WESTERN POWER DISTRIBUTION

Serving the Midlands, South West and Wales
Gwasanaethu Canolbarth a De Orllewin Lloegr a Chymru

Company Directive

ENGINEERING SPECIFICATION
EE SPEC: 1/6

Relating to Continuous Maximum Rated (CMR) System Transformers for use on systems up to 132kV

Policy Summary

This specification covers Western Power Distribution's requirements for 33kV, 66kV and 132kV continuous maximum rated system transformers, and associated earthing / auxiliary transformers. It is based on ENA Technical Specification 35-3 Issue 2 - 2014 and must be read in conjunction with that document.

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Implementation Date: January 2017

Approved by

Policy Manager

Date: 19 January 2017

IMPLEMENTATION PLAN

Introduction
This document defines the 132kV CMR 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**
February 2017	Page 93 - Standard CT arrangement drawings have been added	Andrew Reynolds
January 2017	• Inclusion of inhibited insulating oil • Spelling changes and grammar • Inclusion of latest ENATS • Inclusion of ECO directive	Andrew Reynolds

CONTENTS

1.0 SCOPE AND SERVICE CONDITIONS

This specification covers Western Power Distribution's requirements for 33kV, 66kV and 132kV continuous maximum rated system transformers, and associated earthing / auxiliary transformers for use on 50Hz systems having 33kV or 11kV neutral earthed directly or through resistance, reactance or arc suppression coil at one or more points.

All equipment supplied under this specification will meet the relevant technical requirements of S:\Acrobat\MA\EE\EE001\ENA_TS_35-3_Issue_2_(2014).pdf - Continuous Maximum Rated (CMR) System Transformers for use on systems up to 132kV.

Additional clauses contained within this specification are in addition to the requirements of the standards outlined in ENA Technical Specification 35-3. Where there is any conflict between ENA Technical Specification 35-3 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 not suitable for submersion shall be located above this level, with the exception of cooling fans which although will preferably be fitted above this level, consideration will be given to an arrangement where the fans are below this 1m level. In this case it is accepted that the fan motors will be ruined by the flood. Any items 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 35-3.

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.

2.0 NORMATIVE REFERENCES

Clause 2 of ENA Technical Specification 35-3 applies.

3.0 DEFINITIONS

Clause 3 of ENA Technical Specification 35-3 applies.

5.0 RATING

Clause 5 of ENA Technical Specification 35-3 applies with the addition of -

- Nominal transformer lower voltages shall be either of the following 11kV, 11.5kV, 33kV or 66kV as set out in the Schedule.
- 33kV dual ratio transformers for which the voltage ratio at no-load, on the principal tap, shall be 33000/11500/6900 V.
- All earthing connections shall be capable of withstanding prospective fault currents for a minimum of three seconds.

5.3 The following preferred values of rated power shall be added to Table 1 -

Nominal transformer higher voltage	132kV
Nominal transformer lower voltage	66kV
Transformer continuous maximum rating (CMR) (MVA)	30, 45, 60 or 90

6.0 REQUIREMENTS FOR TRANSFORMERS HAVING A TAPPED WINDING

Clause 6 of ENA Technical Specification 35-3 applies with the addition of -

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

6.4 If no figures are quoted in Item 2 of Appendix 1 - Schedule of Requirements, the tapping range shall be +10% to -20% in 1.67% steps

6.5 If no figures are quoted in Item 3 of Appendix 1 – Schedule of Requirements or impedance graph supplied, the impedance shall be:-

For 132/33kV:- 25% at nominal tap, 22.5% at minimum tap (Tap 19, 105.6/33kV) and 26% at maximum tap (Tap 1,145.2/33kV) all on a 100MVA base.

For 132/66kV:- No 'standard' impedance is used. Please contact WPD for the required impedances.

For 132/11kV:- 85% at nominal tap, 80% at minimum tap (Tap 19, 105.6/11kV) and 89% at maximum tap (Tap 1, 145.2/11kV) all on a 100MVA base.

The impedance at all tap positions shall be within the tolerances quoted in Table 1 of BS EN 60076-1.

6.6 The transformer and all connections shall be capable of operating at any tapping position on a load cycle **preceded by 65% of CMR** for 24 hours then **130% of CMR for 8 hours** followed by **16 hours at 78% of CMR** with an ambient temperature of **20°C** without exceeding a hot spot temperature of **140°C**. It is recognised that under these operating conditions, loss of insulation life will occur.
(Only applies to transformers purchased from February 2017)
The maximum winding hotspot temperature shall be 140°C.

7.0 CONNECTION AND PHASE DISPLACEMENT SYMBOLS

Clause 7 of ENA Technical Specification 35-3 applies with the addition of -

Vector change links shall be provided. These shall be easily accessible via an access port in the tank lid.

8.0 RATING PLATES

Clause 8 of ENA Technical Specification 35-3 applies with the addition of -

All rating plates and valve function diagram plates shall be durable such that they remain legible for a period of 50 years when exposed in an outdoor coastal polluted environment without maintenance other than cleaning with water.

A valve function diagram plate shall be provided - Figure 4 illustrates the required content.

The plates detailed above, shall be fitted to transformers and reactors at an approximate height of 1.7m above plinth level.

8.1 Information to be given in all cases

(k) Connection symbol(s) shown in a manner that states which one has been connected.

(o) The mass of insulating oil shall be shown for each portion of the transformer - main tank, tap-changer, pipework and coolers.

8.2 Additional information to be given when applicable

Vacuum capability will be applicable to all system transformers. These plates shall carry information on the vacuum capability of the unit and containing any necessary information relating to precautions on valve positions, barrier boards, coolers etc.

9.0 MISCELLANEOUS REQUIREMENTS

Clause 9 of ENA Technical Specification 35-3 applies with the addition of -

9.2 Oil preservation system

The oil preservation system shall be free breathing with a maintenance free dehydrating breather. It shall be positioned so that it is accessible for repair/maintenance with the transformer live (3m clearance from live bushings). Details of the system used shall be provided at time of tender for approval.

10.0 TOLERANCES

Clause 10 of ENA Technical Specification 35-3 applies.

11.0 TESTS

Clause 11 of ENA Technical Specification 35-3 applies with the addition of -

11.1 Table 2 - the rated lightning impulse voltage (LI) kV (peak) for 132kV nominal system voltage shall be 650. In-tank surge arrestors are not permitted.

11.2 Determination of Sound Levels

Maximum sound power levels in Table 4 are replaced with the following -

Primary voltage	ONAN Sound Power Level dB(A)	ONAF/OFAF Sound Power Level dB(A)
33kV	65	80
66kV	74	80
132kV	75	80

11.3 Frequency Response Analysis

Frequency Response Analysis is required before leaving the manufacturer's works and again on site. The cost of these tests shall be identified separately at the time of tender.

11.18 Site Tests

All the site tests listed in 11.18 are required, along with those additional site tests listed below. All site tests shall be witnessed by WPD Project Engineer.

(iv) Ratio test at all tap positions (including HV winding magnetisation current measurement in all phases at all taps and proof that no open circuit occurs during each tap-change operation.

(xi) For all C.T.'s:-
- (a) DC resistance measurement (all ratios)
- (b) Polarity check (flick test)
- (c) Magnetisation curves (all ratios)

(xiv) Appropriate tests to prove correct operation of any ancillary equipment.

12.0 ELECTROMAGNETIC COMPATIBILITY (EMC)

Clause 11 of ENA Technical Specification 35-3 applies.

14.0 TRANSFORMER DETAILS

Clause 14 of ENA Technical Specification 35-3 applies with the addition of -

14.2 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.

14.3 Cooling shall be ONAF or OFAF. Unless otherwise specified in writing, a separate cooler bank design is required, which shall be arranged to permit the later construction of a noise suppression building around the transformer without dismantlement of the transformer. Specific requirements are set out in section 15 following.

14.5 Auxiliary DC nominal voltages are either 24, 50V or 110V as stated in the Schedule 1. Whilst minimum voltages shall be taken as 80% of nominal, it should be noted that under boost charge conditions the 110V DC voltage may rise to 138 V. Connected equipment must function correctly and without damage throughout these voltage ranges.

15.0 CONSTRUCTION DETAILS

Clause 15 of ENA Technical Specification 35-3 applies with the addition of -

15.1 Tanks and covers

Fabricated under-bases shall be ventilated to prevent corrosion. Fabricated underbases shall incorporate skids and be designed to prevent retention of water. Detachable underbases shall not be used.

Oil tight welded seams shall not be covered longitudinally by tank stiffeners. Box section stiffeners shall incorporate drainage holes at their lowest point(s).

Transformers with separate coolers shall be arranged to permit connection of the coolers to either end of the tank without modifications to the transformer.

Tanks of transformers/reactors shall permit the complete tanked unit to be moved under the following conditions without damage.

(i) When completely filled with oil: - lifted by jacks, and to be moved, in any direction, using rollers, plates or rails,

(ii) When filled with agreed transport medium:

(a) To be lifted by crane,

(b) To be moved by road, water and, when specified, by rail transport.

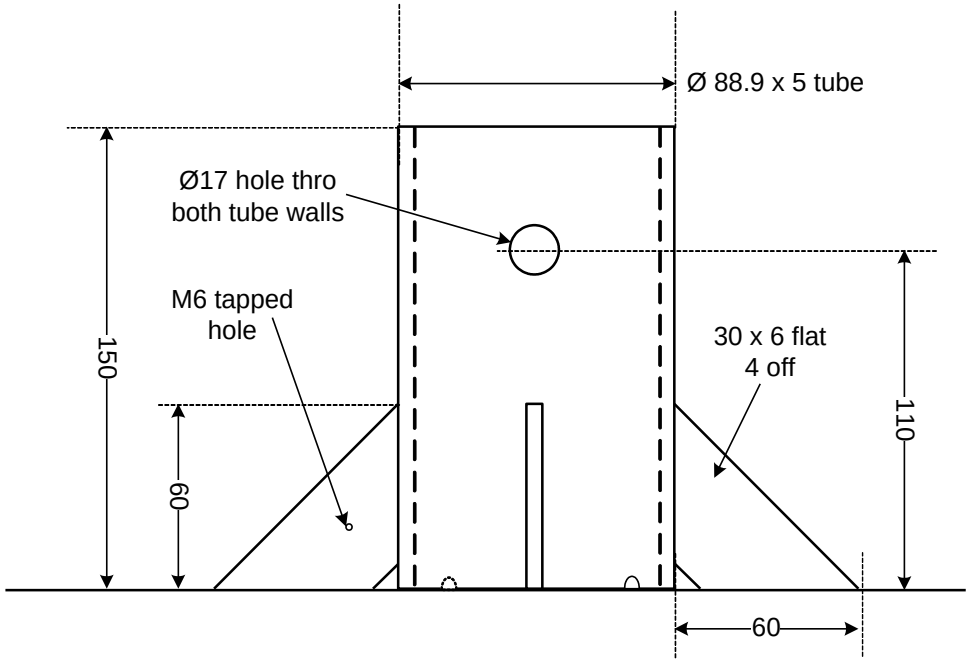
It shall be possible to move the equipment in its tank and filled with oil, in any direction, using rollers, plates or rails, without damage. A design which necessitates slide rails being placed in discrete positions is not acceptable.

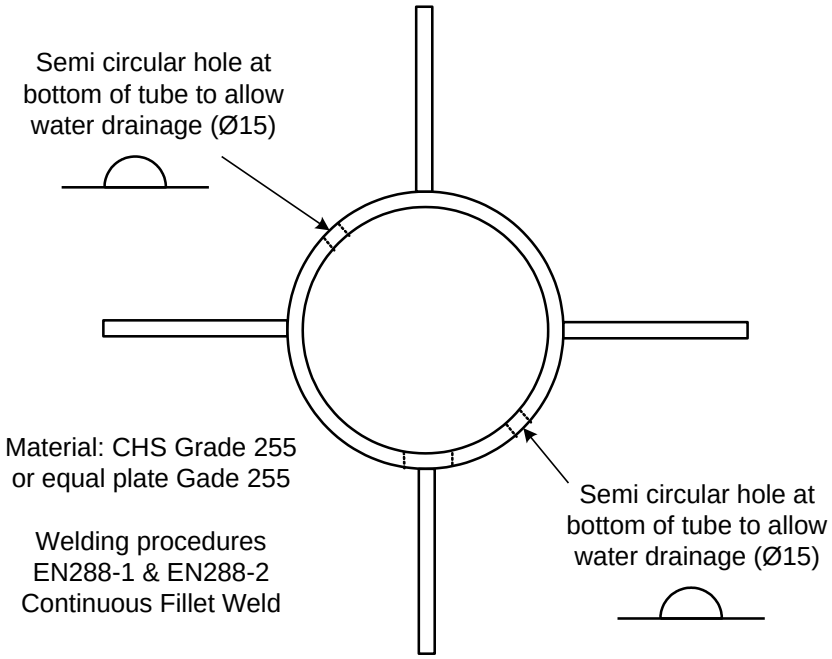
The transformer free standing height when arranged for transportation shall not exceed 4000mm, unless a larger height has been specifically agreed in writing prior to contract placement, up to a maximum of 4880 mm.

15.1.1 Fall arrest

(i) A socket for insertion of a work positioning/restraining post (Ridge Gear 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.

(ii) In addition to the socket above lifting eyes shall be provided, suitably spaced in the centre and along the length of the transformer lid, to be used as clip on points for work positioning restraining.





15.1.2 Shielding of moving parts and 230V connections

Moving parts which pose a risk of injury, such as motors, shafts, fans, tap-changer mechanisms etc, shall be effectively shielded. Removal of shields shall require the deliberate use of tools. Small wiring terminals carrying 230V to earth or higher shall be effectively shrouded.

15.1.3 Inspection openings and label plates

Suitable fixings shall be provided on the tank and its cover for accommodating the rating and information plates specified.

Covers shall be labeled to indicate their function.

Terminals shall be marked with labels approximately 100mm diameter carrying terminal marking eg A_1 a_2 etc.

15.1.4 CT terminal boxes

HV CT terminal box shall be weather-proof and waterproof to prevent water ingress in an outdoor environment. Access to the CT terminals shall be by a removable front cover, with the cable and gland remaining in position when the cover is removed.

15.1.5 Sound attenuation

Every care shall be taken to ensure that the design and manufacture of all transformers and auxiliary plant is to be such as to reduce noise and vibration. This is a matter of primary importance and special attention shall be given by the Contractor to ensure compliance with this requirement

Anti-vibration mountings for separately mounted coolers, pumps, etc, are not required. These shall be bolted to the plinth by the Contractor.

Transformers shall be arranged to permit installation of a sound attenuation enclosure.

In addition to the clearance requirements stated in 13.1 (i), the following apply -

Between nut and bolt fixings of pipe-work, and turrets of transformers/reactors, to:-

(a)	Enclosure walls	150mm
(b)	Enclosure roof	150mm

Special provision in the enclosure roof for easy access to in-tank tap-changers, (and for their maintenance equipment, such as lifting beams), tank inspection covers, and terminal boxes shall be agreed at time of tender. If access to the tank cover is required, this shall be shown on the Contractor's drawings and will be obtained by removing roof cover units as necessary; the roof support construction will be arranged to facilitate such access.

Sound attenuation enclosures will generally be arranged as shown in Fig 5, and the following shall be noted:-

(i) Enclosures will normally be a combination of brick, concrete and steel or laminated sheet, so designed that sections of the structure can be removed without involving complete dismantling. The bonding material of both roof and walls will permit easy removal of appropriate sections, when required.

(ii) The overall thickness of civil works for the sides ends and roof, including any support structures, will not exceed:-

Sides/ends	Roof
460mm	300mm

(iii) Annular spaces around pipe-work, bushing turrets, coordinating gap structures, etc, passing through the walls or roof, will be filled with bitumastic weatherproof felt or equivalent resilient material.

(iv) Ventilation of enclosures will be provided to reduce possible build-up of vapors. The total area of such apertures (inlet and outlet) will not exceed 0.1% of the total area of the walls.

(v) Two doors will be provided in the enclosure, arranged sensibly diagonally opposite, both being fitted with "panic" bolts. One door shall be positioned adjacent to any tap change operating mechanism.

(vi) Normal fire prevention civil works will be incorporated in the enclosure construction, including any necessary effluent pipes to oil soak-away pits due regard being paid to the requirement to maintain the effectiveness of oil containment measures.

(vii) The enclosure roof construction will be designed to support its own weight and allowances made for:-

(a) Wind loading

(b) A point load of 890 Newtons at any position

(c) A uniformly distributed load of 720 N/m^2

(viii) Access requirements to tank inspection covers and terminal boxes shall be separately specified.

15.1.6 Earthing

All tank attached cubicles, cooling fan motors, oil circulating pumps, driving mechanisms, etc, shall be bonded to their supporting structures. All tanks, separately mounted cooler structures and marshalling kiosks will be connected to the main earth bar by means of subsidiary connections, carried out under another Contract.

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.

Cover mounted structures such as the tanks of externally mounted protection current transformers and shields to give protection from arc damage, shall be bonded to one of the tank earthing points by a separate connection having a cross-sectional area of not less than 300 mm² copper.

These earth connections shall be securely bolted to the transformer tank at a minimum of 300mm spacing with shear head stainless steel bolts.

Earthing tags shall be provided on the main tank, as close as possible to, and below, each surge diverter mounting point. The facility shall be provided to support 50mm x 6mm copper earth tape horizontally between the 3 earth tags mentioned above and vertically from each tag to ground level. For security reasons (copper theft) it shall be possible to securely bolt the earth tape to the transformer using stainless 12mm shear head bolts at a maximum spacing of 300mm.

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.

15.2 Surface finish

Unless otherwise agreed the following equipment shall be hot dipped galvanised:

(a) Radiators

(b) Fan supports spiders and guards

(c) Arcing horns

(d) Marshalling kiosk base support frames

(e) External guards eg neutral CTs, expansion joints

Unless otherwise agreed the exterior of following equipment shall be zinc sprayed:

(a) Marshalling kiosks and cubicles

(b) Refrigerated breather control boxes

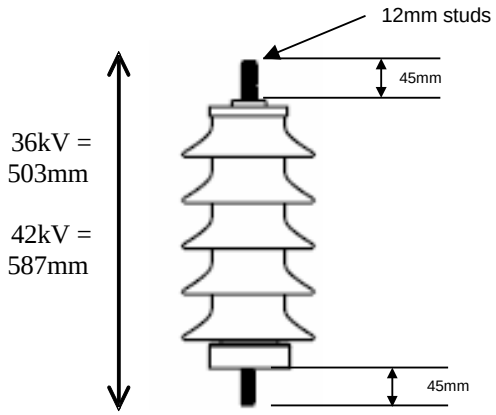
15.3 Terminals

Fixings shall be provided on the tank adjacent to the neutral terminal(s), to accommodate support for externally mounted protective current transformers connected either in the neutral or in the neutral phase ends.

Bushing terminations shall be provided with surge arrester brackets, located such that the arrester would be outside a sound attenuation enclosure. The earthing arrangement shall be brought to ground level from the mounting brackets and fixed to the transformer along the route, leaving earthing points at the base of the transformer. These earth connections shall be securely bolted to the transformer tank at a minimum of 300mm spacing with shear head stainless steel bolts approval of arrangement will need to be sought from WPD prior to build.

The following surge diverters are in current use -

33kV (42kV used on arc suppression earthed systems in Cornwall) utilise a Coopers arrester as shown below:



At 132kV, ABB is PEXLIM Q132-XV145E arresters without insulating base are currently used.

15.3.1 and 15.3.2 Cable terminations

This section details the requirements for: -

- Unfilled Cable Enclosures / Cable Boxes

- Inner Cone Separable Connector Chambers

Environmental protection shall: -

Comply with the requirements of EN 60529 IP33 classifications. Holes in equipment, e.g. cable boxes, gland plates, glands etc., and shall be sealed during transport and storage, to avoid ingress of water and dirt.

When carrying continuous rated current or any other specified loading, the temperature of the filling medium (oil or air) shall not exceed 70ºC, with the cable conductors at a temperature of 90ºC and the external ambient at 40ºC; the effects of solar gain shall be taken into consideration.

Boxes/chambers shall: -

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

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

(a) Not disintegrate

(b) Control emission of arc products safely (particularly with regards to personnel) and without penetration into the main tank.

Fixing studs/bolts for cover plates and flanges shall: -

(i) Be not less than M10,

(ii) Be spaced not more than 75mm between centres,
(iii) Not penetrate the casing. Where blind tapped holes are employed, studs shall be used; set screws and bolts are not permitted.

Flanges shall have: -

(i) A thickness of at least 4 mm,

(ii) Not less than 12 mm between the inner edge of the flange and the hole for the securing studs.

Cover plates shall: -

(i) Be separate and removable,

(ii) Have a thickness of not less than 5 mm,

(iii) Not exceed 25 kg in weight.

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

(i) An uncompressed thickness of not less than 5 mm,

(ii) An effective width on the inside of the fixing studs/bolts of not less than 12 mm,

Terminals shall be marked in a clear and permanent manner.

Provision shall be made for earthing the body of each cable box. Such earthing connections shall have a cross sectional area of not less than 125mm^2.

When an earthing transformer is to be connected to a primary transformer, and where the LV side of the said primary transformer is cable connected, then a separate cable box shall be included to facilitate the connection of the earthing transformer, the cable shall be 185mm², solid Al. conductor, EPR insulation triplex cable. The earthing transformer cable box shall be of an unfilled type and comply with the relevant applicable clauses below.

The bushings for the earthing transformer cable box shall be 1250A separable bolted connectors to interface C bushings in accordance with EN 50181 for 36kV. Bushing to Fig SD 567/E.

A supporting bracket shall be provided on the side of the transformer to support the 11kV triplex cable and pre-drilled to mount an Ellis Patent twin bolt fixing Atlas cable cleat. The Ellis Patent Atlas cable cleat shall be commensurate for the 185mm^2 solid aluminium conductor EPR cable required for the earthing transformer connection. 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 cleat is fitted, the cable shall pass through the centre of the cleat and enter straight into the base of the separable connector housing. The Ellis Patent, Atlas cable cleats will not be supplied with the transformer; they will be supplied under a separate contract.

UNFILLED CABLE ENCLOSURES / CABLE BOXES

General

Tables 13, 14, and 15 specify the details for unfilled enclosures cable boxes; the particular requirements, in accordance with the Schedule 1 will be specified by the main Contractor.

Table 13 - Details for unfilled 1.1kV cables boxes

Transformer Rating kVA	200-500	800-1000	1600-2000	2,500
Number of Cable Boxes	1	1	2	3
Maximum Cable size, phase and neutral:-				
Sectoral mm²	1200	1200	1200	1200
Stranded Cu or Al mm²	630	630	630	630
Bushing Rating	800	1600	1600	(2x1600) (1x800)
Poles per box	4	4	4	4
Glands per box	4	7	7	(2x7) (1x4)
Drawing Numbers:-				
Unfilled Enclosures	Fig 8	Fig 8	Fig 8	Fig 8
(BS 2562 Shell Number)	36	37	37	(2x37) (1x36)

Note: - The cast epoxy mono-bloc is not permitted as transformers to this Specification have higher prospective fault levels than distribution transformers.

Table 14 - Details for unfilled 3.6kV enclosures

Transformer Rating	MVA	Up to 1.5	2 - 2.5	5 - 8	10-16
Maximum Cable Size, per Phase					
Sectoral Aluminium	mm²	185*	-	-	-
Stranded Cu or Al	mm²	185	400	400	400
Bushing Rating	Amps	400	800	1600	1600
Poles per Box		3	1	1	1
Glands per Box		1	1	2	4
Drawing Number		Fig 8	Fig 9	Fig 9	Fig 9
BS 2562 Shell Number		91	-	-	-

* Three-core cable to BS 6346

Table 15 - Details for 12kV Unfilled Enclosures

Transformer Rating	MVA	Up to 16	Above 16 up to 30	Above 30 up to 46	Above 46 up to 61
Number of Cable Boxes	Phases	3	6*	3	3
	Neutral	1	1	1	1
Maximum Cable Size, stranded copper or aluminium:- either Phases or Neutral	mm²	630	630	630	630
Bushing Rating		1250	1250	1250	1250
Poles per Box	Phases	1	1	3	4
	Neutral	1	1	1	1
Cables per Box	Phases	1	1	3	4
	Neutral	1	1	1	1
Glands per Box	Phases	1	1	3	4
	Neutral	1	1	1	1
Drawing Number (Phase and Neutral)		Fig 10	Fig 10	Fig 10	Fig 10

* Fit two single-phase enclosures per phase to accommodate two cables per phase

The arrangement drawing shown in figure 10 is a typical general arrangement, the dimensions for the cable box shall be commensurate to fit the Cenelec interface C outer cone bushing shown in drawing SD 567/E and the pictures shown below.

Equipment shall be capable of withstanding the prospective fault currents specified by the main Contractor selected from one of the ratings of Table 16.

Table 16 - Table of phase to phase to earth short-circuit current withstand capabilities for cable boxes.

Voltage kV	kA (rms) for 2 seconds
36	17.5
11	15, 30 or 40
3.3	26 or 44
0.415	43 or appropriate Fused

Note: - For service, the first peak shall be assumed to attain a magnitude equal to 2.55 times the rms value, and this magnitude shall be used for Type Testing purposes.

Any additional insulation for conductor fittings required for cable boxes up to 36kV, will be provided by the purchaser.

Where phase isolation is specified, single-phase boxes shall be used.

Unless otherwise specified, cable entries shall be vertical from below.

Cast resin bushing assemblies shall comply with the following requirements:-

(i) <12 kV working voltage - BS 2562.
(ii) >12 kV and <36 kV working voltage - be to the approval of the Purchaser.

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

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

(i) It is expected that the conductor contact or connector used in the separable connector shall be of the mechanical type which shall use shear-bolts to make contact with the stranded copper conductor of the cable; these will be provided by the purchaser.

(ii) Compression sockets to suit the rating of the equipment; these will be provided by the purchaser.

Glands for single-core cables shall be on the same axis as the cable connector.

Each cable shall be provided with an individual removable split gland plate. Gland plates for single-core cables shall be manufactured from non-magnetic material.

Unfilled Enclosures

Enclosures shall comply with the requirements of BS 6435 except where modified by this Section.

Enclosures incorporating separable bolted connectors shall be equipped with interface C bushings in accordance with EN 50181 for 36kV. Bushing to Fig SD 567/E. (see page 20)

Compression type cable glands will be supplied by the Purchaser.

Enclosures shall incorporate:-

(i) Two 100 x 100mm holes double louvered, with gauze sandwiched between the two louvers, 25mm up from the gland base plate, one on each side of the cable box for breathing.

(ii) Two 12mm holes in the base for drainage.

The protection shall also prevent the insertion of any object liable to cause a dangerous occurrence.

Enclosures shall be provided with 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 65 mm 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.

Unfilled Enclosures <1.1 kV

Either cable boxes or enclosures, as specified in the Schedule shall be provided. Cable boxes/enclosures on transformers of less than 2.5 MVA are not covered by this Specification. The requirements for such boxes will be detailed by the Purchaser.

Cable Boxes shall be as specified in Table 13.

Enclosures for use with cables having extruded insulation, on transformers of greater than 2.5 MVA, shall be as specified in Table 13.

Unfilled Enclosures >1.1 kV and up to 3.6 kV

Either cable boxes or enclosures, as specified in the Schedule, shall be provided.

Cable boxes shall be as specified in Table 15.

Unfilled Enclosures >3.6 kV and up to 12 kV

Either cable boxes or enclosures, as specified in the Schedule

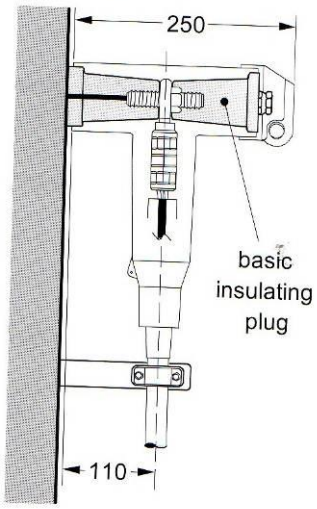
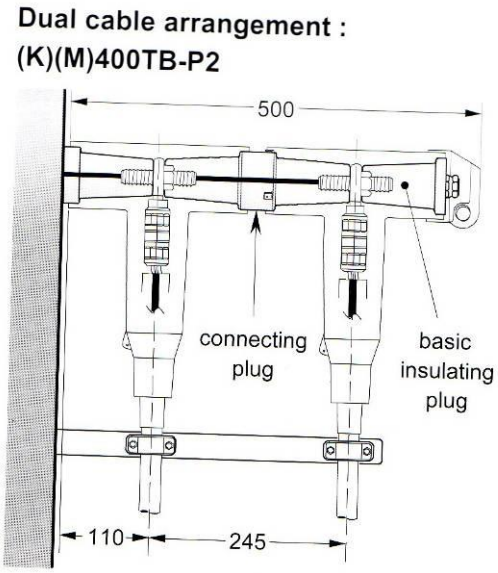
Cable boxes shall be as specified in Table 15.

Enclosures shall be dimensioned to be suitable for -

(i) These Outer Cone bolted separable connectors bushings, shall be designed to EN 50181 for 36kV and shall be of the interface C type and shall be capable of having a 1250A rating, e.g. Euromold type M400AR - 4, see fig SD 567/E, or as otherwise agreed at time of Tender.

(ii) Depending on the rating of the transformer the cable box and bushings shall be suitable for one cable per phase, two cables per phase or three cables per phase. If three cables per phase are required then there shall be an individual outer cone bushing for each cable, see pictures below. The outer cone bushings shall be spaced to ensure that bushing extenders are not required.

A supporting bracket/s 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. This bracket/s shall be capable of cleating one, two or three cable/s per phase. 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/s shall be mounted no more than 1 metre below the gland plate. The bracket/s shall be positioned in such a way that when the Atlas cable cleats are fitted, the cable/s shall pass through the centre of the cleat/s and enter straight into the base of the separable connector housing/s. The Ellis Patent, Atlas cable cleats will not be supplied with the transformer.

		
11 or 33kV Outer cone single cable arrangement		11 or 33kV Outer cone dual cable arrangement

Unfilled Enclosures for 36 kV

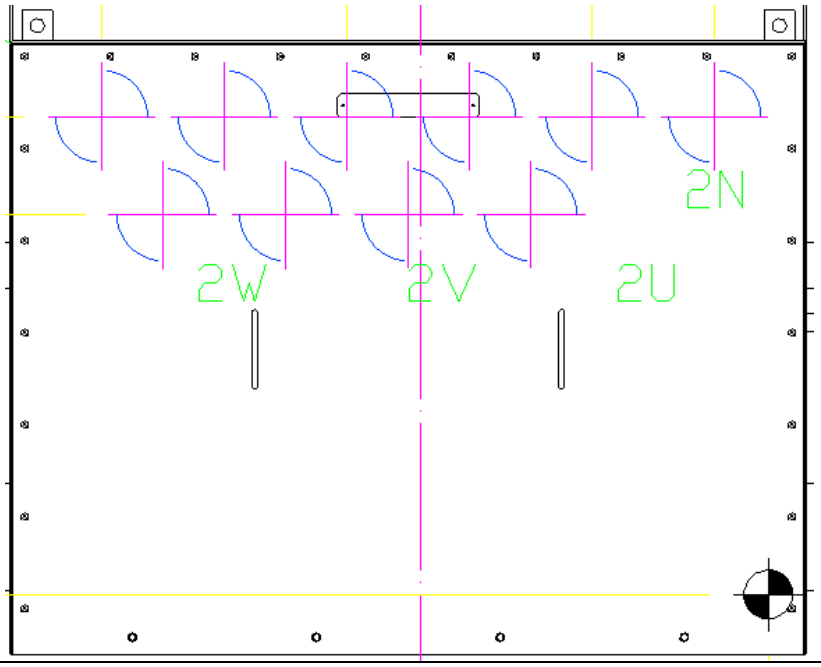
Either cable boxes or enclosures, as specified in item 19 in the Schedule 1, shall be provided. Where phase isolation is required, a separate cable box/enclosure for each phase, which may terminate more than one cable, shall be provided.

Enclosures shall be dimensioned to be suitable for -

(i) These Outer Cone bolted separable connectors, shall be designed to EN 50181 for 36kV and shall be of the interface C type and shall be capable of having a 1250A rating, Euromold type M400AR - 4, see fig SD 567/E, or as otherwise agreed at time of Tender.

(ii) Depending on the rating of the transformer the cable box and bushings shall be suitable for one cable per phase, two cables per phase or three cables per phase. If three cables per phase are required then there shall be an individual outer cone bushing for each cable, see pictures below

A supporting bracket/s 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. This bracket/s shall be capable of cleating one, two or three cable/s per phase. 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/s shall be mounted no more than 1 metre below the gland plate. The bracket/s shall be positioned in such a way that when the Atlas cable cleats are fitted, the cable/s shall pass through the centre of the cleat/s and enter straight into the base of the separable connector housing/s. The Ellis Patent, Atlas cable cleats will not be supplied with the transformer.



Typical 11 or 33kV Outer cone separable connectors 3 cable per phase cable box.

Three cables per phase showing the configuration of the equipment interface bushings (M)400AR-4, utilizing the single cable arrangement shown previously. Each (M)400AR-4 shall be fitted in such a way so as to not interfere with the adjacent separable connector or require the use of stand-off bushings. The layout of the bushings in the cable box shall be similar to that shown by the red crosses in the sketch above.

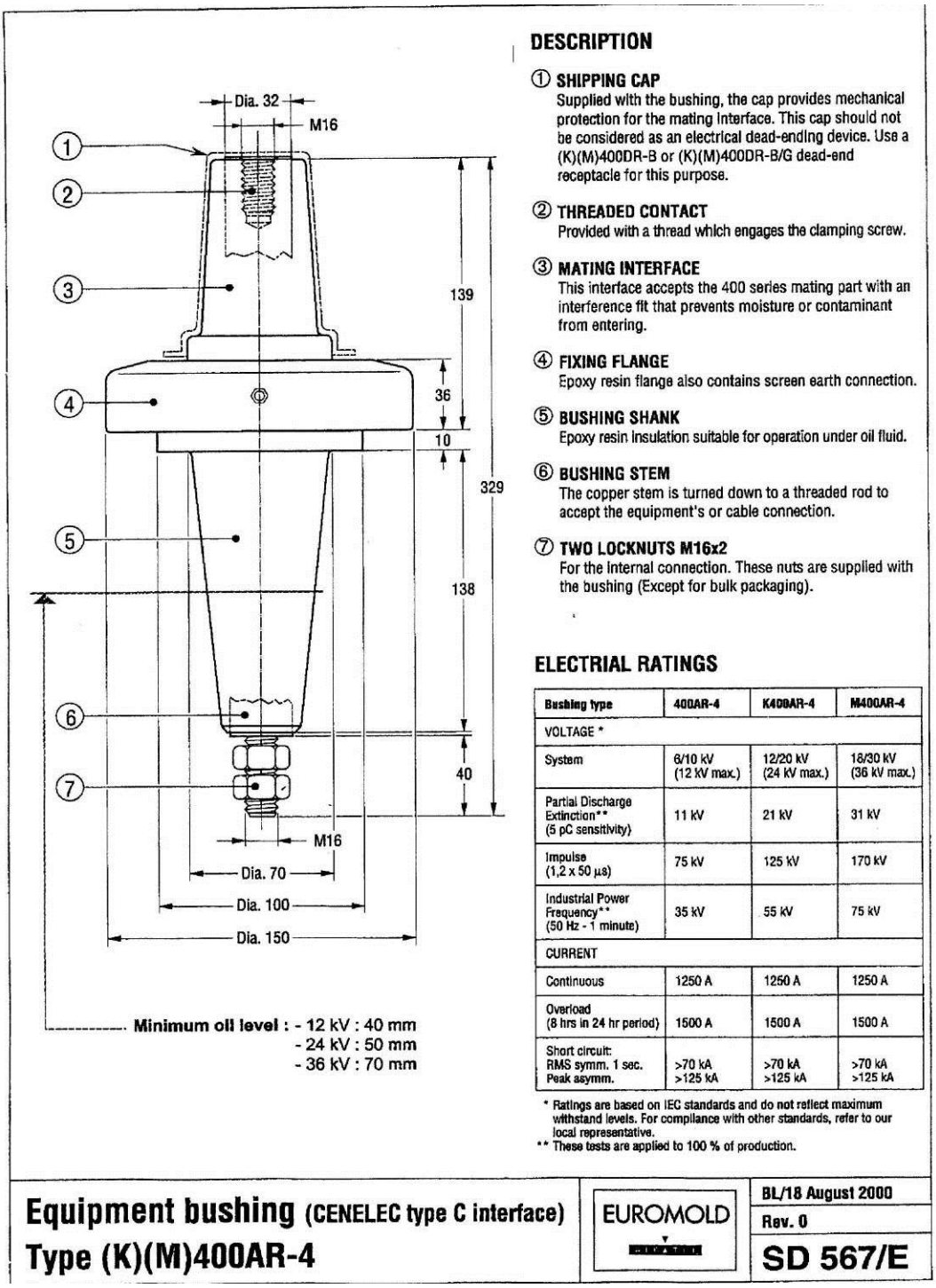


Figure SD 567/E

INNER CONE SEPARABLE CONNECTOR CHAMBERS

General

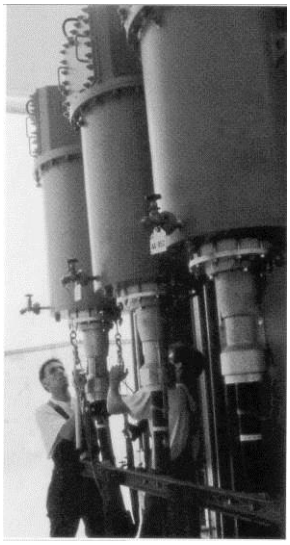
Cable connected transformers/reactors having voltage ratings of 66 kV and above, shall have their cables terminated using inner cone Pfisterer Size 5S separable connectors the separable connectors shall have individual phase chambers.

Where inner cone separable connectors are fitted to transformers/reactors 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 IEC 60296-2003. 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/reactor, 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 5S 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 and associated disconnecting chambers shall permit either the transformer/reactor 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/reactor 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/reactor, 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.

15.3.3 Outdoor bushings

Bushings shall be to pollution class IV of IEC 60815 with a minimum creepage of 31.5mm / kV.

As noted above, brackets for mounting surge arresters are required.

HV terminals shall be arranged so that the connections can be taken away horizontally.

Facilities to release air trapped during transformer/reactor assembly, with the minimum dismantling of component parts, shall be provided.

15.3.4 Unit auxiliary transformer

The Schedule in Appendix 1 will state if a separate, ground mounted auxiliary / earthing transformer is required. If so, requirements follow applicable clauses of this specification, with the addition of requirements as set out in Annex A attached.

15.4 On-Load Tap-changer

Tap-changers shall also comply with IEC 60214-1

Tap changing equipment shall be suitable for full bi-directional power flow.

Internal type (oil environment) tap-changers shall be of vacuum diverter switch design and arranged such that contacts are not immersed in the transformer main tank oil due to the inability to separately monitor dissolved gases in main tank and tap-changer oils.
Internal type tap changers may be "externally mounted" by the use of a separate enclosure and an oil-tight barrier board designed to separate the oil surrounding the tap selector contacts from the transformer tank oil.

The tap-changer make and type shall be approved by WPD prior to order of the transformer.

Mechanism enclosures shall be protected to EN 60529, Class IP54. On load tap change equipment driving mechanisms containing 400V connections shall be provided with an approved danger notice.

It shall not be possible for the oil in diverter-switch or selector-switch compartments to mix with oil in the transformer tank or any other compartments. Oil in the tap selector compartment shall be maintained under oil head by means of a pipe connection from the highest point of the compartment to the conservator pipework. A valve, complying with the requirements of 13.6.8 shall be fitted at the exit from the tap selector compartment and a gas and oil actuated relay, complying with the requirements of 13.6.3. Shall be provided as close as practicable to this valve. Where duplicate outlets from the tap selector compartment are provided, the valve and the gas and oil actuated relay shall be fitted as close as practicable to the common point, on the conservator side. Where the tap changing equipment comprises phase isolated tap selectors, these requirements shall apply for each phase.

The nominal resistance of diverter resistors shall be inscribed on the tap changer rating plate.

15.4.2 Segregation of Compartments

All types of tap-changer, including those with vacuum diverter switches, shall be provided with a separate tap-change conservator fitted with an oil level gauge.

A maintenance free de-hydrating breather shall be provided. To facilitate replacement or servicing, the breather shall be mounted at approximately 1400mm above ground level. De-hydrating breathers having a total weight greater than 10kg shall be supported separately from the breather pipe. When necessary the breather pipe shall be braced for stability. The unit shall be self-monitoring and a voltage free changeover contact for alarm condition provided (2A at 230V AC/DC)

A weatherproof and air-tight oil filling pipe, brought down to ground level and fitted with a non-return DN25 (minimum) valve at its termination shall be provided.

Drainage facilities, brought down to ground level, fitted with DN25 (minimum) valves adjacent to the conservator and at its termination shall be provided.

15.4.3 Method of operation

Electrical Control - on-load tap-change equipment

General Requirements

All on-load tap change equipment shall be provided with facilities for local and remote electrical control. These facilities shall permit extension for independent automatic or group parallel automatic operation from the control source. The form of electrical control required is a circulating current scheme typically as shown in Fig 6 Drawing EM1 which is based on use of the MR Vacutap tap---changer. The latest WPD drawings will be issued at the time of tender.

The electrical control circuits for each primary unit shall operate at 110 volts ac, single phase, derived from a control circuit transformer (CCT), which shall comply with the requirement of EN60742, having a ratio of 240/55-0-55 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 (or MCB) and a neutral link. The outgoing connections shall be supplied with a fuse (or MCB) in each pole. This transformer, with its fuses and links, shall be mounted in the marshalling kiosk or cubicle, as applicable. MCBs shall be lockable to provide isolation. Fuses shall be Red Spot.

All motor contactors and their associated control apparatus and indicating devices shall function correctly over the range of voltages, frequencies loads and durations specified.

It shall not be possible for more than one electrical control point to be in operation at any time except when voltage reduction facilities for load reduction at a REMOTE CONTROL panel are required for Independent automatic and Group Parallel automatic control.

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 ac tap-changer supply at each marshalling kiosk or cubicle by means of a three-position LOCAL/OFF/REMOTE local selector switch (LSS). This switch shall be capable of being padlocked in the OFF position. The two remaining positions of the local selector switch, complete with the necessary contacts, shall be available to permit extension, without alteration, for other forms of control.

When REMOTE CONTROL facilities are specified in the Schedule, either of the following alternatives shall be provided for each transformer or reactor, and specified at time of tender.

(i) a separate panel having a layout typically in accordance with WPD drawings

or

(ii) As loose items for mounting in general control panels by another Contractor.

or

(iii) The remote panel will be provided complete under a separate contract.

For any CT information please see appendix 6.The dimensions for the current transformer shall fit within the accommodation detailed in the Schedule. This current transformer shall be capable of carrying 150% transformer rated current continuously.

Local/Remote Control

Circuits and arrangements for local and remote control of on-load tap change equipment shall comply, as applicable, with the schematic diagrams, supplied with each tender.

Facilities shall be provided at the local position and remote position to enable the tap-changer position number to be raised or lowered. The controllers 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 or cubicle shall be operative only when its associated LOCAL/OFF/REMOTE local selector switch at the marshalling kiosk or cubicle is set to LOCAL. Under this condition, all other control points shall be inoperative.

The remote control panel shall be provided with a three position panel selector switch (PSS):

Position 1: HAND

Position 2: AUTO

Position 3: PARALLEL

The controller at the remote control panel shall be operative only when its associated LOCAL/OFF/REMOTE local selector switch at the marshalling kiosk or cubicle is set to REMOTE and the selector switch at the remote control panel is set to HAND. 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.

15.5 Clearances to exposed conductors

The minimum clearance between live metal to any oil pipework, coolers,
s and pressure relief devices shall be -

Highest voltage for equipment (kV)		
33	66	132
500mm	864mm	1300mm

If these clearances cannot be obtained they can be reduced to those given in Table 10 – External Air Clearances of ENATS 35-3 providing the oil pipework etc. is adequately shielded to give protection from arc damage. Such shielding shall comprise a 6mm thick mild steel plate located to avoid fault currents passing through fittings. The shield shall be bonded by a separate connection to an earthing terminal and no reliance placed on fortuitous earthing via gasketed joints.

15.6 Fittings

15.6.1 Conservator

The conservator shall have a capacity between highest and lowest indicated oil levels of not less than 7.5% of the total oil volume (including tap changer tap-selector and cooling equipment) at 15°C.

The conservator(s) shall be positioned not to obstruct the incoming and outgoing electrical connections the preferred location is on the cooler bank to prevent clearance issues and further difficulties when a noise enclosure is to be erected. The conservator should be positioned with pipework to allow topping up from the ground ideally while the transformer is still live.

The removable end cover shall be complete with integral lifting lugs.

The valve referred to in Clause 15.6.1 (v) of ENATS 35-3 shall be of the non-return type and the oil filling pipe shall enter the conservator above the oil level.

15.6.2 Cooling plant

Cooling banks alone shall be capable of dissipating the total losses at CMR and when operating at any loading within the normal loading cycle.

Provision shall be made to mount the separate cooler bank at either end of the tank without modifications to the transformer and the additional valves and blanking plates specified in 15.6.2 shall be provided.

Transformers rated at 30 MVA and above having natural and forced cooling shall, unless tank attached coolers are specified, have radiator banks on free standing frames with the cooling equipment and separate from the main tank.

Cooling plant shall be designed so that all painted surfaces can be thoroughly cleaned in situ and subsequently repainted by suitable brushes or sprays.

The design of cooling plant shall ensure that pockets of gas do not accumulate internally, or water collect externally.

Pipework shall be provided for connecting each transformer/reactor tank to its cooling plant. Cast iron shall not be used. Oil piping shall be provided with flanged joints.

It should be noted that as provision for fitment of a sound attenuation enclosure has been specified, duplicated expansion joints are required as specified in clause 13.1 (iii) of ENATS 35-3. Such devices shall be capable of withstanding the stresses likely to be encountered during installation, service and maintenance. Where such devices are of thin-wall construction (less than 1.7 mm) and within 2 metres of plinth level, they shall be provided with mechanical protection.

Fans shall be supported from the cooler bank structure and incorporate an approved form of anti-vibration mounting. It shall be possible to remove any fan, complete with its motor, without disturbing or dismantling any part of the cooling bank structure.

Fan cowlings and steel fan supporting "spiders" shall be galvanised. Galvanised wire-mesh guards shall be provided to prevent accidental contact with the blades of the fans. Protective guards shall also be provided over all moving shafts and couplings. These guards shall be designed and manufactured to ensure compliance with EN 60526 class IP3 or as otherwise agreed.

Oil circulating pumps shall be accessible and supported without the need for separate foundation fixings. Housings of pumps and their motors shall incorporate plugs for air release and oil drainage.

The electrical control of oil circulating pumps and cooling fans shall be in accordance with the relevant WPD drawings supplied at the time of tender.

All transformers and reactors having mixed cooling shall be provided with facilities for selection of AUTOMATIC or MANUAL control of the cooling plant. These control facilities shall be located at the marshaling kiosk (MK) or at a cubicle associated with the cooling plant.

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 marshaling kiosk or cubicle. 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 Motor contactors shall comply with the requirements of EN 60947.

Circuits and control arrangements for automatic electrical and manual (testing) electrical control of cooling equipment of mixed cooled transformers and reactors shall comply with WPD latest revision of drawings

Automatic starting and stopping of the cooler motors shall be controlled by winding temperature indicators.

Where the transformer cooling design requires a pump two will be supplied to mitigate against a single pump failure, it shall only be possible to start the pump motors in sequence. To achieve this, a sequence starting scheme shall be inter-connected between the motor contactors (PMC) of each pump.

A multi-position cooler control switch (CCS) shall be mounted in the marshaling kiosk or cubicle, shall provide for automatic control and operational checking of:

(i) Each fan or group of fans,

(ii) Each pump

(iii) Fans and pumps

The temperature indicators shall control the operation of the cooling plant motors automatically when the associated cooler control switch is set for AUTOMATIC.

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 or miniature circuit breakers (MCB) mounted in the marshaling kiosk or cubicle.

Facilities shall be provided in the marshaling kiosk or cubicle to enable the cooling plant motors to be isolated by means of an ON/OFF switch. This switch shall have auxiliary contacts arranged to close after, and open before, the main contacts, and suitably inter-connected with the contactor coil circuits to enable the normal switching duty to be performed by the fan and pump motor contactors.

15.6.3 Gas and Oil Actuated Relay

Each conservator oil feed pipe shall be fitted with an approved design of gas-and-oil actuated relay having alarm contacts which close on collection of gas and low oil level, and tripping contacts which close following oil surge and low oil level (double element type). The alarm and trip functions shall not be operated by hollow floats. All sampling and drain points need to be brought down to ground level to allow access from the ground.

Relays shall be provided with two visible scales, one each side, calibrated in increments of 100 cc up to 400 cc, or as otherwise agreed, to provide indication of gas collection.

15.6.4 Pressure Relief Device

Pressure relief devices shall be located so that their function is not inhibited by operation of isolating valve(s).

Pressure relief devices shall be provided with means to:-

(i) Prevent the ingress of rain or snow into any part.

(ii) Prevent continued oil flow from the transformer following operation to relieve internal pressure.

Spring operated, self-sealing devices shall:-

(iii) be capable of withstanding a full vacuum,

(v) have a hand hole giving access to the tripping and reset lever. The outer end of the pipework is to be protected from ingress of vermin etc. by a grid; paint spray or ice formation shall not seal the outlet. Any bends shall have a radius of the central axis of the bend not less than the equivalent pipe diameter.

15.6.5 Winding Temperature Indicators

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

The current transformers providing winding temperature indication, as detailed in Item 26 of Appendix 1, shall be located under the main tank cover, accessible via a cover plate. CT Test loops (10mm^2 max for RSF1 termination) to facilitate primary injection of the CTs.

A current transformer for voltage compounding, as detailed in Clause 15.4.3 of this specification, shall be provided.

The standard current transformers for protection and measurement shall be provided as per drawings listed in appendix 6 this shows the location of the CT compared to the windings and its use. Site specific CT details if required will be identified at time of tender

15.6.7 Other fittings

All oil containing parts liable to entrap air shall be fitted at their highest points with an air release plug to permit release of any air trapped following oil filling.

A valve shall be provided on the tank at each point provided for connection to separate radiators or coolers (ie both ends of the tank). Where cooler pipes enter the tank cover vertically, such valves may be at the cooler headers. For any design where the inlet or outlet arrangement at the tank consists of a single pipe, an additional valve shall be provided in each branch pipe to the coolers.

Tank attached radiators shall be provided with isolating valves.

A valve shall be provided in the main oil connections at the bottom of each cooler when oil circulating pumps are fitted, to allow removal of the pump without draining oil from the transformer or cooler.

A 50mm valve shall be provided in the oil feed pipe to each tap selector compartment positioned to permit maintenance of the tap selectors

A 15mm isolating valve shall be provided in any equalising pipe arranged between tap changer selector compartments and main tank to facilitate oil draining for maintenance of tap selectors.

For transformers and reactors having oil quantities exceeding 18,000 litres, a valve of minimum size 80 mm shall be provided together with such arrangements as may be necessary within the tank to ensure that the tank can be drained of oil as far as is practicable.

A 50mm valve shall be provided at the top of each oil-filled cable sealing or disconnecting chamber for 66kV and above.

Plugs shall be provided to permit as far as is practicable, drainage of detachable radiators, whether connected directly to the tank or to cooler headers.

Plugs shall be provided to permit effective drainage of oil from circulating pumps, and gas and oil actuated relays.

If specified in Schedule 1 all filter valves and combined drain and filter valves shall be fitted with flexible hose adapters, provided with suitable gaskets and caps of the size specified in accordance with Fig7 attached.

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 tank of power transformers and reactors. Plugs shall be provided at the top and bottom of each radiator for air release and oil draining purposes. Where a transformer is provided with cable connections, the arrangement of such radiators shall give unrestricted access for the cables when rising vertically from below.

15.7 Thompson Strap

Transformers with double delta 11kV secondary windings shall be fitted with a Thompson Strap connection used to link the "c" phase windings. The strap shall be accessible by the removal of a suitably labeled bolted cover in the lid of the transformer and storage facilities for the strap when not in use shall be provided in the same compartment. The transformer nameplate should indicate if the strap is connected or not connected at time of dispatch. The Thompson strap shall be rated to carry full LV current continuously.

15.8 Marshalling and / or Control Box

Common Requirements for electrical control and marshalling

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

All hand operated electrical control switches shall be clearly labeled and inscribed, as applicable, to indicate the function of the apparatus with which they are associated.

The OFF position for switches shall be lockable, with rotation to ON.

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).

Vibration in service however caused, shall not result in mal-operation of switches contained in protective devices eg gas and oil actuated relays, or of oil flow indicators, temperature indicating devices, relays, instruments etc.

Control, protection and wiring arrangements shall be in accordance with ENA Technical Specification 50-18 unless otherwise agreed with the Purchaser.

All protection, monitoring and control facilities shall be wired out within the relevant panel to provided alarms and indications as specified in the Schedule and shown on detailed diagrams listed in the Schedule. All cabling from the transformer to remote equipment (ie outside the transformer bund) shall be terminated in the free standing marshalling kiosk (MK).or Marshalling Cubicle (MC)

15.8.1 General Requirements

The following definitions apply:-

(a) Marshalling kiosk (MK) - a free-standing enclosure,

(b) Marshalling cubicle (MC) - an enclosure fixed either to the separate cooler, where provided, or to the transformer/reactor.

Requirements for either a MK or a MC are specified in Appendix 1.

Unless otherwise agreed prior to contract Marshalling Kiosks shall be arranged to provide 1 metre resilience to flooding, but not have overall height of more than 2.0 metres. Equipment shall be housed in separate compartments as follows:-

(i) Temperature indicators and their ancillaries

(ii) Cooler control

(iii) On-load tap changer control

(iv) Interposing CTs

(v) Terminals and cable glands

The construction and mounting arrangement of MK/MCs shall:-

(i) be weatherproof, and have a rating of IP55 to EN60529,

(ii) prevent the retention of water externally,

(iii) be proofed against vermin,

(iv) be ventilated and heated to prevent condensation.

Proposed materials for the construction of walls, sides, covers and doors; shall be subject to approval. Galvanised mountings shall be provided.

Cables shall enter from the bottom, and removable gland plates shall be provided at not less than 460 mm from plinth level.

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

Divisions between internal compartments shall be of steel, securely fixed in position, and arranged to permit natural air circulation.

Two lifting lugs shall be provided at diagonally opposite corners.

All compartments shall have both front and rear hinged doors with the following exceptions unless otherwise agreed:-

(i) the cable compartment of MKs shall have no front door,

(ii) the interposing current transformer compartment shall have no rear door.

Doors shall comply with the following requirements:-

(i) have oil and weather resisting gaskets arranged to create a labyrinth seal against the compartment flange,

(ii) open through approximately 180°

(iii) have integral 'stay-bars' for positive location at approximately 90°,

(iv) be fastened by integral handles; nuts, bolts or carriage keys shall not be used,

(vi) Have external fittings that are of suitably durable, non-corroding materials.

Provision shall be made for padlocking. The padlock will have a shackle of 7 mm diameter, a shackle height of 20 mm and radius of 8 mm. Other forms of locking are not acceptable. Handles and padlocking facilities shall be not be more than 1525 mm above plinth level.

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

15.8.2 Terminals, and Ferruling

Terminal blocks shall be angled towards the appropriate doorway to assist access and visibility, arranged as follows:-

Cables and cores shall be numbered in accordance with a schematic diagram or multicore schedule provided by the purchaser.

Terminal boards shall 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. Alternative makes of similar type terminals may be approved at the time of tender providing full details (incl. samples) are provided at the time of tender.

15.8.3 Earthing

A 25 x 3 mm copper bar, mounted on stand-off insulators, shall form the ring circuit earth (RCE) inside the MK/MC, entering all compartments. A steel boss or bar shall pass through, and be welded to, the side wall of the cable compartment to permit connection to the RCE internally and to the substation earth externally.

Each metal case of apparatus mounted in MK/MCs shall be connected to the RCE 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 RCE.

Ventilation and Heating

An approved type of 230 volt, metalclad, anti-condensation, heater(s) shall be provided. The heater shall be protected by a fuse and neutral link, and controlled by a weatherproof, single pole, ironclad, rotary switch, mounted on the outside. The surface temperature of heaters shall not exceed 65°C.

Ventilation louvres shall be provided near the top and bottom on the sides of MK/MC.

15.8.4 Fittings - General

Unless otherwise specified in the Schedule the MK/MC shall be fitted with an externally mounted switched socket outlet, comprising:-

> 1 - 13 amp 3 pin British Standard switched socket with 30mA residual current device for 240 V ac supply. This switched socket is to be connected to the kiosk heater supply circuit through a fuse in the "live" lead and a link in the neutral lead.

Labels shall be provided for all apparatus mounted inside and outside MK/MCs and, to identify the compartments, on outside of doors.

Where 230 volt, phase to neutral, connections are taken into MK/MCs, "400 VOLT DANGER" notices must be affixed to the outsides of the doors of the appropriate compartments.

Connections and wire numbers for the switched socket, heaters, shall be in accordance with Drawing Nos SPC 206 and SPC 207 for WPD Midlands and SWest and Drgs PSD0802-2 and PSD0803 for WPD SWales.
Elements of three phase relays, contactors, isolating switches, supply fuses and thermal devices, shall be marked with the appropriate phase colour.

15.8.5 Labels

All marshalling kiosks or cubicles shall be provided with appropriate labels of durable, rigid material for all internal components.

Labels bearing an appropriate legend shall be fixed to all terminal blocks. The legend shall be clear and concise to indicate the function of groups of terminals and shall have upper and lower case letters, the upper case height being 3 mm.

Labels provided for all apparatus such as relays, switches, fuses etc, contained in any marshalling kiosk or cubicle and REMOTE CONTROL panel shall be so placed that there can be no ambiguity as to the apparatus or equipment to which they refer.

All labels fitted inside marshalling kiosks or cubicles and inside and outside STANDBY CONTROL panels shall be secured with non-corrodible screws or rivets.

Labels fitted to apparatus at the back of panels shall be fixed so that they are not coverable by wiring. They shall not be attached to removable covers.

15.8.6 TERMINAL HOUSINGS (other than MK/MCs)

Housings shall be of durable materials, of rigid construction and free from distortion.

Each housing shall be provided with a cover which can be easily removed and replaced, to provide access to terminations. Covers exceeding 15 kg in weight shall be fitted with hinges.

Housings shall be mounted with their covers in the vertical or near vertical plane. They shall be provided with suitable cowled ventilation.

Housings shall be weatherproof and not allow water to collect on any surface. The top of fabricated housings shall be sloped to shed water away from the cover.

Terminals and their connections shall be easily accessible from the front of the housing.

The fixing of terminals and terminal boards within housings, shall be independent from fixings for the housings.

Housings which are not welded to structures shall be fitted with an external earth terminal stud which shall not penetrate the housing.

15.8.7 CONNECTIONS AND WIRING

General Requirements

Insulated wires shall comply with BS 6231/HD 21. Due consideration shall be given to requirements for fuse grading, current rating, voltage-drop, mechanical strength and terminations.

Fuses shall be Red Spot and comply with the requirements of EN 60269 and application shall be in accordance with ENA Technical Specification 50-18.

MCBs shall comply with the requirements of EN 60947. Application of MCBs shall follow the general principles of ENA Technical Specification 50-18 as applied to fuses. MCBs shall be lockable to provide isolation.

Terminals, terminations and wiring identification shall comply with the requirements of ENATS 50-18

15.9 Interconnecting Cables

The supplier shall provide, for approval by the Purchaser, a schedule detailing the multi-core cables, to be supplied under the Contract, for interconnection of ancillary equipment.

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

External cables shall be adequately fixed to galvanized cable trays using cleats or saddles. Routing through oil containment walls is prohibited.

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

15.10 Magnetic Circuit

The maximum flux density in the limbs any part of the magnetic circuit for any tap position, with rated voltage between terminals, shall not exceed 1.65 Tesla under normal excitation condition.

16.0 DOCUMENTATION

Clause 16 of ENA Technical Specification 35-3 applies with the following additions –

16.1 Drawings

Tenderers shall provide with their tender, the following drawings -

(i) A preliminary outline showing side and end elevations and plan of the equipment offered, including indications of tap changer, terminations, cooling equipment, parts to be removed for transport and principle dimensions.

(ii) A typical arrangement of the tapchanger showing external clearance and any lifting apparatus necessary to undertake maintenance.

The drawings listed in 16.1 together with those additional drawings listed below, shall be provided for comment by the date specified in the Schedule, which shall be prior to commencement of manufacture

(i) A general arrangement comprising: HV and LV side elevations, end elevations and plan, indicating, as appropriate, the following items

- centre lines of pipe-work and turrets, etc., (with respect to the longitudinal and transverse centre lines of the tank in the plan view, and from plinth level in the elevation views) which pass through the sound attenuation enclosure walls and roof,
- parts to be removed for transport
- boundary lines depicting the sound attenuation enclosure
- the principal dimensions, including clearances required for tapchanger maintenance
- the transport dimensions

(ii) General arrangement of Marshalling Kiosk/Cubicle

(iii) Name, Rating and Diagram Plate and diagram of connections of transformer/reactor and associated equipment indicating the relative positions of connections and terminations

(iv) Schematic diagrams, as applicable, of:-

(a) tap change control,

(b) tap changer driving mechanism,

(c) cooler control,

(d) Marshalling kiosk/cubicle,

(e) Remote Control Panel.

(v) Details and connection diagrams of Winding Temperature Indicator (WTI) alarm, trip and cooler control arrangements, Protection CT Scheme Connections

(vi) Details of oil coolers, as applicable,

(vii) Valve function plate,

16.2 Assembly, Operating and Maintenance Instructions

One month PRIOR to delivery, the Contractor shall submit, for approval by the Purchaser, Assembly, Operating and Maintenance Instructions, and Diagrams. After approval, but not later than one month before the commencement of the maintenance period, the Contractor shall supply, in a durable form, the number of copies specified under the Schedule These shall include operation and maintenance instructions for tapchanger, r breather, gas and oil relays, temperature instruments and oil filled bushings.

These instructions and drawings shall include information necessary to form the health and safety file for the equipment, in accordance with the requirements of the Construction (Design and Management) Regulations 1994. The file shall include relevant material safety data under Control of Substances Hazardous to Health legislation.

16.3 Test Certificate

Three paper copies of test certificates shall be provided, together with a .pdf format Acrobat electronic copy.

17.0 TRANSPORT AND ERECTION

17.1 TRANSPORT

The Contractor shall be responsible for arranging transport to site and for ensuring the equipment is delivered to site fit for storage, service or normal future transport.

The costs of transport shall be included in the Tender.

'Datum centre lines' and 'the centre of gravity' shall be clearly and permanently marked on each side and each end of the tank.

Where no transport limitation exists, the transformer/reactor shall be transported complete with tap changer. Tap changing equipment shall not be removed from the transformer/reactor for transport unless specifically approved in writing by the Purchaser.

Filling medium conditions for transport, and whilst awaiting site assembly, shall comply with one of the following:-

- be completely oil filled,
- be allowed to breathe to atmosphere via a breather (equivalent to the in-service breather) provided that the windings and insulations are fully immersed in oil within seven days from factory draining.

- be pressurised by dry air or dry nitrogen provided the pressure is checked monthly to ensure that it does not fall below 35mbar gauge, and the windings and insulations are wholly immersed in oil within three months of factory draining. Where this method is adopted, pressure gauges having a full scale reading not exceeding 500mbar must be fitted. During such time the diverter switch tank of on-load tap changers shall be filled with oil, as for service.

17.2 ERECTION

The transformer shall be erected in accordance with the relevant drawings and include the positioning of anti-vibration pads.

Ferrous bolt threads on all equipment external to the transformer/reactor tank shall be greased before erection.

All pipe-work shall be checked for cleanliness before erection.

The Contractor shall be responsible for cutting any fixing holes that are required in the prepared foundations on site eg for separate cooler banks and for undertaking fixing down and providing all necessary fixing materials.

Transformers transported filled with nitrogen must be purged with dry air before permitting personnel to fit associated internal accessories.

Transformers which have been transported filled with dry air or dry nitrogen shall have their windings and insulation exposed to atmosphere only under dry site conditions and then for a cumulative period of not greater than eight hours.

During and after erection, precautions shall ensure that moisture and air are not trapped within the tank, pipe-work and coolers.

Transformers/reactors shall be supplied complete with the first filling of insulating oil, unless otherwise specified. For testing and commissioning, the oil shall be based and comply with the requirements of IEC 60296 High Grade Inhibited Oil,

Samples shall be taken from the transformer/reactor after the completion of site processing, and be shown to comply with the following requirements.

Requirements for Insulating Oil shall be in accordance with section 14.2 of this specification

The oil in radiators, conservators, coolers and pipe-work shall be processed to remove any impurities, after filling, until it complies with the above requirements before being allowed to mix with the oil in the main tank.

After all compartments of transformers/reactors are filled with oil to their correct level and pressures equalised, the oil shall be circulated through the processing plant and circulation maintained for a minimum duration of eight hours, when the oil quality shall be checked for compliance with the above requirements. If necessary, the processing shall continue until these requirements are met. Transformers/reactors having forced oil cooling shall have their oil pumps running to circulate the oil through the tank and coolers during oil processing.

Note: The Purchaser will be responsible for ensuring that the necessary site supplies are available at the time of oil filling and processing.

The specified breathers must be fitted and made operational within forty-eight hours of the final oil filling and processing. Where this cannot be achieved due to site supplies not being available, a temporary silica-gel breather having a capacity equal to, or greater than, the specified breather, shall be fitted.

After erection, all blanking plates and special fittings shall be stored on site.

Damage to paint-work shall be made good.

The Contractor shall supply, erect and connect-up the apparatus provided under the Contract, including cabling to the approved terminal positions. He shall co-operate with the other contractors concerned in the completion and testing of this work, including the final checking and connecting-up of the small wiring, fitting of approved numbered ferrules and making the transformer/reactor ready for service.

Gap settings for protection devices for open terminal arrangements shall be set, at commissioning, as follows, unless otherwise stated by the Purchaser:-

HV windings of 132kV 710mm

HV windings of 33kV and below 315mm

The Contractor shall provide a Statement to the Purchaser, before commissioning, certifying that a site examination of all tap changer parts, after assembly to the associated transformer, has been made and that the tap changer is in correct working order.

Figure 4 - Valve Function plate

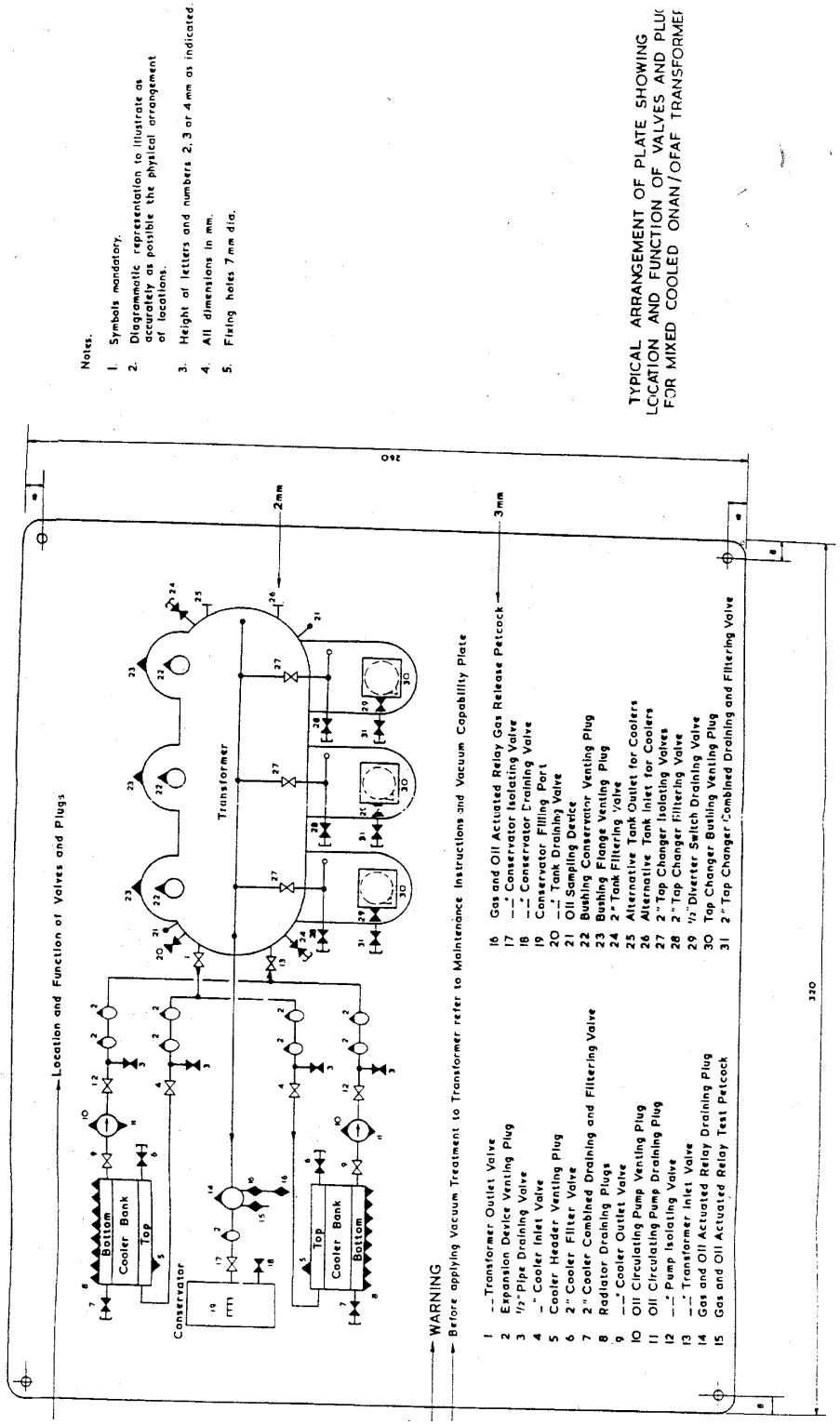


Figure 5 - Sound Attenuation Enclosure

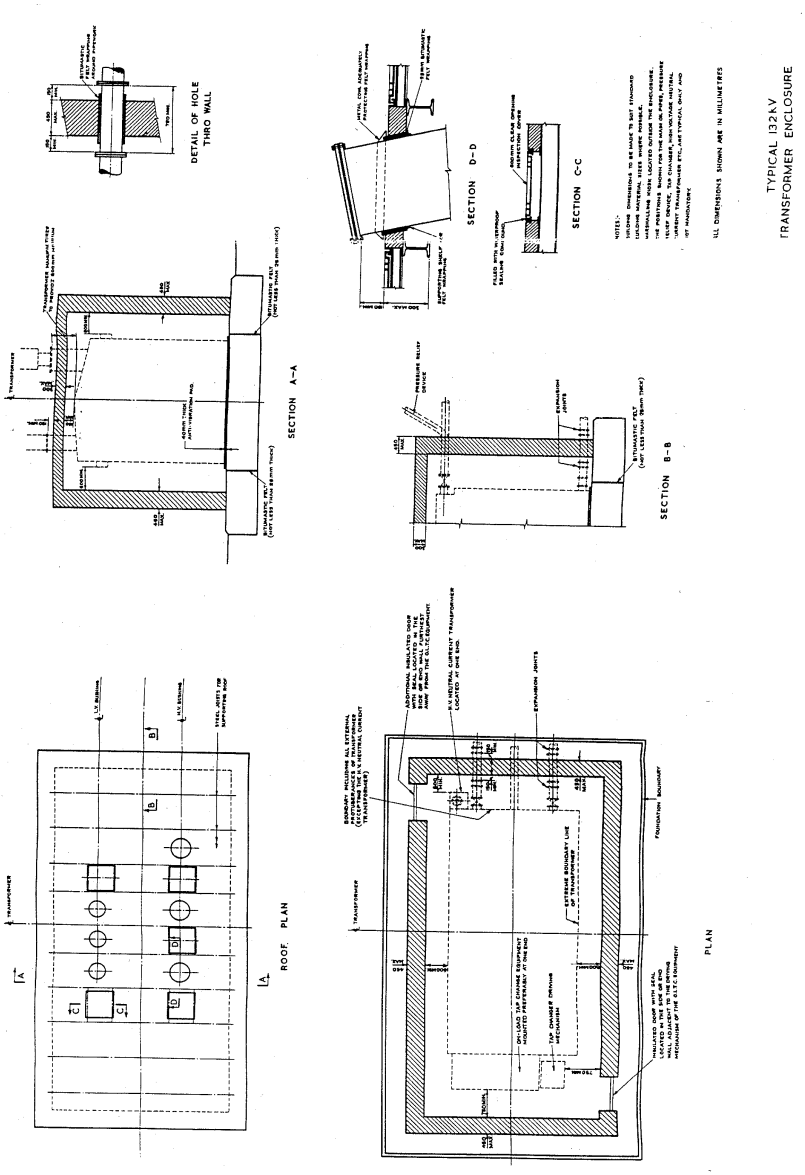


Figure 7

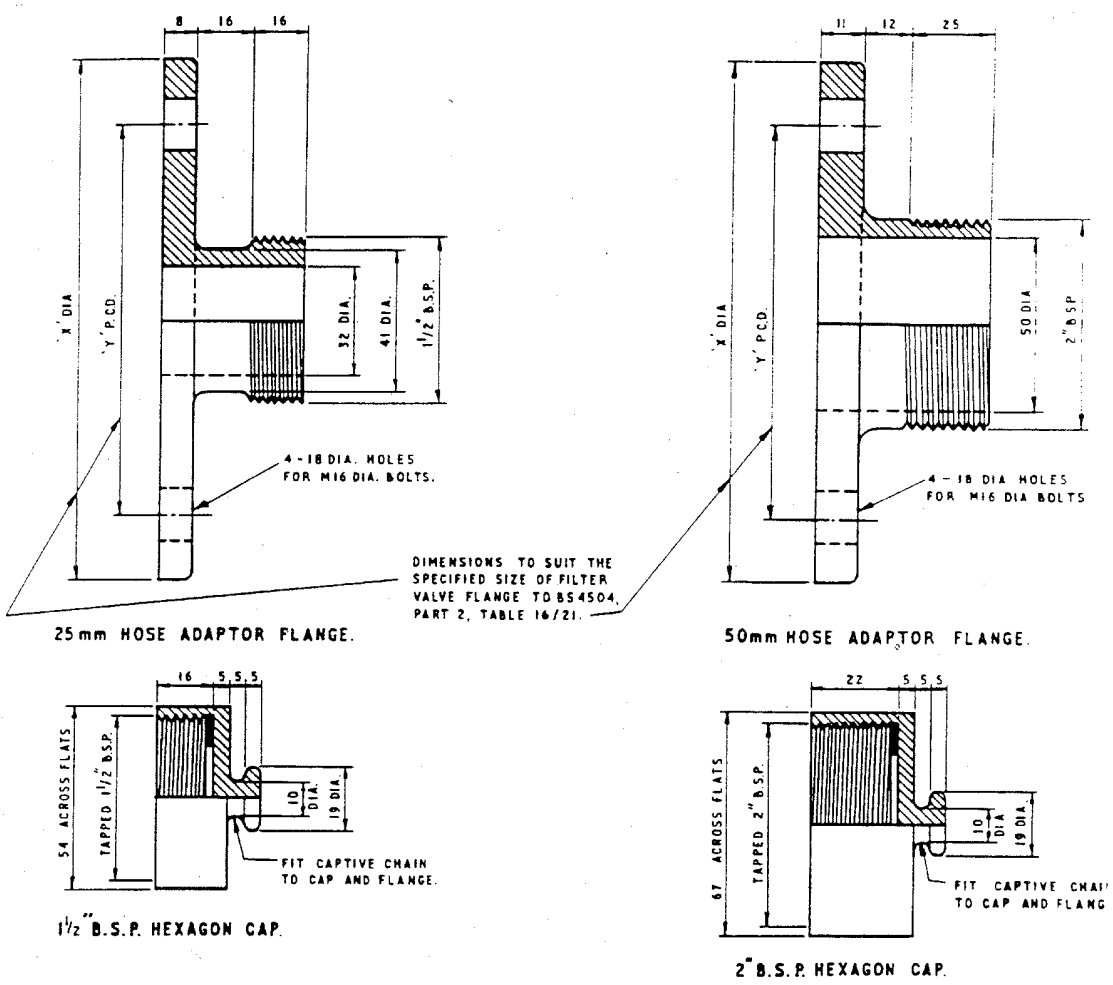

8
16
16
'X' DIA
'Y' P.C.D.
32 DIA.
41 DIA.
1½" B.S.P.
4 - 18 DIA. HOLES FOR M16 DIA. BOLTS.
DIMENSIONS TO SUIT THE SPECIFIED SIZE OF FILTER VALVE FLANGE TO BS 4504, PART 2, TABLE 16/21.
25mm HOSE ADAPTOR FLANGE.
11
12
25
'X' DIA
'Y' P.C.D.
50 DIA
2" B.S.P.
4 - 18 DIA HOLES FOR M16 DIA BOLTS
50mm HOSE ADAPTOR FLANGE.
16
5.5.5
54 ACROSS FLATS
TAPPED 1½" B.S.P.
10 DIA.
19 DIA.
FIT CAPTIVE CHAIN TO CAP AND FLANGE.
1½" B.S.P. HEXAGON CAP.
22
5 5 5
67 ACROSS FLATS
TAPPED 2" B.S.P.
10 DIA.
19 DIA.
FIT CAPTIVE CHAI
TO CAP AND FLANG
2" B.S.P. HEXAGON CAP.

Figure 8

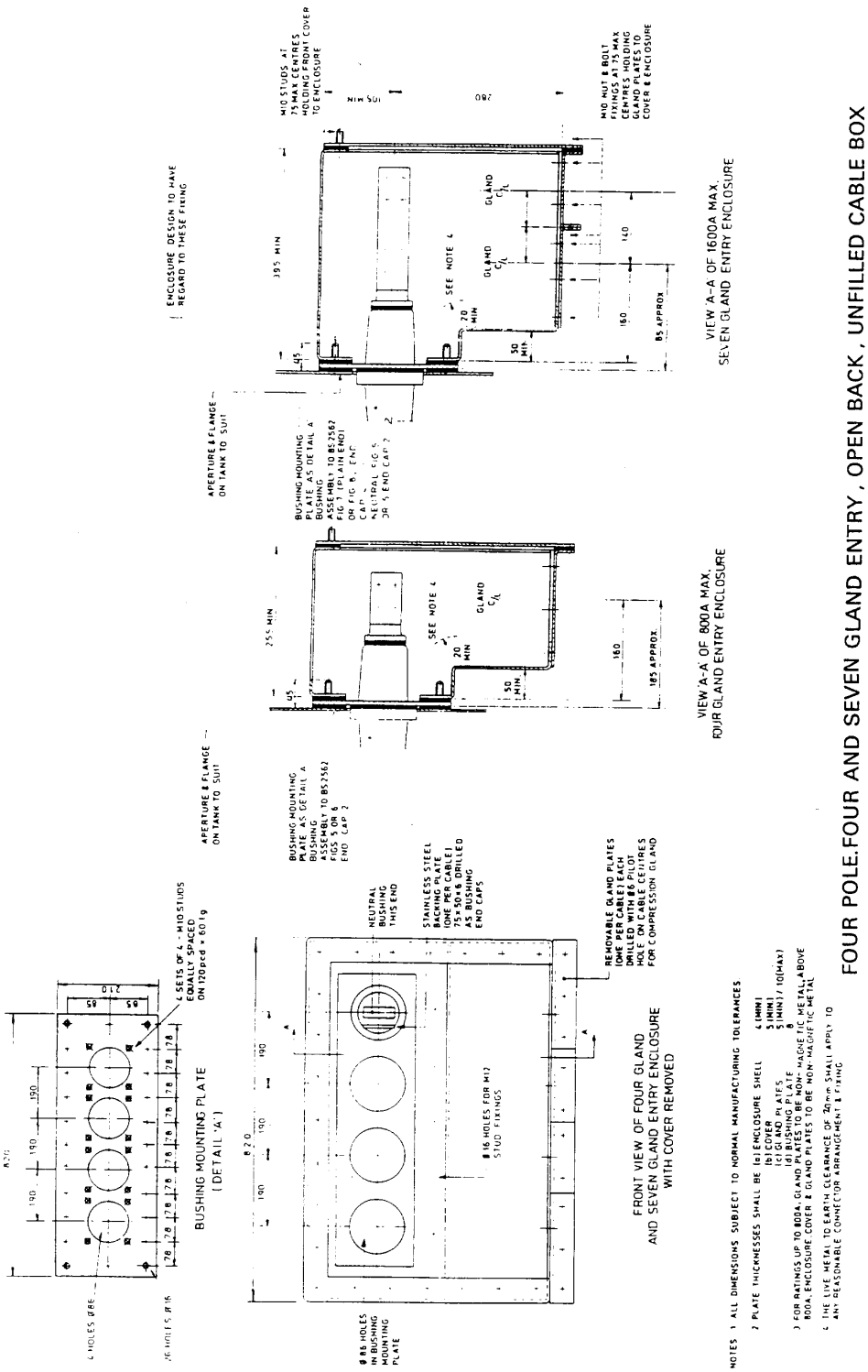

FOUR POLE.FOUR AND SEVEN GLAND ENTRY , OPEN BACK , UNFILLED CABLE BOX
FOR TERMINATING UP TO 1.1 kV RATED VOLTAGE , SINGLE-CORE CABLES
HAVING EXTRUDED INSULATION.CABLE ENTRY VERTICAL FROM BELOW.
NOTES 1 ALL DIMENSIONS SUBJECT TO NORMAL MANUFACTURING TOLERANCES
2 PLATE THICKNESSES SHALL BE (a) ENCLOSURE SHELL 4 (MIN)
(b) COVER 5 (MIN)
(c) GLAND PLATES 5 (MIN) / 10 (MAX)
(d) BUSHING PLATE 8
3 FOR RATINGS UP TO 800A, GLAND PLATES TO BE NON- MAGNETIC METAL ABOVE 800A, ENCLOSURE COVER & GLAND PLATES TO BE NON- MAGNETIC METAL
4 THE LIVE METAL TO EARTH CLEARANCE OF 24mm SHALL APPLY TO ANY REASONABLE CONNECTOR ARRANGEMENT & FIXING
FRONT VIEW OF FOUR GLAND
AND SEVEN GLAND ENTRY ENCLOSURE
WITH COVER REMOVED
NEUTRAL BUSHING THIS END
STAINLESS STEEL BACKING PLATE (ONE PER CABLE) 75 x 50 x 6 DRILLED AS BUSHING END CAPS
REMOVABLE GLAND PLATES (ONE PER CABLE) EACH DRILLED WITH Ø6 PILOT HOLE ON CABLE CENTRES FOR COMPRESSION GLAND
Ø16 HOLES FOR M12 STUD FIXINGS
Ø18 HOLES IN BUSHING MOUNTING PLATE
BUSHING MOUNTING PLATE (DETAIL 'A')
4 SETS OF 4 - M10 STUDS EQUALLY SPACED ON 120pcd x 80lg
APERTURE & FLANGE ON TANK TO SUIT
BUSHING MOUNTING PLATE AS DETAIL A BUSHING ASSEMBLY TO BS:2562 FIGS 5 OR 6 END CAP 2
VIEW A-A OF 800A MAX. FOUR GLAND ENTRY ENCLOSURE
VIEW A-A OF 1600A MAX. SEVEN GLAND ENTRY ENCLOSURE
ENCLOSURE DESIGN TO HAVE REGARD TO THESE FIXING
M10 STUDS AT 75 MAX CENTRES HOLDING FRONT COVER TO ENCLOSURE
M10 NUT & BOLT FIXINGS AT 75 MAX CENTRES HOLDING GLAND PLATES TO COVER & ENCLOSURE
SEE NOTE 4
GLAND C/L
185 APPROX
255 MIN
395 MIN

Figure 9

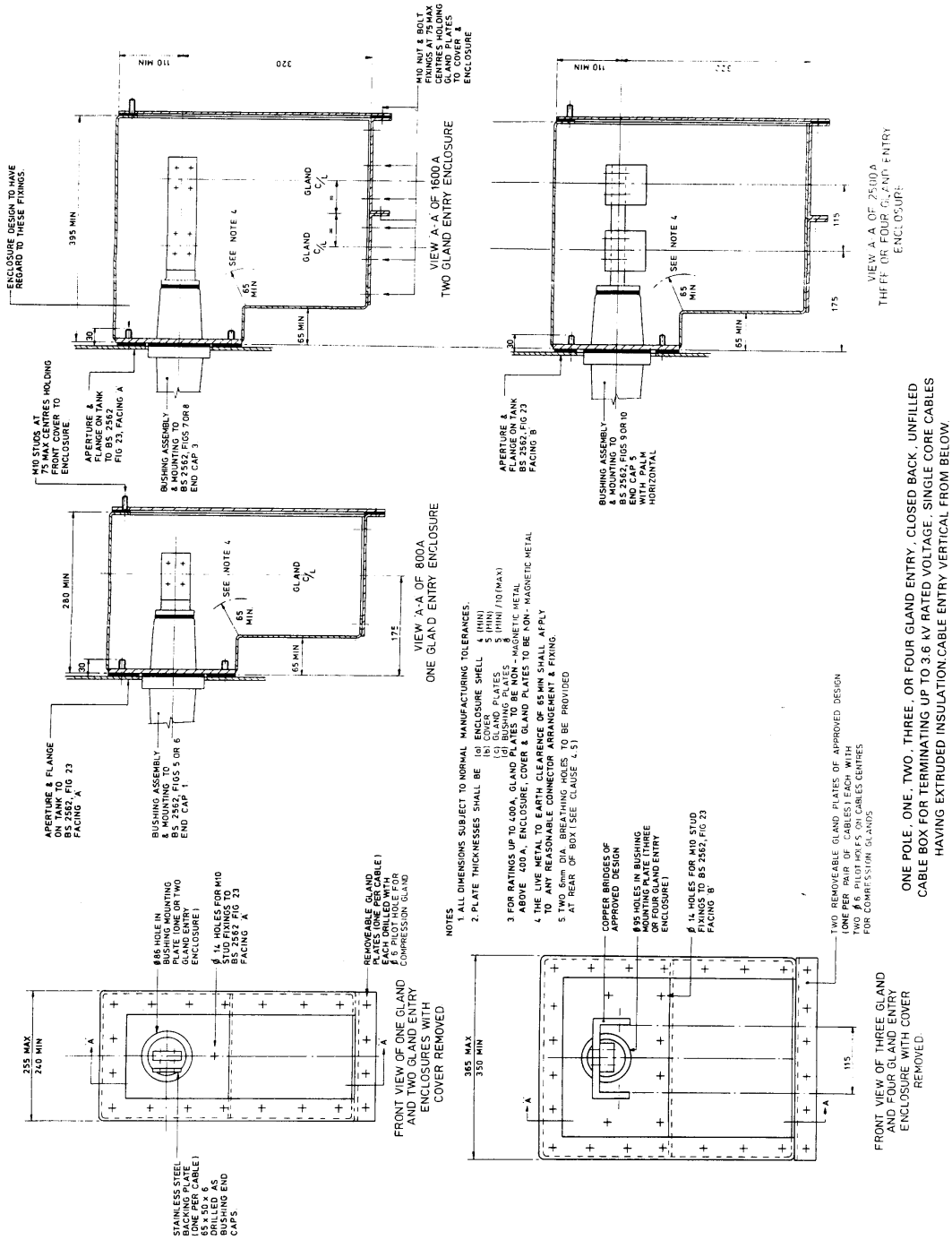
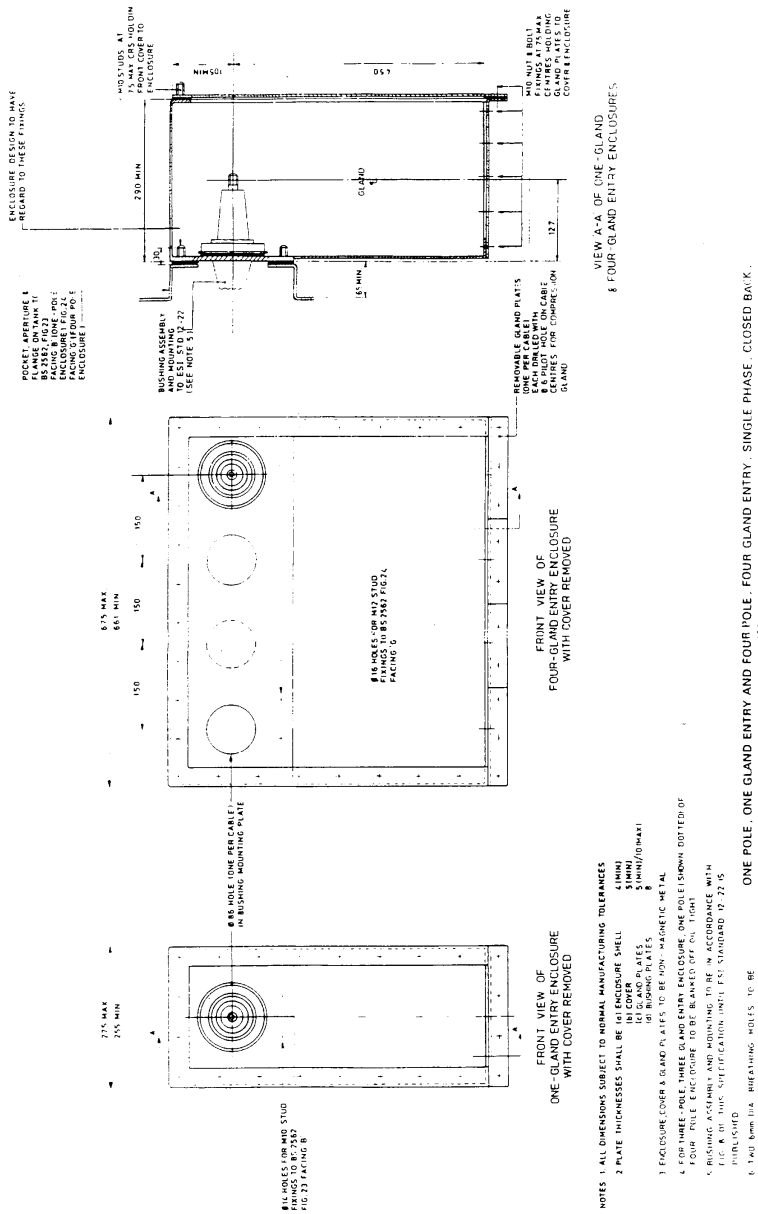

ENCLOSURE DESIGN TO HAVE REGARD TO THESE FIXINGS
395 MIN
110 MIN
320
M10 NUT & BOLT FIXINGS AT 75 MAX CENTRES HOLDING GLAND PLATES TO COVER & ENCLOSURE
VIEW A-A OF 1600A TWO GLAND ENTRY ENCLOSURE
SEE NOTE 4
65 MIN
GLAND C/L
65 MIN
M10 STUDS AT 75 MAX CENTRES HOLDING FRONT COVER TO ENCLOSURE
APERTURE & FLANGE ON TANK TO BS 2562 FIG 23, FACING A
BUSHING ASSEMBLY & MOUNTING TO BS 2562 FIGS 7 OR 8 END CAP 3
APERTURE & FLANGE ON TANK BS 2562, FIG 23 FACING 'B'
BUSHING ASSEMBLY & MOUNTING TO BS 2562, FIGS 9 OR 10 END CAP 5 WITH PALM HORIZONTAL
VIEW A-A OF 2500A THREE OR FOUR GLAND ENTRY ENCLOSURE
280 MIN
SEE NOTE 4
65 MIN
GLAND C/L
65 MIN
125
VIEW A-A OF 800A ONE GLAND ENTRY ENCLOSURE
APERTURE & FLANGE ON TANK TO BS 2562, FIG 23 FACING 'A'
BUSHING ASSEMBLY & MOUNTING TO BS 2562 FIGS 5 OR 6 END CAP 1
NOTES
1. ALL DIMENSIONS SUBJECT TO NORMAL MANUFACTURING TOLERANCES.
2. PLATE THICKNESSES SHALL BE (a) ENCLOSURE SHELL 4 (MIN)
(b) COVER 5 (MIN)
(c) GLAND PLATES 5 (MIN) /10 (MAX)
(d) BUSHING PLATES 8
3 FOR RATINGS UP TO 400A, GLAND PLATES TO BE NON-MAGNETIC METAL
ABOVE 400A, ENCLOSURE, COVER & GLAND PLATES TO BE NON-MAGNETIC METAL
4 THE LIVE METAL TO EARTH CLEARANCE OF 65 MIN SHALL APPLY TO ANY REASONABLE CONNECTOR ARRANGEMENT & FIXING.
5 TWO 6mm DIA BREATHING HOLES TO BE PROVIDED AT REAR OF BOX (SEE CLAUSE 4.5)
COPPER BRIDGES OF APPROVED DESIGN
Ø95 HOLES IN BUSHING MOUNTING PLATE (THREE OR FOUR GLAND ENTRY ENCLOSURE)
Ø14 HOLES FOR M10 STUD FIXINGS TO BS 2562, FIG 23 FACING 'B'
TWO REMOVEABLE GLAND PLATES OF APPROVED DESIGN (ONE PER PAIR OF CABLES) EACH WITH TWO Ø6 PILOT HOLES ON CABLES CENTRES FOR COMPRESSION GLANDS
ONE POLE, ONE, TWO, THREE, OR FOUR GLAND ENTRY, CLOSED BACK, UNFILLED CABLE BOX FOR TERMINATING UP TO 3.6 kV RATED VOLTAGE. SINGLE CORE CABLES HAVING EXTRUDED INSULATION: CABLE ENTRY VERTICAL FROM BELOW
255 MAX
240 MIN
Ø86 HOLE IN BUSHING MOUNTING PLATE (ONE OR TWO GLAND ENTRY ENCLOSURE)
Ø14 HOLES FOR M10 BUSHING FIXINGS TO BS 2562, FIG 23 FACING 'A'
REMOVEABLE GLAND PLATE (ONE PER CABLE) EACH DRILLED WITH Ø6 PILOT HOLE FOR COMPRESSION GLAND
STAINLESS STEEL BUSHING PLATE (ONE PER CABLE) 65 x 50 x 6 DRILLED AS BUSHING END CAPS
FRONT VIEW OF ONE GLAND AND TWO GLAND ENTRY ENCLOSURES WITH COVER REMOVED
365 MAX
350 MIN
115
FRONT VIEW OF THREE GLAND AND FOUR GLAND ENTRY ENCLOSURE WITH COVER REMOVED

Figure 10


ENCLOSURE DESIGN TO HAVE REGARD TO THESE FIXINGS
POCKET APERTURE & FLANGE ON TANK TO BS 3562 FIG 23 FACING B FOR ONE POLE ENCLOSURE FIG 24 FACING G FOUR POLE ENCLOSURE FIG 25
BUSHING ASSEMBLY AND MOUNTING TO BS 3562 FIG 22 (SEE NOTE 5)
M10 STUDS AT 75 MAX CRS HOLDING COVER TO ENCLOSURE
230 MIN
GLAND
127
M10 NUT & BOLT FIXINGS AT 75 MAX CENTRES HOLDING GLAND PLATES TO COVER & ENCLOSURE
REMOVABLE GLAND PLATES (ONE PER CABLE) EACH DRILLED WITH 6 HOLES AT 100 PCD FOR CABLE GLAND
VIEW A-A OF ONE-GLAND & FOUR-GLAND ENTRY ENCLOSURES
675 MAX
661 MIN
150
150
150
150
Ø16 HOLES FOR M12 STUD FIXINGS TO BS 3562 FIG 24 FACING G
FRONT VIEW OF FOUR-GLAND ENTRY ENCLOSURE WITH COVER REMOVED
275 MAX
255 MIN
Ø86 HOLE (ONE PER CABLE) IN BUSHING MOUNTING PLATE
Ø16 HOLES FOR M10 STUD FIXINGS TO BS 3562 FIG 22 FACING B
FRONT VIEW OF ONE-GLAND ENTRY ENCLOSURE WITH COVER REMOVED
NOTES 1 ALL DIMENSIONS SUBJECT TO NORMAL MANUFACTURING TOLERANCES
2 PLATE THICKNESSES SHALL BE (a) ENCLOSURE SHELL 4 MIN
(b) COVER PLATE 5 MIN
(c) GLAND PLATES 5 MIN
(d) BUSHING PLATES 5 MIN/10 MAX
3 FOR ENCLOSURE COVER & GLAND PLATES TO BE NON - MAGNETIC METAL
4 FOR THREE - POLE, THREE GLAND ENTRY ENCLOSURE, ONE POLE IS SHOWN DOTTED OF FOUR POLE ENCLOSURE TO BE BLANKED OFF ALL TIGHT
5 BUSHING ASSEMBLY AND MOUNTING TO BE IN ACCORDANCE WITH FIG 22 OF THIS SPECIFICATION UNTIL FOR STANDARD 12 22 15 PUBLISHED
6 140 mm DIA BREATHING HOLES TO BE PROVIDED AT HEAD OF BOX (SEE CLAUSE 4.5.1)
ONE POLE, ONE GLAND ENTRY AND FOUR POLE, FOUR GLAND ENTRY, SINGLE PHASE, CLOSED BACK, UNFILLED CABLE BOX FOR TERMINATING 12 kV CABLES HAVING EXTRUDED INSULATION, BY MEANS OF ELBOW CONNECTORS CABLE ENTRY VERTICAL FROM BELOW

ANNEX A

EARTHING AND AUXILIARY TRANSFORMERS

A1.1 General Requirements

This appendix details requirements for earthing and auxiliary transformers AND SHALL BE READ IN CONJUNCTION WITH THE FULL SPECIFICATION.

A1.1.1 Unless otherwise specified, the type of cooling shall be ONAN as defined in IEC 60076.

A1.1.2 The higher voltage terminals will be directly connected to the lower voltage terminals or the tertiary terminals, as applicable, of the associated transmission transformer.

A1.1.3 Unless otherwise specified, the fault level at the LV or tertiary terminals of the transmission transformer will be as stated below unless in the Schedule.

System Fault Levels

Nominal System Voltage -	kV	66	33	22	11	6.6	0.415
Fault Level at relevant terminals	MVA	3,600	1,500	750	400	250	31

A1.1.4 The insulation levels shall be in accordance with IEC 60076:Part 3, Table II, (List 2).

A1.1.5 Transformers shall comply with the requirements of IEC 60289 in their ability to withstand short-circuits except that the over-current conditions shall be as defined below and the initial winding temperature shall be the sum of the maximum ambient temperature (40°C) and the temperature rise obtained by the continuous operation at continuous maximum rating (CMR).

A1.1.6 When operating at CMR, all transformers shall be capable of withstanding, for 3 seconds, the current occurring when a short circuit is applied between any or all of the lower voltage terminals with full line voltage maintained at the higher voltage terminals.

A1.1.7 The guaranteed no-load and load losses of each transformer shall be as stated in the Schedule. Unless otherwise specified they shall be guaranteed subject to the tolerances permitted by IEC 60076.

A1.1.8 With the exception of auxiliary transformers having an HV winding rated at <11 kV the sound power level and vibration of all transformers shall comply with Clause 10, Table 4 of this WPD Specification. The guaranteed sound power value shall be stated by the Tenderer in the Schedule; the measured value shall not exceed the declared value.

A1.1.9 The Vector group(s) of all transformers may be such that the voltage of the secondary windings will be in phase with the higher voltage system to which the transmission transformer is connected. Where the transmission transformer is arranged for alternative vector groups, a corresponding arrangement shall be included for the earthing transformer or auxiliary transformer by means of links, which shall be located within the tank and readily accessible through an inspection opening.

A1.1.10 When on normal tap, with rated voltage applied between terminals at rated frequency, the magnetic circuit of earthing transformers and auxiliary transformers shall have a flux density not exceeding 1.65 Tesla

A1.1.11 The LV windings shall be terminated as follows:-

(i) CMR <550kVA:

Unless otherwise specified in the Schedule the transformer shall be fitted with an approved type of three-pole, air-break, industrial pattern, fully weatherproof, combined switch-fuse incorporating a bolted neutral link and a gland entry for a 4-core cable. No part of the switch-fuse operating handle, when in the closed position, shall be at a height greater than 1.4 m above plinth level and the arrangement for operation shall comply with the safety air clearances detailed in Table 10. The transformer side of the bolted neutral link shall be earthed to a boss, within the chamber, by a removable connection strap. Removal of the neutral link shall not disrupt the transformer earthing.

(ii) CMR >550kVA:

A cable box as detailed in the Schedule.

Note: Where cable boxes are used, disconnection chambers are not required but, to facilitate cable testing, hand holes shall be provided giving access to the inside of the transformer tank to permit disconnection of the bushings. With the internal connections removed and the bushings covered by at least 50 mm of oil, adequate clearances shall exist to withstand the application of the appropriate cable test voltage.

A1.1.12 The following tanks and fittings, complying with this Specification requirements, shall be provided:-

(i) conservator

(ii) maintenance free de-hydrating breather as detailed in Clause 13.4 of this specification

(iii) pressure relief device (either bursting diaphragm or spring operated)

(iv) gas and oil actuated relay.

(v) oil temperature indicator on transformers having a CMR >550kVA.

A1.1.13 Radiators shall comply with the requirements of the specification, with the exception that valves between the radiators and the tank need not be supplied.

A1.1.15 Valves shall be fitted in accordance with the requirements of the Specification, except that the combined drain/filter valve and the 'diagonally opposed filter valve', shall be 25 mm.

A2 **Earthing Transformers**

A2.1.1 The HV windings shall be terminated with bushings or cable boxes as detailed in the Schedule.

A2.1.2 The rated short time current through the HV neutral unless otherwise stated shall be as given below:-

Lower voltage of main transformer	kV	6.6	11	22	33	66
Rated short-time current (30 seconds)	Amp	1,320	1,050	750	750	500

A2.1.3 When operating at CMR of the secondary winding, the HV winding shall be capable of withstanding, simultaneously, the rated short-time current and, for 3 seconds, the current obtained with a short-circuit applied between one HV line terminal and the HV neutral terminal with full line voltage maintained at the HV line terminals.

A2.1.4 Lower voltage windings shall be provided to give a 415/230 volt, 3 phase, 4 wire supply - unless this requirement is specifically excluded in the Schedule.

A2.1.5 Unless a higher rating is specified by the Purchaser the standard rating for the lower voltage winding of earthing transformers shall be 200 kVA.

A2.1.6 Unless specified by the Purchaser the declared HV/LV impedance for earthing transformers shall not exceed the value given for auxiliary transformers of equal rating, see Table 17 below.

Table of Standard Ratings, Voltage Ratios and Impedance.

	No-load Voltage Ratio (kV)	**Continuous Maximum Rating (kVA)**	**Impedance at CMR at 75°C (%)**
Auxiliary Transformers	6.6/0.415 or 11/0.415	200	4.75
		400	4.75
		500	4.75
		800	4.75
		1,000	4.75
	22/0.415 or 33/0.415	200	5.5
		400	5.5
		500	5.5
		800	5.5
		1,000	5.5
	66/0.415	200	6.0
		400	6.0
		500	6.0
		800	6.0
		1,000	6.0
Earthing Transformers	11/0.415	)	See Clause A2.1.6
		)	
	22/0.415	) 200	
		) See Clause	
	33/0.415	) A2.1.5	
	or	)	
	66/0.415	)	

A2.1.7 The zero sequence impedance of the HV winding may be specified, by the Purchaser, to have a minimum value. The guaranteed value shall be stated by the Tenderer in the Schedule The measured value shall be within the range plus 20% and minus zero of the guaranteed value.

A2.1.8 The impedance between the higher and lower voltage windings shall comply with the requirements of Table 17; the guaranteed value shall be stated by the Tenderer in the Schedule.

A2.1.9 The Vector group symbol shall be Zyl with changeover links provided on the lower voltage winding to permit reconnection equivalent to Zyll.

A2.1.10 A thermometer pocket shall be provided.

A3. **Auxiliary Transformers**

A3.1.1 The HV windings shall be fitted with bushings or cable boxes as detailed under item in the Schedule.

A3.1.2 The CMR and the voltage ratio shall be as specified under the Schedule chosen from the standard ratings and voltage ratios listed in Table 17.

A3.1.3 Transformers having their HV winding rated at <11kV, shall have a sound power level of less than 63dBA.

A3.1.4 Unless otherwise specified, the impedance between the higher and lower voltage windings shall be as specified in Table 17, subject to the tolerances permitted by IEC 60076.

A3.1.5 Unless otherwise required for compliance with the Schedule or Clause A1.1.9, the Vector symbol shall be DzO with changeover links on the higher voltage winding to permit reconnection to Dz6.

A3.1.6 A thermometer pocket shall be provided.

A4. **Neutral Coupler**

A4.1 A neutral coupler shall be supplied with all Earthing/Auxiliary transformers and shall be matched to that transformer. The neutral coupler shall be designed to limit the rise of phase to neutral voltage under system earth fault conditions. It shall comply with all relevant sections of this Specification.

A4.2 The Neutral Coupler shall have the following characteristics

a) Vector Symbol: Zn
b) Rated Power: 66.7kVA
c) Rated Voltage: 415V
d) Rated Current: 92.7A, continuous
e) Rated Neutral Current: 278A, continuous
f) Zero sequence impedance per phase: 0.027 Ω
g) Insulation level: 50Hz withstand: 3kV rms

Alternative ratings may be specified, at time of tender, where a neutral coupler is being purchased to match an existing earthing transformer.

A4.3 The neutral coupler shall be mounted on the earthing transformer and connected as shown in Figure A1. As an alternative, if specified at time of tender, the coupler may be plinth mounted and connected as shown in Figure A2.

A4.4 The connections between the Earthing Transformer, Neutral Coupler and LV fuse switch shall be provided by the manufacturer. The terminations shall be within suitable cable boxes. Shrouded open terminal bushings are not acceptable

A4.5 The unit shall be suitable for outdoor use and have the following features

a) Lifting lugs
b) Tank earthing terminal
c) Silica gel breather
d) An oil level gauge
e) Combined drain and sampling valve

Figure A1 - Earthing transformer mounted arrangement

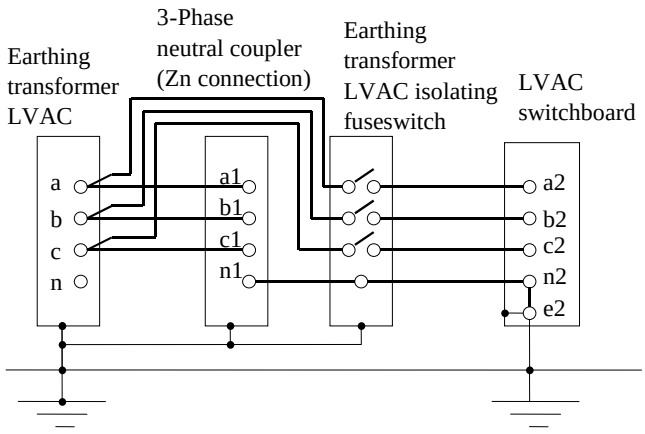


Figure A2 - Plinth-mounted, Arrangement A

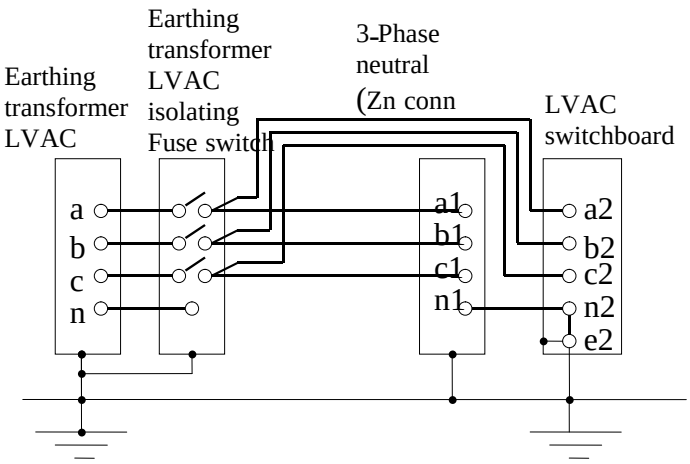
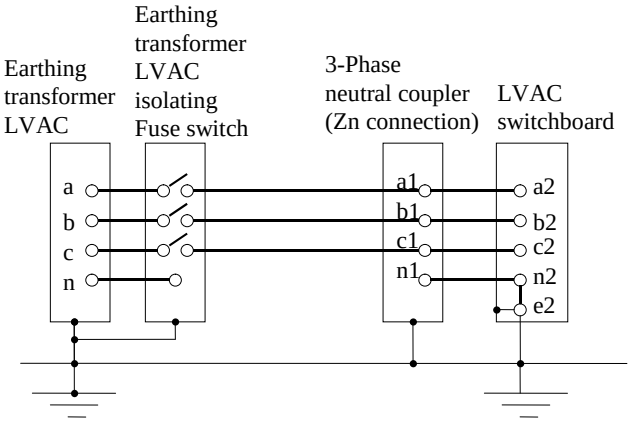


Figure 2A Plinth mounted, Arrangement B



CONTINUOUS MAXIMUM RATED (CMR) SYSTEM TRANSFORMERS (FOR USE ON SYSTEMS UP TO 132kV)

APPENDIX 1 - SCHEDULE OF REQUIREMENTS

Appendix 1 - Schedule of Requirements (to be completed by Purchaser)			
Item	**Clause**	**Description**	
1	5.1.1	Rated Power MVA Tertiary Rated Power (if applicable) MVA No-load Voltage Ratio kV Alternative voltage ratio kV	
2	5.3	Generator transformer load rejection required	**Yes/No**
3		HV rated voltage kV LV rated Voltage kV	
4	5.4.2	Rated Frequency Hz	**50**
5	6.4	Tapping Range	
6	6.5	Short Circuit Impedances based on CMR On Principal tap % On Minimum Tap (Tap 19, V/R 105.6/LV) Maximum Impedance % Minimum Impedance % On Maximum Tap (Tap 1, V/R 145.2/LV) Maximum Impedance % Minimum Impedance % Short circuit Impedance HV/Tertiary % At rating MVA For Dual LV windings, LV1 to LV2 Impedance %	
7	6.6	Loss Capitalization Values (i) No-load Loss £/kW (ii) Load Loss at CMR rating £/kW Maximum Guaranteed Losses in accordance with 5.6 (i) No-load Loss W (ii) Load Loss at CMR rating W	
8	7	Vector group(s)	
9	7	Vector Links required If yes, alternative vector group	*Yes / No
10	7	Stabilising winding required on Star Star transformers	Yes/No
11	9.2	Neutral conductor and terminal intended to carry load	*~~Yes~~ / No

Appendix 1 - Schedule of Requirements (to be completed by Purchaser)			
Item	**Clause**	**Description**	
12	9.3	Oil preservation system If free breathing, breather type	*Free breathing / ~~Diaphragm conservator~~ *~~Desiccant~~ / dehydrating
13	9.4	Level of d.c. currents in neutral circuits A	
14	11.1.1	For equipment voltage (U_m) of 12 kV r.m.s Rated lightning impulse voltage (LI) kV peak	95kV
15	11.1.2.1	FRA test required at works and/or on site If yes - specify where the test is required Costs to be identified separately at time of tender	*Yes / ~~No~~ *~~Works/Site~~/Both
16	11.1.4	Short circuit test required	*~~Yes~~ / No
17	11.13	Temperature rise test required for overload condition	*~~Yes~~ / No
18	11.14	Sound power level ONAN dB(A) Sound power level at CMR dB(A) *[1] If blank the default levels given in Cl 10.10 apply	*[1] *[1]
19	14.6	Maximum HV system short circuit capacity Maximum LV system short circuit capacity	
15	12.5	Auxiliary DC nominal voltages Supervisory/Scada transducers control trip/alarms	 24/50 110
20	15.1.5	Transformer to be suitable for sound attenuation enclosure Access through enclosure roof permitted	*Yes / ~~No~~ *~~Yes~~ / No
21	15.2	Finish colour required	
22	15.3	Type of HV Terminations Type of LV Terminations Type of tertiary terminations Type of HV neutral termination Type of LV neutral termination NVD capacitor taps required NVD capacitance if required pF	 Yes / No * 60 / 90 / 140
23	15.3.1	Details of HV cable termination Number and size of single core cables for cable termination Oil-filled disconnecting chamber Position of cable boxes	 *Yes/No
25	15.3.2	 HV bushings (if applicable) Stem material Co-ordinating gaps required Surge arresters required Brackets for surge arresters required	 Yes / No * Yes / No * Yes / No
26	15.3.5	HV neutral terminal arrangement Accessible isolatable link required	a) / b) / c) / d) * Yes / No

Appendix 1 - Schedule of Requirements (to be completed by Purchaser)			
Item	**Clause**	**Description**	
27	15.3.6	LV terminal arrangement Number and size of single core cables to be terminated Cable disconnecting links required	a) / b) / c) * Yes / No
28	15.3.7	LV neutral terminal arrangement Size of single core cable to be terminated LV neutral current transformer(s) required Details of LV neutral current transformer(s) Accessible isolatable link required	a) / b) / c) * Yes / No * Yes / No
29 29a	15.3.8 A3.1.5	Separate Earthing / Auxiliary transformer required If Yes: No load voltage ratio Zero sequence impedance Ohms/phase HV rated short-time neutral current (if not standard A HV terminations Vector Group (if not standard) Auxiliary Voltage tappings required	*Yes / No *Outdoor bushings / cable box No these are not required
30	15.4.1	Max / min tap position indicator required	*Yes / No
32	15.6.2	Separate cooler bank required Mounting of cooler bank at either end of the tank	*Yes / No *Yes / No
33	15.6.5	Winding temperature indicators or sensors Output required from sensor Winding temperature indicator type Electronic WTI d.c. supply voltage Minimum V Maximum V	*Indicator / Sensor *Dial / electronic
34	15.6.6	Winding temperature indicator C T position HV LV Tertiary Protection/measurement CTs required HV HVN LV LVN Additional current transformer accommodation required CT Test Loops Required	 *Yes / No *Yes / ~~No~~
35	15.12	 Condition monitoring equipment required Monitoring system type Remote indication of WTI's required Provision of top oil indicator required Provision for future gas in oil device required Provision for future fibre optic winding temperature sensor required Gas in oil device required Additional remote TPI required	 * Yes / No Current loop / Digital * Yes / No * Yes / No * Yes / No * Yes / No * Yes / No * Yes / No
36		Marshalling Kiosk(MK) or Marshalling Cubicle (MC) required	MK / MC
38		Oil filled disconnection chamber required	*Yes / No

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CONTINUOUS MAXIMUM RATED (CMR) SYSTEM TRANSFORMERS (FOR USE ON SYSTEMS UP TO 132kV)

APPENDIX 2 – SELF-CERTIFICATION CONFORMANCE DECLARATION

CLAUSE BY CLAUSE CONFORMANCE WITH ENA TS 35-3

Transformers covered by ENA TS 35-3 shall comply with the latest issues of the relevant international and British Standards. ENA TS 35-3 is intended to amplify and/or clarify the requirements of those standards.

This check sheet identifies the clauses in ENA TS 35-3 and the clauses of IEC 60076-1. The manufacturer shall declare conformance or otherwise, clause by clause, using the following levels of conformance declaration codes.

Conformance declaration codes	Instructions for Completion
N/A = Clause is not applicable / appropriate to the product Cs1 = The product conforms fully with the requirements of this clause Cs2 = The product conforms partially with the requirements of this clause Cs3 = The product does not conform to the requirements of this clause	• When Cs2 or Cs3 is entered, the reason for non-conformance shall be entered • Where options are specified, the remark should identify the option offered by the manufacturer • The manufacturer should complete the schedule items in the Remarks column. Additional sheets may be referred to if more detail is required.

Appendix 2 – Self-Certification Conformance Declaration					
Clause / Sub-clause	**Requirement**	**Conformance Code IEC 60076-1**	**Conformance Code ENA TS 35-3**	**Schedule Item**	**Remarks**
1 1.1	Scope and service conditions Scope			N/A	
1.2	Normal Service Conditions		N/A	N/A	

Appendix 2 – Self-Certification Conformance Declaration					
Clause / Sub-clause	**Requirement**	**Conformance Code IEC 60076-1**	**Conformance Code ENA TS 35-3**	**Schedule Item**	**Remarks**
1.2.2	Provision for Unusual Service Conditions		N/A	N/A	
2	Normative references			N/A	
3 3.1	Definitions General		N/A	N/A	
3.2	Terminals and Neutral Point		N/A	N/A	
3.3	Windings		N/A	N/A	
3.4	Rating		N/A	N/A	
3.5	Tappings		N/A	N/A	
3.6	Losses and No-load Current		N/A	N/A	
3.7	Short-circuit Impedance and Voltage Drop		N/A	N/A	
3.8	Temperature Rise		N/A	N/A	
3.9	Insulation		N/A	N/A	
3.10	Connections		N/A	N/A	
3.11	Kinds of Tests		N/A	N/A	

Appendix 2 – Self-Certification Conformance Declaration					
Clause / Sub-clause	**Requirement**	**Conformance Code IEC 60076-1**	**Conformance Code ENA TS 35-3**	**Schedule Item**	**Remarks**
3.12	Meteorological Data with Respect to Cooling		N/A	N/A	
4 4.1	Rating Rating			Rated power MVA No-load voltage ratio kV	
4.2	Loading cycle			N/A	
4.3	Preferred values of rated power		N/A	N/A	
4.4	Operation at higher than rated voltage and/or at disturbed frequency			N/A	
5 5.1	Tapped windings Notation of tapping range		N/A	N/A	
5.2	Tapping voltage current, etc		N/A	N/A	
5.3	Tapping power		N/A	N/A	
5.4	Specification of tappings			Tapping range offered	
5.5	Specification of short-circuit impedance Short-circuit impedance between HV and Tertiary			Graph of impedance Vs. tap position Maximum impedance (%) at rating MVA	

Appendix 2 – Self-Certification Conformance Declaration					
Clause / Sub-clause	**Requirement**	**Conformance Code IEC 60076-1**	**Conformance Code ENA TS 35-3**	**Schedule Item**	**Remarks**
5.6	Load loss and temperature rise			Guaranteed load loss at 50% of CER rating kW	
6	Connection and phase displacement symbol			Vector group Alternative vector group where links are provided	
7 7.1	Rating plates Information to be given in all cases		N/A	N/A	
7.2	Additional information to be given		N/A	N/A	
8 8.1	Miscellaneous requirements Dimensioning of neutral connection			Is neutral connection dimensioned for load current?	
8.2	Oil preservation system			Description of oil preservation system	
8.3	Load rejection on generator transformers			Is the transformer suitable for generator transformer load rejection?	
9	Tolerances		N/A	N/A	

Appendix 2 – Self-Certification Conformance Declaration					
Clause / Sub-clause	**Requirement**	**Conformance Code IEC 60076-1**	**Conformance Code ENA TS 35-3**	**Schedule Item**	**Remarks**
10 10.1	Tests General requirements			N/A	
10.1.1	Routine tests			N/A	
10.1.2	Type tests			Are type test results from an identical unit available?	
10.1.3	Special tests			Guaranteed and expected change of impedance after short-circuit test Special tests included in offer	
10.2	Measurement of winding resistance		N/A	N/A	
10.3	Measurement of winding ratio and phase displacement		N/A	N/A	
10.4	Measurement of short-circuit impedance and load-loss			N/A	
10.5	Measurement of no-load loss and current		N/A	Guaranteed no-load loss kW	

Appendix 2 – Self-Certification Conformance Declaration					
Clause / Sub-clause	**Requirement**	**Conformance Code IEC 60076-1**	**Conformance Code ENA TS 35-3**	**Schedule Item**	**Remarks**
10.6	Measurement of harmonics		N/A	N/A	
10.7	Measurement of ZPSI			Expected ZPSI at 10% flc Ω/ph Expected ZPSI at flc Ω/ph	
10.8	Tests on OLTC		N/A	N/A	
10.9	Temperature rise test	N/A		N/A	
10.10	Determination of sound levels	N/A		Guaranteed sound power level (ONAN) dB(A) Guaranteed sound power level (CMR) dB(A)	
10.11	Pressure Test	N/A		Maximum permanent deflection mm	
10.12	Frequency Response Analysis	N/A		Is frequency response analysis included in offer?	

Appendix 2 – Self-Certification Conformance Declaration					
Clause / Sub-clause	**Requirement**	**Conformance Code IEC 60076-1**	**Conformance Code ENA TS 35-3**	**Schedule Item**	**Remarks**
10.13	Site tests	N/A		N/A	
10.14	Insulation resistance measurements	N/A		N/A	
10.15	Magnetic circuit withstand test	N/A		N/A	
10.16	Vacuum test	N/A		Maximum permanent deflection mm	
11	EMC		N/A	N/A	
12 12.1	Transformer details No. of phases and frequency	N/A		N/A	
12.2	Cooling medium	N/A		Cooling medium offered	
12.3	Cooling	N/A		Cooling type at CMR	
12.4	Anti-vibration mounting	N/A		Percentage isolation value and description of AV mountings	
12.5	Auxiliary supply voltage	N/A		Supply voltage for tap-changer and cooler	
12.6	Duty under fault conditions	N/A		N/A	

Appendix 2 – Self-Certification Conformance Declaration					
Clause / Sub-clause	**Requirement**	**Conformance Code IEC 60076-1**	**Conformance Code ENA TS 35-3**	**Schedule Item**	**Remarks**
13	Construction details	N/A		N/A	
13.1	Tanks and covers	N/A		Is offer for bolted or welded cover? Total oil required (including cooling system) litres Filling medium for transport Overall height when arranged for transport on trailer mm Overall weight when arranged for transport on trailer tonnes Total weight as installed in service including cooler plant, all fittings and oil tonnes Type of haulage facilities offered	

Appendix 2 – Self-Certification Conformance Declaration					
Clause / Sub-clause	**Requirement**	**Conformance Code IEC 60076-1**	**Conformance Code ENA TS 35-3**	**Schedule Item**	**Remarks**
13.1.1 13.1.2	Covers Gaskets	N/A N/A		N/A N/A	
13.2	Surface finish	N/A		Finish colour offered	
13.3	Terminals	N/A		Type of terminals offered HV LV Tertiary HV neutral LV neutral	
13.3.1	Cable boxes and unfilled cable enclosures	N/A		Are Separate disconnecting chambers provided?	
13.3.2	Cable sealing end chambers	N/A		N/A	
13.3.3	Outdoor bushings	N/A		Stem diameters and lengths Description of surge protection provision	

Appendix 2 – Self-Certification Conformance Declaration					
Clause / Sub-clause	**Requirement**	**Conformance Code IEC 60076-1**	**Conformance Code ENA TS 35-3**	**Schedule Item**	**Remarks**
13.3.4	Unit auxiliary transformer	N/A		N/A	
13.4	On-load tap-changer	N/A		N/A	
13.4.1	Operating mechanism	N/A		Description of motor protection Is a max/min tap position indicator included?	
13.4.2	Segregation of compartments	N/A		N/A	
13.4.3	Method of operation	N/A		N/A	
13.5	Clearance to exposed conductors	N/A		N/A	
13.6	Fittings	N/A		N/A	
13.6.1	Conservator	N/A		Is low oil level alarm included?	

Appendix 2 – Self-Certification Conformance Declaration					
Clause / Sub-clause	**Requirement**	**Conformance Code IEC 60076-1**	**Conformance Code ENA TS 35-3**	**Schedule Item**	**Remarks**
13.6.2	Cooling plant	N/A		Cooling loss kW Number of pumps Continuous rating of pump motor shaft kW Starting current of pump motor A Number of fans Continuous rating of fan motor shaft kW Starting current of fan motor A Fan diameter mm Speed of fans rpm	
13.6.3	Gas-and-oil actuated relay	N/A		N/A	
13.6.4	Pressure relief device	N/A		N/A	
13.6.5	Winding temperature indicators	N/A		Description of provision of winding temperature indication	

Appendix 2 – Self-Certification Conformance Declaration					
Clause / Sub-clause	**Requirement**	**Conformance Code IEC 60076-1**	**Conformance Code ENA TS 35-3**	**Schedule Item**	**Remarks**
13.6.6	Current transformers	N/A		Is current transformer accommodation included? Are CT's included in purchaser's specification?	
13.6.7	Other fittings	N/A		N/A	
13.6.8	Valves	N/A		N/A	
13.7	Marshalling/control box	N/A		Means of condensation protection Description of security	
13.8	Interconnecting cables	N/A		N/A	
13.9	Magnetic Circuit	N/A		N/A	
13.10	Core and Winding assemblies	N/A		N/A	
13.11	Padlocks	N/A		N/A	
13.12	Condition Monitoring	N/A		Is additional condition monitoring specified?	

Appendix 2 – Self-Certification Conformance Declaration					
Clause / Sub-clause	**Requirement**	**Conformance Code IEC 60076-1**	**Conformance Code ENA TS 35-3**	**Schedule Item**	**Remarks**
14	Documentation	N/A		Proposed maintenance schedule	
14.1	Drawings	N/A		Electronic drawing format	
14.2	Assembly, operation and maintenance instructions			Electronic drawing format	

CONTINUOUS MAXIMUM RATED (CMR) SYSTEM TRANSFORMERS (FOR USE ON SYSTEMS UP TO 132kV

APPENDIX 3.1 – MANUFACTURERS AND PLACES OF MANUFACTURE , TESTING AND INSPECTION

Appendix 3.1 – Self-Certification Conformance Declaration				
Item	**Manufacturer's Drawing Number and/or Type Designation**	**Manufacturer**	**Place of Manufacture**	**Place of Testing and Inspection**
Transformers complete On-load tap-changer equipment Transformer core HV Bushings LV Bushings Neutral bushings Winding conductor Solid insulation kits Tertiary bushings Transformer tank Radiators Pipe work expansion devices Oil Oil valves Oil pumps Oil pump motors Fans				

Appendix 3.1 – Self-Certification Conformance Declaration				
Item	**Manufacturer's Drawing Number and/or Type Designation**	**Manufacturer**	**Place of Manufacture**	**Place of Testing and Inspection**
Fan motors Dehydrating breather Conservator diaphragm system Gas and oil actuated relay(s) Main tank Tap-changer Pressure relief device Outdoor marshalling/control box Temperature indicating devices Material for anti-vibration mounting				
Any deviation from this Schedule shall be notified in writing as soon as possible for the Purchaser's approval.				

CONTINUOUS MAXIMUM RATED (CMR) SYSTEM TRANSFORMERS (FOR USE ON SYSTEMS UP TO 132kV)

APPENDIX 3.2 – ADDITIONAL TECHNICAL SCHEDULES TO BE COMPLETED BY MANUFACTURER

Appendix 3.2 – Additional Technical Schedules to be Completed by		
Item	**Description**	**Details**
1	Core construction: (a) Taped/Banded/Bolted limbs (b) Taped/Banded/Bolted yokes (c) Number of limbs (d) Number of limbs wound	
2	Insulation of (a) Core bolts (b) Core bolt washers (c) Side plates (d) Core laminations	
3	Whether tank or other flux shields are incorporated Yes/No (if "YES" a full description to be supplied with the Tender)	
4	Flux density in the core: (a) Maximum value at rated voltage, 50 Hz, normal tap: (i) wound limbs (ii) yokes (iii) shields associated with magnetic circuit (iv) tank shields (b) Maximum value under any condition of voltage and frequency specified in the Schedules in Part D: (i) wound limbs (ii) yokes (iii) shields associated with magnetic circuit	

Appendix 3.2 – Additional Technical Schedules to be Completed by		
Item	**Description**	**Details**
	WINDINGS	
5	Winding types eg interleaved disc, helical etc: (a) HV windings (b) LV windings (c) Tapping windings (as applicable) (d) Winding sequence, ie Core/__/__/__/__	
6	Arrangement of tappings (Linear, Coarse/Fine, Reversing)	
7	Type of tap changer: (a) Neutral end (b) Line end (c) Separate tank design (d) In-tank design in separate tank	
8	Conductor material for : (a) HV windings (b) LV windings (c) Tapping windings (as applicable)	
9	Conductor insulation: (a) HV windings (b) LV windings (c) Tapping windings	
10	Oil circulation (ie Natural/Partially directed/Directed: (a) To the windings: (i) HV windings (ii) LV windings (iii) Tapping windings (b) Through the windings: (i) HV windings (ii) LV windings (iii) Tapping windings	

Appendix 3.2 – Additional Technical Schedules to be Completed by		
Item	**Description**	**Details**
11	Short circuit capability: (a) Potential axial thrust for worst fault condition of each winding: (i) HV windings (ii) LV windings (iii) Tapping windings (b) Coil clamping short circuit withstand capacity: (i) HV windings (ii) LV windings (iii) Tapping windings	
12	Current density in windings (at normal tapping position): (a) HV windings (at rated power) (b) LV windings (at rated power) (c) Tapping windings (at rated power)	
	PERFORMANCE CHARACTERISTICS	
13	No-load loss at rated voltage, 50 Hz and normal tapping (excluding cooling plant loss) kW (Guaranteed parameter)	
14	Magnetising current (not guaranteed) at: (a) 90% voltage (b) 100% voltage (c) 110% voltage	
15	Cooling plant loss kW	
16	Load losses at rated power and 75^{O}C (a) On normal tapping: (i) HV/LV (guaranteed parameter) kW (b) On tapping for maximum loss: Tap position number (i) HV/LV kW	
17	Maximum volts per step as seen by on-load tap changer at system highest voltage (a) At maximum tapping	

Appendix 3.2 – Additional Technical Schedules to be Completed by Manufacturer		
Item	**Description**	**Details**
	(b) At minimum tapping kV/step	
18	Impedance voltage at rated power and 75^{O}C (a) On normal tapping: HV/LV % (b) Impedance on minimum tapping: Tap position number HV/LV % (c) Impedance on maximum tapping: Tap position number HV/LV %	
19	Demonstrable zero phase sequence impedance at 75^{O}C and on normal tapping, referred to HV side, at 10% full load current in each phase winding (tertiary terminal open circuit): (a) HV-N (HV-/N) Ω/phase *[Connect A-B-C: a-b-c open circuit: supply ABC to YN]* (b) HV-LV//N Ω/phase *[Connect A-B-C: Connect a-b-c-YN: supply ABC to YN]*	
20	Calculated zero phase sequence impedance at 75^{O}C and on normal tapping, referred to HV side, assuming rated voltage (single phase) applied between line terminals and neutral: (a) Z_H Ω/phase (approx) (b) Z_L Ω/phase (approx)	
21	Hottest spot winding temperature, most onerous tap position (ambient air temperature 30^{O}C): Tap No. (a) At rated power (tertiary windings not loaded): (i) HV ^{O}C (ii) LV ^{O}C	
22	Maximum observable oil temperature (ambient air temperature 30^{O}C): (a) At rated power : (i) top oil ^{O}C (ii) at inlet to cooler ^{O}C (iii) at outlet from cooler ^{O}C (b) At ONAN rating:	

Appendix 3.2 – Additional Technical Schedules to be Completed by Manufacturer		
Item	**Description**	**Details**
	(i) top oil ^{O}C	
23	Anticipated hottest spot winding temperature: (a) Emergency cyclic loading conditions: (i) HV ^{O}C (ii) LV ^{O}C (b) With 1.5 pu loading for 30 mins. At 20OC ambient temperature with pre-load of 0.7 pu ^{O}C	
24	Percentage of sum of load and no-load losses, at rated power, that will be supplied during temperature rise tests %	
25	Calculated winding capacitance: (a) Approximate series capacitance of each phase winding: (i) HV pF (ii) LV pF (b) Approximate shunt capacitance to earth of each phase winding with core and tank earthed: (i) HV to earth with LV winding unearthed pF (ii) LV to earth with LV winding unearthed pF (c) Approximate capacitance HV to LV phase winding with LV winding un-earthed pF	
26	Guaranteed sound power level: (a) main unit dB(A) (b) cooler bank dB(A)	
	TANK AND COOLER	
27	Tank material	
28	Thickness of tank: (a) sides mm (b) base mm (c) cover mm	
29	Whether tank base suitable for air cushion equipment	

Appendix 3.2 – Additional Technical Schedules to be Completed by Manufacturer		
Item	**Description**	**Details**
30	Thickness of radiator plates and/or cooling tubes mm	
31	Total oil required, including cooling system litres	
32	Volume of oil to be removed to effect in-situ change of: (a) HV bushing litres (b) LV bushing litres (c) Fitting of bushing turret litres	
33	Total volume of conservator(s)	
34	Volume of oil in (each) conservator between highest and lowest visible levels litres	
35	Height of oil above pad level at maximum level in the conservator(s) metres	
36	Total number of oil pumps	
37	Output of each oil pump under service conditions: (a) quantity litres/sec (b) head metres head of oil (approx)	
38	Continuous rating of each oil pump motor shaft kW	
39	Starting current of each pump motor Amps	
40	Rated normal output of each fan (a) Quantity m^3/s (b) Head mm water gauge	
41	Total number of fans	
42	Nominal diameter of fans mm	
43	Speed of fans rpm	
44	Continuous rating of each fan motor shaft kW	
45	Starting current of each fan motor Amps	
46	Maximum temperature of tank surface, measured from ground level: (a) rated power and at 30^OC ambient: (I) above 2.6 metres ^OC Location (ii) below 2.6 metres ^OC	

Appendix 3.2 – Additional Technical Schedules to be Completed by		
Item	**Description**	**Details**
	Location (b) under cyclic load at 10^{O}C ambient: ^{O}C	
	GENERAL	
47	Filling medium for transport	
48	Total weight as installed for service, including cooling plant, all fitting and oil: (a) quotation estimate tonnes (b) final design calculation tonnes	
49	Weight arranged for transport: (a) excluding vehicle tonnes (b) including vehicle tonnes	
50	Weight of each individual cooler, including oil tonnes	
51	Weight of each bushing insulator: (a) HV kg (b) LV kg (c) Neutral kg	
52	Tanks, conservators and oil filled compartments: (a) permanent deflection after vacuum test: (i) tank mm (ii) conservator mm (iii) other oil filled compartments (specify) mm (b) Permanent deflection after oil pressure test: (i) tank mm (ii) conservator mm (iii) other oil filled compartments (specify) mm	

APPENDIX 4

Clause 1.0 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**

WESTERN POWER DISTRIBUTION - TRANSFORMER TEST SHEET	
Substation:	**Circuit:**
Transformer Ratio:	**Serial Number:**
Vector Group:	

Main Transformer

TAP	HV Volts L-L	AΦ mA	BΦ mA	CΦ mA	LV Volts					
					A-B	B-C	C-A	A-N	B-N	C-N
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										
13										
14										
15										
16										
17										
18										
19										
20										
21										

Confirmation of winding continuity during tap change operation, to be observed when carrying out Transformer Mag Curve test in both the raise and lower directions

Winding Continuity during Tap Change operation in Raise Direction																		
Φ	1 - 2	2 - 3	3 - 4	4 - 5	5 - 6	6 - 7	7 - 8	8 - 9	9- 10	10 - 11	11 - 12	12 - 13	13 - 14	14 - 15	15 - 16	16 - 17	17 - 18	18 - 19
A																		
B																		
C																		

Winding Continuity during Tap Change operation in Lower Direction																		
Φ	19 - 18	18 - 17	17 - 16	16 - 15	15 - 14	14 - 13	13 - 12	12 - 11	11 - 10	10 -9	9 - 8	8 - 7	7 - 6	6 - 5	5 - 4	4 - 3	3 - 2	2 - 1
A																		
B																		
C																		

VECTOR GROUP MEASURED WITH PHASE ANGLE METER.

R PHASE HV to R PHASE 33KV –

Phase rotation 33KV Winding– A-N = B-N = C-N =

Alternative Test for VECTOR RELATIONSHIP (Tie A to a)

A - B _____ Volts
B - C _____ Volts
C - A _____ Volts
B - b _____ Volts
C - b _____ Volts
B - c _____ Volts
C - c _____ Volts

Vector Symbol from test

Earthing Auxiliary Transformer

TAP	HV VOLTS L-L	AΦ mA	BΦ mA	CΦ mA	Earthing Transformer LV Volts					
					A-B	B-C	C-A	A-N	B-N	C-N
1										
2										
3										
4										
5										

A PHASE HV to A PHASE Aux Tx LV A-N = B-N = C-N =

Phase rotation Aux TX LV Winding– A-N = B-N = C-N =

Alternative Test for VECTOR RELATIONSHIP (Tie A to a)

A - B _____ Volts
B - C _____ Volts
C - A _____ Volts
B - b _____ Volts
C - b _____ Volts
B - c _____ Volts
C - c _____ Volts

Vector Symbol from test

PRIMARY INSULATION RESISTANCE

Test Time 60secs		
	Applied Voltage	**Insulation Value**
Main transformer		
Transformer Core Earth		
HV WDG. to Earth		
LV WDG. to Earth		
HV WDG. to LV WDG.		
Earthing/Auxiliary Transformer		
Transformer Core Earth		
HV WDG. to Earth		
LV WDG. to Earth		
HV WDG. to LV WDG.		

TRANSFORMER DEVICES

	Alarm on	Alarm off	Trip Pressure	WDG Temp Alarm	WDG Temp Trip	Coolers On	Coolers Off
Main Buchholz							
Earthing Buchholz							
Tap Change Buchholz							
Main Pressure Relief							
Earthing Pressure Relief							
HVWDG Temp Alarm							
LVWDG Temp Alarm							
Drycol Fail Alarm							
Main Oil Level Alarm							
Tap Chg Oil Level Alarm							
Aux Tx Oil Level Alarm							
Cooler Fail Alarm							

Winding / Oil temp instruments

Manufacturer -
Serial Number HV - LV – Oil Temp -

Serial N°	Function	Contact Function N° 1	N° 2	N° 3	N° 4	Settings (Degrees) N° 1	N° 2	N° 3 on	N° 3 off	N° 4 on	N° 4 off

CALIBRATION TEST

Test Temp	°C	30	50	70	90	110	130	150
HV WTI	°C							
LV WTI	°C							
OTI	°C							
HV Transducer	output							
LV Transducer	output							
OTI Transducer	output							

WTI SECONDARY INJECTION TEST

Function	Heater Resistance	Shunt Resistor ONAN	OFAF	Amps Injected ONAN	OFAF	Initial Temp	Final Temp°C ONAN	OFAF	Increment °C ONAN	OFAF
HV WTI										
LV WTI										

CURRENT TRANSFORMERS

Function	Ratio	Resistance	Polarity	IR @ 1kV
Line Drop compensation				
HV Winding temperature				
LV Winding Temperature				
HV Protection “A” ph Set 1				
HV Protection “B” ph Set 1				
HV Protection “C” ph Set 1				
HV Protection “A” ph Set 2				
HV Protection “B” ph Set 2				
HV Protection “C” ph Set 2				
HV Protection “A” ph Set 3				
HV Protection “B” ph Set 3				
HV Protection “C” ph Set 3				
HV Protection “A” ph Set 4				
HV Protection “B” ph Set 4				
HV Protection “C” ph Set 4				
HV Protection “A” ph Set 5				
HV Protection “B” ph Set 5				
HV Protection “C” ph Set 5				
HV Neutral CT				

CT MAG CURVES

Note – Ct to be tested at a minimum of 8 points of which one point to be the declared knee point value on class X Ct's. Alternately Ct test can be carried out using Omicron Ct Analyzer Test equipment

Current Transformer	**Volts**								
Line Drop compensation	**mA**								
HV Winding temperature	**mA**								
LV Winding temperature	**mA**								
HV Protection "A" ph Set 1	**mA**								
HV Protection "B" ph Set 1	**mA**								
HV Protection "C" ph Set 1	**mA**								
HV Protection "A" ph Set 2	**mA**								
HV Protection "B" ph Set 2	**mA**								
HV Protection "C" ph Set 2	**mA**								
HV Protection "A" ph Set 3	**mA**								
HV Protection "B" ph Set 3	**mA**								
HV Protection "C" ph Set 3	**mA**								
HV Protection "A" ph Set 4	**mA**								
HV Protection "B" ph Set 4	**mA**								
HV Protection "C" ph Set 4	**mA**								
HV Protection "A" ph Set 5	**mA**								
HV Protection "B" ph Set 5	**mA**								
HV Protection "C" ph Set 5	**mA**								
HV Neutral Ct	**mA**								

COOLING EQUIPMENT

	COOLING FANS							
	N°. 1	**N°. 2**	**N°. 3**	**N°. 4**	**N°. 5**	**N°. 6**	**N°. 7**	**N°. 8**
Insulation Resistance								
Rotation correct								
Motor current (Rated)								
(Starting)								
(Running)								
Adopted O/L settings								
Measured operating R								
time when starting Y								
with one fuse removed B								
Measured operating R								
time when running Y								
with one fuse removed B								

	COOLING FANS							
	N°. 9	**N°. 10**	**N°. 11**	**N°. 12**	**N°. 13**	**N°. 14**	**N°. 15**	**N°. 16**
Insulation Resistance								
Rotation correct								
Motor current (Rated)								
(Starting)								
(Running)								
Adopted O/L settings								
Measured operating R								
time when starting Y								
with one fuse removed B								
Measured operating R								
time when running Y								
with one fuse removed B								

OPERATION

Buchholz relay stable when pumps running	

Cooler auto/manual test	

Fans have run for minimum 4Hrs	

Cooler monitoring relays proven	

Cooler operation from remote control relay	

INSULATION RESISTANCE @ 1KV

Cooler Control circuit		**MΩ**
Tap Change Circuits		**MΩ**
Alarm circuits		**MΩ**
Tripping Circuits		**MΩ**

TAPCHANGE CONTROL

1	**Local Raise & Lowering (Full Range)**	
2	**Limit Switches Proved**	
3	**Single Step Feature**	
4	**Hand Operation & Safety Interlock**	
5	**Mechanical Tap Position Indicator Accurate In All Positions**	
6	**Tap change Counter Operated Correctly**	
7	**Selector switches proven, manual /local**	
8	**Tap change runaway circuit Proven**	
9	**Winding Temperature Alarm/Trip Proven**	
10	**Buchholz Relays Alarm/Trip Proven**	
11	**Cooling Equipment Fail Alarm**	

GENERAL CHECKS

1	**Heaters Working Correctly**	
2	**All Equipment Supplied** To **Contract**	
3	**Drawings Correct**	
4	**Wiring Terminals Correct**	
5	**Breather Functioning correctly**	
6	**Breather Fail Alarm proven**	
7	**Drawings Correct**	
8	**Wiring Terminals Correct**	
9	**Pressure Relief Diaphragm Intact**	
10	**All valves in correct position**	

INSULATING OIL TESTS

Sample Position	**Dielectric 40KV for 1min**	**Dielectric Breakdown**
Main Body Bottom		
Main Body Top		
Conservator		
Tap Change		
Earthing Tx Main Body Bottom		
Earthing Tx Main Body Top		
Earthing Tx Conservator		

Commissioning Engineer :	**Date :**
WPD Commissioning Engineer :	**Date :**

APPENDIX 6

CT details

SPC11-1 (30MVA)

SPC11-2 (45MVA)

SPC11-3 (60MVA)

SPC11-4 (90MVA)

SPC11-5 (30-30MVA)

Page revised 17 February 2017

APPENDIX A

SUPERSEDED DOCUMENTATION

This document supersedes EE: SPEC 1/5 dated November 2011 which has now been withdrawn.

APPENDIX B

ASSOCIATED DOCUMENTATION

ENA Technical Specification 35-3 Issue 2 2014

A hyperlink to that document is provided below for use by WPD staff.

S:\Acrobat\MA\EE\EE001\ENA_TS_35-3_Issue_2 (2014).pdf

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APPENDIX C

IMPACT ON COMPANY POLICY

The following changes have been made in this version:-
inclusion of inhibited oil

APPENDIX D

IMPLEMENTATION OF POLICY

This document shall be implemented on issue.

APPENDIX E

KEY WORDS

Transformer, CER, CMR, Tapchanger.