be passed outside WPD.
Copies can be purchased from Energy Networks Association.
Manufacturers tendering WPD would be expected to already hold a copy.

APPENDIX C

IMPACT ON COMPANY POLICY

Introduction of inhibited insulating transformer oil.

APPENDIX D

IMPLEMENTATION OF POLICY

This document shall be implemented on issue.

APPENDIX E

KEY WORDS

Transformer, CER, CMR, Tapchanger.