



GS 112-5

Guidance for Specification 112-5

TRANSFORMERS AND REACTORS

September 1993

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SCOPE AND PURPOSE This document specifies the general requirements for the design, selection and testing of Transformers and Reactors. Its purpose is for the specification of fit-for-purpose Transformers and Reactors at minimum cost. It is based on IEC Standards 76, 269 and 726											
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FOREWORD

Introduction to BP Group Recommended Practices and Specifications for Engineering

The Introductory Volume contains a series of documents that provide an introduction to the BP Group Recommended Practices and Specifications for Engineering (RPSEs). In particular, the 'General Foreword' sets out the philosophy of the RPSEs. Other documents in the Introductory Volume provide general guidance on using the RPSEs and background information to Engineering Standards in BP. There are also recommendations for specific definitions and requirements.

Value of this Guidance for Specification

This Guidance for Specification identifies the general requirements for the design, selection and testing of Transformers and Reactors.

It identifies the international standards that are applicable to Transformers and Reactors and further defines specific requirements from a range of options within the international standards.

Application

This Guidance for Specification is intended to guide the purchaser in the use or creation of a fit-for-purpose specification for enquiry or purchasing activity.

Text in *italics* is Commentary. Commentary provides background information which supports the requirements of the Specification, and may discuss alternative options. It also gives guidance on the implementation of any 'Specification' or 'Approval' actions; specific actions are indicated by an asterisk (*) preceding a paragraph number.

This document may refer to certain local, national or international regulations but the responsibility to ensure compliance with legislation and any other statutory requirements lies with the user. The user should adapt or supplement this document to ensure compliance for the specific application.

Specification Ready for Application

A Specification (BP Spec 112-5) is available which may be suitable for enquiry or purchasing without modification. It is derived from this BP Group Guidance for Specification by retaining the technical body unaltered but omitting all commentary, omitting the data page and inserting a modified Foreword.



Feedback and Further Information

Users are invited to feed back any comments and to detail experiences in the application of BP RPSE's, to assist in the process of their continuous improvement.

For feedback and further information, please contact Standards Group, BP International or the Custodian. See Quarterly Status List for contacts.



1. INTRODUCTION

1.1 Scope

- 1.1.1 This Specification gives BP requirements for power transformers, reactors and earthing transformers with highest voltage (U_m) up to and including 36 kV. It is based on the requirements of [IEC Standards 76, 289 and 726](#).

It is intended for use in conjunction with a functional specification (where required), associated Data Sheets and drawings (where required) which give specific project requirements.

- 1.1.2 The Specification is applicable to transformers and reactors for installation in the power generation and the power distribution systems of oil refineries, chemical plants, offshore drilling and production platforms, marketing depots, and similar locations.

- 1.1.3 The following transformers and reactors are excluded from this Specification:-

- (i) Those transformers listed under the exceptions to Clause 1 of [IEC 76-1](#).
- (ii) Equipment for use under extreme environmental conditions or for installation in hazardous areas.

- 1.1.4 Transformers and reactors purchased by BP may be used in radial or parallel arranged installations. They shall be suitable for switching by all normal switching devices including air, bulk/minimum oil, SF6 and vacuum break types of device.

1.2 Quality Assurance

Verification of the vendor's quality system is normally part of the pre-qualification procedure, and is therefore not specified in the core text of this specification. If this is not the case, clauses should be inserted to require the vendor to operate and be prepared to demonstrate the quality system to the purchaser. The quality system should ensure that the technical and QA requirements specified in the enquiry and purchase documents are applied to all materials, equipment and services provided by sub-contractors and to any free issue materials.

Further suggestions may be found in the BP Group RPSEs Introductory Volume

2. GENERAL

2.1 Documentation

- 2.1.1 This Specification shall be read in conjunction with an enquiry or purchase order and all Data Sheets associated therewith.
- 2.1.2 A manufacturer shall complete pages 3 and 4 of the BP Specification Data Sheet, a sample of which is attached to this Specification. (Appendix C)

2.2 Exceptions

- 2.2.1 Tenders for the supply of equipment against this Specification shall either include an unqualified affirmation regarding compliance with the Specification, or a complete list of specific exceptions.
- 2.2.2 A manufacturer may offer alternative proposals for price or technical advantage if he wishes, but such proposals shall form a supplement to the main tender.

3. DESIGN REQUIREMENTS

3.1 General

- 3.1.1 Liquid-immersed power transformers shall comply with the requirements of [IEC 76, Parts 1 to 5](#).
- 3.1.2 Dry type transformers shall comply with the requirements of [IEC 726](#).
- 3.1.3 Reactors and earthing transformers shall comply with the requirements of [IEC 289](#).
- 3.1.4 Where generator duty type is specified on the Data Sheets, the transformer shall be capable of accepting full rated voltage at 80% normal frequency in order to meet a generator auto start condition with AVR in circuit. The transformer shall be further capable of withstanding without damage the load rejection overvoltage specified on the Data Sheets.

[IEC 76-1](#) declares that the standard load rejection overvoltage shall be 1.4 times normal for 5 seconds. This would allow any saturation effects to take place which may affect unit protection schemes. The limiting condition for transformer design is considered to be the requirement for 100% Volts at 80% frequency to match the run up expectations of the generator and it could be possible to additionally declare a time expectation for this condition in order to ensure that the transformer were more exactly matched to the generator.

3.1.5 The transformer shall be capable of continuous duty at any frequency within the tolerance band declared on the Data Sheets.

3.2 Service Conditions

* The normal service conditions defined in [IEC 76-1](#), shall apply to all transformers and reactors, unless otherwise specified in the Data Sheet.

3.3 Insulation Levels

* Unless otherwise specified in the Data Sheet, insulation levels for all transformers and reactors shall be selected from Table II, List 1, of [IEC 76-3](#).

Where a transformer or reactor is to be directly connected to overhead lines, which do not incorporate surge arrestor equipment, the Rated Lightning Impulse Withstand Voltage should be selected from List 2.

In areas of the world where American practice is applied to power systems, the rated 'Lightning Impulse Withstand Voltage' should be selected from Table III of [IEC 76-3](#). On system voltages up to 15 kV the value shall be selected from the column headed 'Distribution Transformers', unless the transformer or reactor is directly connected to an overhead line which has no surge arrestor equipment, in which case the value should be selected from the column headed 'Other Transformers'.

3.4 Short Circuit Withstand

* The ability of transformers and reactors to withstand short circuit shall be as specified in [IEC 76-5](#). Unless higher values are specified in the Data Sheet, transformers and reactors will be located within systems whose short circuit power will be as specified in [IEC 76-5](#), Table II.

3.5 Rating

* 3.5.1 Rating(s) and associated cooling configuration(s) shall be as specified in the Data Sheet.

3.5.2 Liquid immersed transformers and reactors shall be continuously maximum rated, with cyclic duty capacity in accordance with [IEC 354](#).

3.5.3 Transformers and reactors shall be designed to ensure that under the cyclic loading conditions, as defined in [IEC 354](#), no limitations on rating by bushings, on load tap changers, or other auxiliary equipment, shall apply.

4. CONSTRUCTION

4.1 General

* 4.1.1 Transformers and reactors together with their fittings and control cabinets shall, unless otherwise specified in the Data Sheet, be suitable



for outdoor use, with a minimum degree of ingress protection IP 55 to IEC 529.

- 4.1.2 Materials employed in the transformer construction shall be arranged and/or treated in a manner suitable for the elimination of electrochemical corrosion.

Any aluminium to be mounted against the transformer tank would be expected to be fixed using galvanised or cadmium plated nuts and washers and to include stand-off washers. The most likely instance of this type of concern is where single core cables may be used for transformer secondary tails. Use of an aluminium gland plate to eliminate hysteresis losses can cause electrochemical problems when in contact with the steel cable box and when in contact with the brass glands. Such electrochemical problems may be removed by careful fixing detail and cadmium plating of the cable glands. Alternatively a non metallic gland plate could be used.

4.2 Mechanical Handling

- * 4.2.1 Unless otherwise specified in the Remarks Section of the Data Sheet, tank bases shall be designed to facilitate skid movement in any direction without necessitating the use of rollers, plates or rails. Where tank bases are of channel construction they shall be designed to prevent retention of water. Facilities shall be provided in tank bases for bolting down.
- 4.2.2 Lifting and jacking points shall be mounted on tank sides and so arranged as to prevent damaging stresses on tanks during lifting and jacking operations. Where there are separate lifting facilities for tank tops, cores and coils, these shall be removed or rendered unusable during transport and erection.
- 4.2.3 Where tank covers are removable they shall be so designed as to prevent distortion when lifted.
- 4.2.4 Where it is intended to use spreader bars for lifting all, or part of the tank, this requirement shall be identified on a suitable plate attached to the external surface of the tank.
- 4.2.5 The location of lifting and jacking points shall be identified on the general arrangement drawing.

4.3 Tank and Radiators

- 4.3.1 Liquid-immersed transformers and reactors shall be fitted with filling and draining orifices. The tank drain off orifice of conservator type transformers and reactors shall be fitted with a valve.
- 4.3.2 Any device affixed to the tank or the lid of the tank of a breathing type transformer shall be arranged in a manner that no direct penetration of the tank is possible by the fixing bolts, studs or screws. Any device

fixed to the tank or tank lid above any insulating liquid level shall be arranged with a stand off lip to prevent any possibility of water tracking to the interior of the tank.

Past experience has shown that there is always the possibility of water ingress into transformer tanks unless rigorous attention is paid to the way in which cover plates and other tank penetrations are arranged. Welded studs which penetrate the tank and are dependent upon the integrity of the weld for water protection are not found to be satisfactory. It is to be recommended that any inspection/other covers are arranged to have a stand up lip and a gasketed cover on the stand up lip. In this manner the cover may be fixed to the stand up lip by bolts which can penetrate the lip flange without penetrating the tank interior. This would avoid the possibility of water ingress into the tank.

- 4.3.3 The cover of a sealed tank transformer or reactor shall be welded to the tank. Gasketed joints, with the exception of those associated with pressure relief devices, shall be below the level of the cold liquid. Filling and draining orifices shall be sealed with screwed plugs.

It is to be noted that, despite the sealed tank design, there should be a drain cock on the tank. This would also facilitate the sampling of the insulating liquid for test purposes.

- 4.3.4 The expansion space above the liquid level in a sealed tank transformer or reactor shall be filled with either dry air or dry inert gas.

- 4.3.5 The construction and sealing arrangements of sealed tank transformers or reactors shall be such that the internal pressure in service shall not exceed 0.5 bar (g) negative and 0.7 bar (g) positive for a top liquid temperature range from -25°C to +100°C. The maximum and minimum operating pressures (negative and positive) shall be indicated on the rating plate.

- 4.3.6 Demountable cooling tubes or radiators shall be provided with isolating valves together with screwed plugs for venting and draining.

Sealed transformer designs are not expected to employ the technique of demountable cooling tubes owing to the need for ensuring a seal and inert gas topping which would prove difficult to achieve in a site situation.

- * 4.3.7 Tanks shall be fitted with at least one earthing boss complete with a 12 mm dia minimum brass bolt and phosphor bronze washers. The number of earthing bosses shall be as detailed in the Data Sheet.

Refer also to 4.1.1 for the need to take precautions against electrochemical corrosion.

4.4 Windings

- 4.4.1 Transformer or reactor windings shall be uniformly insulated.

- * 4.4.2 The conductor material shall be copper, unless otherwise approved by BP.

Copper is the generally accepted standard for transformer windings. However aluminium windings should be acceptable where the possibility of corrosion will not be significant and where cost advantages can be realised. For liquid insulated transformers aluminium windings should be satisfactory in any application however it is likely that the transformer will be connected to copper cabling.

4.5 Insulating Liquid

- 4.5.1 Where practicable, transformers or reactors shall be shipped filled with insulating liquid. Where tanks require to be shipped unfilled, they shall be designed for vacuum filling in the field. Auxiliary compartments such as expansion tanks, when not designed for vacuum filling, shall be so designated and provided with isolating valves.

- * 4.5.2 Oil shall be of the mineral type complying with the test requirements of [IEC 296](#), unless otherwise specified in the Data Sheet. Maximum water content shall be as specified in [IEC 296](#) Table 1.

For offshore use Silicon Fluid insulation is preferable to mineral oil as it offers less fire risk. Other fluids which offer reduced fire risk would also be acceptable in principle although the questions of cost, toxicity, impact on physical size and weight, reliability over long timeframes and ease of handling should be considered in the comparison.

- 4.5.3 When insulating liquid other than mineral oil is used, the rating plate shall include details of the liquid used.

- 4.5.4 Polychlorinated biphenyl-based insulating liquid shall not be used.

4.6 Winding Termination's and Connections

- 4.6.1 Tappings and winding connections shall be based on the principles specified in [IEC 76-4](#).

- 4.6.2 Internal connections and those passing through the tank wall, together with any associated gaskets, shall be situated below the cold liquid level. Means shall be provided to prevent rotation of all terminal stems.

- 4.6.3 Terminals for receiving external connections shall be marked in accordance with [IEC 616](#) and shall be suitable for bolted type cable lugs. Connections having pinch screws bearing directly on the conductor are not acceptable.

4.7 Bushings

- 4.7.1 Bushings shall comply with the requirements of [IEC 137](#). Creepage distances shall be suitable for heavily polluted atmospheres.

- * 4.7.2 Unless otherwise specified in the Remarks Section of the Data Sheet, exposed bushings connected to overhead line systems shall be equipped with arcing horns or surge diverters.

The appropriate settings or specifications which are appropriate for the overhead line should be advised to the transformer manufacturer in order for the correct type or setting to be provided.

4.8 External Finish

- 4.8.1 Details of the manufacturer's standard painting system shall be submitted to BP for approval.
- * 4.8.2 Colour shall be as specified in the Data Sheet.

5. FITTINGS

5.1 General

- * 5.1.1 Fittings shall be supplied and located as shown in the Data Sheets. If the purchaser does not indicate his desired locations for these fittings the manufacturer shall indicate his proposed locations on the Data Sheet.
- 5.1.2 If the manufacturer considers that fittings not specified by the purchaser should be provided, the requirements of Clause 3.2 shall apply.
- 5.1.3 Control and Alarm Contacts
- 5.1.3.1 The settings on instruments and protective relays shall be directly visible. The contacts shall be suitable for making or breaking not less than 150 VA between the limits of 30 V and 250 V a.c. or d.c.
- 5.1.3.2 The contact insulation and that of associated terminals shall be capable of withstanding an applied voltage test of 2 k V r.m.s. for 1 minute, both between individual circuits, and between individual circuits and the instrument or relay case.

5.2 Disconnecting Chamber

- 5.2.1 The transformer shall include means for testing the cables connected either to the HV or the LV windings. Any Disconnecting chamber provided for this purpose shall be separate from the main transformer or reactor tank and for sealed tank designs, it shall not be possible for an interchange of liquid with the main tank.

It is common that liquid-immersed transformers and reactors rated 1000 kVA and above have liquid filled disconnecting chambers fitted to high voltage terminations



exceeding U_m 1000 V. However air filled disconnection chambers would be satisfactory provided there were negligible risk of flasher due to contamination or overheating.

Disconnecting means for voltages of up to and including U_m 1000 V may be included as part of the termination cable box in the form of bolted links. In general the disconnection of cables from transformer bushings is considered acceptable for test purposes provided that in doing so undue stress is not placed upon either cable or on the transformer bushing.

- 5.2.2 Liquid filled disconnecting chambers shall be provided with separate drainage facilities and an external indication of the liquid level. All terminals and their gaskets shall be situated below the cold liquid level.

5.3 Main External Termination's

- * 5.3.1 These shall be as specified in the Data Sheet.

- 5.3.2 Cable boxes shall be so arranged that they can be removed from the transformer or reactor tank without breaking the cable seal or affecting the sealing of the tank.

This provision should enable very rapid transformer replacement. However it should be recognised that this provision would be effective only in the event that replacement transformers arranged for cable boxes to be located in the same positions on the tank as well as being of the same pattern. Therefore where replacement transformers are being specified, the pattern and location of the cable boxes relative to the tank dimensions must be additionally specified.

- * 5.3.3 Where an air filled cable box is fitted, the terminal arrangement shall be phase insulated, phase separated, or phase segregated, as specified in the Data Sheet. Means shall be provided in all three types of cable box to facilitate fault pressure relief in such a manner as to direct fault arc emissions between the cable box and the main tank, to minimise danger to personnel.

- * 5.3.4 Cable boxes shall be provided with a gland plate suitable for the cables specified in the Data Sheets. The gland plate shall be equipped with cable glands suitable for the cables specified in the Data Sheet.

It is considered that a gland plate no less than 8 mm in thickness should be provided. For single core cables, a non magnetic gland plate shall be provided. Aluminium or aluminium alloy used as a gland plate will eliminate magnetic hysteresis loss in the gland plate but some small eddy current loss will remain. The resulting heating effect may be found acceptable.

- * 5.3.5 When a bus duct termination is required, it shall be air filled and shall be phase insulated, phase separated, or phase segregated as specified in the Data Sheet.

Prior to specifying the transformer, the design engineer needs to have investigated the options of high current termination to the transformer and be in a position to

provide the detail required for bus ducting should this prove the most economic choice.

5.4 Current Transformers

- * 5.4.1 If specified in the Data Sheet, current transformers, which will be supplied by the purchaser to the manufacturer, shall be fitted.

Typically current transformers may be mounted in the neutral terminal as part of a Restricted Earth Fault arrangement.

- 5.4.2 Current transformers shall not be installed within the main tank but within either the appropriate disconnecting chamber or within a separate chamber arranged in a manner similar to the disconnecting chamber and containing the same insulating medium.

- 5.4.3 Means shall be provided to permit primary injection testing of the current transformers.

5.5 Tap Changers

5.5.1 Off-circuit Tap Changers

Off-circuit tap changers should be fitted to all transformers and reactors where it is anticipated that after the optimum tapping is selected there will be no further requirement to alter the tapping except under exceptional circumstances.

- * 5.5.1.1 Where off-circuit tap changing equipment is specified, the higher voltage winding shall be provided with one principal and four constant kVA tapplings to compensate for supply voltage variations of $\pm 2\%$ and $\pm 5\%$, unless specified otherwise in the Data Sheet.

Where a transformer reactance is specified to limit the amount of fault current which can flow, there can be a voltage regulation appreciably above that which can be compensated by the standard range of tapplings. In this circumstance a differing tapping range may be specified. Under such circumstances it is also necessary to specify the maximum HV voltage for the minimum tap position in order to be assured of having the appropriate flux design for the transformer when operation on maximum boost.

- 5.5.1.2 Off-circuit tap change tapplings shall be selected by means of an externally operated switch which shall be provided with a clearly marked position indicator and mechanical stops to prevent overrunning. The tap switch shall be pad lockable with the switch only on a definite tapping. Numbering of the tap positions shall be such that an increase in number corresponds to a decrease in the effective number of turns on the tapped winding.

It should be noted that the tap switch should not be operated unless the transformer has been completely de-energised.

- 5.5.1.3 Off-circuit tap changers on dry type transformers and reactors may be in the form of links. The position of these links shall be observable from outside the transformer or reactor enclosure.
- 5.5.2 On load Tap Changers
- * 5.5.2.1 Where on load tap changers are required, they shall comply with [IEC 214](#) and [IEC 542](#). The tapping range, number of taps and winding to be tapped, shall be as specified in the Data Sheet. The high speed, resistance type of tap changer is preferred.
- Normally, only main incoming supply transformers receiving power from a public utility and rated 5 MVA and above should be fitted with on-load tap changers and specific attention should be given to voltage profiles.*
- The use of on-load tap changers fitted to site distribution transformers should be permitted only if it is anticipated that plant non-transient voltage variations of greater than $\pm 6\%$ could occur as a result of normal process operations and also that there would be process disruption if a transformer was switched out of circuit to alter the tapping.*
- 5.5.2.2 The on load tap changer shall be designed to ensure that when a step movement has commenced, it shall be completed independently of the operation of the control switches or relays. Limit switches and mechanical stops shall be provided to prevent the possibility of overrunning the mechanism.
- Where transformers with on load tap changers will be operated in parallel, consideration should be given to the provision of an out of step protection for the automatic tap change feature, This would ensure that when selected to auto/follower, the transformer tapping action would cease and alarm should the transformers experience more than 2 tap steps out of sequence.*
- 5.5.2.3 A mechanically operated device shall indicate the number of the tap position in use. Numbering of tap positions shall be such that an increase in number corresponds to a decrease in the effective number of turns on the tapped winding. A device shall be fitted to the tap change mechanism to indicate the number of operations completed.
- * 5.5.2.4 Where automatic or remote voltage control of the tap changer is required, the associated equipment shall be the subject of a separate specification by the purchaser.
- A supplementary specification should be prepared to indicate the requirements for control. See also the commentary for section 5.5.2.2 above. The requirements for control including selector switches, control relay provision and position should be specified together with the requirements for alarms.*

5.6 Conservators

5.6.1 Any conservators shall be removable for transport purposes and shall be equipped with a liquid level indicator, liquid filling hole with screwed plug, combined filter and drain valve, detachable end plate, lockable isolating valve and dehydrating breather.

5.6.2 The conservator, complete with sump and drain valve, shall be in such a position as not to obstruct the electrical connections to the transformer or reactor. It shall have a capacity of not less than 8% of the total cold liquid volume in the main tank and cooling equipment.

5.6.3 A sump shall be provided to prevent sludge and moisture being drawn into the transformer or reactor.

This may be achieved either by extending the feed pipe inside the conservator vessel, or by arranging its entry through the conservator wall.

5.6.4 Conservators shall be fitted with a prismatic or magnetic liquid level indicator which shall be readable from ground level.

* 5.6.5 Means shall be provided for directing the emission of liquid from the conservator breather in the direction specified in the Data Sheet.

Any emissions from the transformer under fault or other conditions needs to be away from the area likely to have personnel present.

5.7 Valves

5.7.1 Valves shall be provided with a position indicator which shows clearly whether the valve is in the open or closed position.

5.7.2 Means shall be provided to padlock each valve in the 'open' or 'closed' position.

5.7.3 Drain valves and those provided for the connection of mobile liquid filtration equipment shall be provided with screwed plugs.

5.8 Dehydrating Breather

5.8.1 Liquid level containers of the breathing type shall be fitted with a dehydrating breather. The breather shall be accessible from ground level.

Silica gel type dehydration breathers are acceptable. Any alternative to this type should be viewed in comparison to the ease of replacement, ready inspection capability and maintenance of this type of breather.

5.8.2 The design of the breather shall be such that it shall not require recharging at less than six month intervals under the ambient conditions specified in the Data Sheet.

5.8.3 A protective mesh screen with a minimum degree of ingress protection IP 20 to IEC 529, shall be provided around the breather.

5.9 Sunshades

* When specified in the Data Sheets, detachable sloping sunshades shall be fitted over transformers or reactors, to protect them from excessive temperatures due to direct sunlight.

The provision of sunshades is considered necessary only in tropical areas. However where it is expected that solar radiation will be considerable, the merit of sunshades should be investigated prior to completion of the specification for the transformer.

5.10 Thermometer Pocket

5.10.1 Thermometer pockets shall be provided for all liquid filled transformers. These shall have an internal diameter of not less than 15 mm, an internal depth of not less than 115 mm and shall be equipped with a sealing cap held captive by an external chain.

5.10.2 The pocket shall be welded into the transformer or reactor tank wall in such a position that a thermometer will always indicate the top liquid temperature.

5.11 Gas and Liquid Actuated Relays

* 5.11.1 Gas and liquid actuated relays shall be fitted for the protection of conservator type liquid-immersed transformers and reactors. They shall be of the Bucholz type, unless additional specification is made in the Remarks Section of the Data Sheet. They shall be equipped with bolted flange connections to facilitate their removal for maintenance or repair. The design of the relay and its mounting arrangement shall be such that it will not sustain damage due to vibration under service conditions. The relay shall be equipped with facilities for permitting the injection of the appropriate liquid or air on site, for testing purposes.

The Bucholz should be of the gas and oil initiated type in order to be of maximum sensitivity for the detection of slow gas generation and high surge generation.

Additional provision for protection of the transformer tank may include a pressure relief device to relieve pressure by venting liquid through the tank wall and into a banded area. For large transformers where Bucholz devices and pressure relief disks may not be sufficient to protect the transformer tank in the event of internal arcing, additional pressure relief devices (Qualitrol) may be specified for fitting in the tank wall.

For transformers with oil immersed tap changer compartments, the Bucholz relays should also be arranged to act should there be a surge in that compartment. This may take the form of a separate Bucholz relay for that compartment.

5.12 Pressure Relief and Indication Devices

- 5.12.1 Pressure relief devices shall be fitted to all liquid-immersed transformers and reactors.

For breathing type transformers, the pressure relief device is expected to comprise a vent connected to the top of the tank in the form of a chimney and sealed by a membrane which would burst under pressure. This method of pressure relief would be effective only for relatively small transformer ratings and a Qualitrol device may be additionally required. (See commentary under 5.11.1 above).

- 5.12.2 Pressure relief devices fitted to sealed tank transformers and reactors shall be of the resetting rapid acting relief valve type fitted with a mechanical operation indicator. The device shall operate at a static pressure appropriate for the protection of the tank and shall be mounted on the tank cover. The device shall be fitted with at least one pair of changeover contacts.

It is expected that the pressure relief device would be set to operate at not exceeding 0.7 bar (g). However the actual setting should be to the requirements of the transformer tank design.

- * 5.12.3 Means shall be provided for directing any emission of liquid from the relief device in the direction specified in the Data Sheet.

- * 5.12.4 When specified in the Data Sheet, sealed tank transformers and reactors shall be fitted with an indicating device in the form of a pressure vacuum gauge, equipped with one set of changeover alarm contacts.

Where considered appropriate this indicator would provide information regarding the integrity of the oil seal. However the pressure indication at any time would be dependent upon the transformer load and the ambient temperature. The selection of this form of indication is not generally recommended and would be considered most useful if the pressure device were constantly monitored by a control system to indicate trends and alarm unexpected or uncorrelated changes.

5.13 Liquid Level Gauge

Liquid-immersed transformers and reactors shall be fitted with a liquid level gauge preferably of the prismatic or magnetic type. The liquid level corresponding to an ambient of 15°C, no load together with the maximum and minimum levels, shall be permanently marked on the gauge.

5.14 Liquid and Winding Temperature Indicators

- 5.14.1 General

- 5.14.1.1 Temperature indicators shall be glass fronted to permit readings to be taken, and so designed that they will not sustain damage or maloperate due to vibration under service conditions.
- 5.14.1.2 The dials of temperature indicators shall have a preferred scale range from 30°C to 150°C (liquid-immersed transformers and reactors) and 30°C to 250°C (dry type transformers and reactors), uniformly divided. They shall indicate the temperature of the sensing element to a tolerance of $\pm 1\%$ of the difference between the highest and lowest scale reading.
- 5.14.1.3 Temperature indicators shall be provided with a maximum temperature pointer, together with an adjustable pair of changeover alarm contacts.
- 5.14.2 Liquid Temperature Indicators
- * 5.14.2.1 When specified in the Data Sheet, liquid temperature indicators shall be fitted and shall be arranged to indicate the temperature of the hottest liquid in the transformer or reactor.
- Liquid temperature indicators should be provided on all liquid immersed transformers and reactors rated 800 kVA and above.*
- 5.14.2.2 Alarm contacts shall close at the temperature value specified in Table 1, and open when the temperature has fallen by not more than 7°C.
- 5.14.3 Winding Temperature Indicators
- * 5.14.3.1 When specified in the Data Sheet, winding temperature indicators shall be fitted. For liquid-immersed transformers and reactors, the indicators shall be preferably of the thermal image type. For dry type transformers and reactors the indicators shall either be of thermal image type, or be operated by temperature sensors placed adjacent to hot spots in the windings.
- Winding temperature indicators should normally only be provided on liquid-immersed transformers and reactors rated 10 MVA and above, and on dry type transformers and reactors rated 2 MVA and above.*
- 5.14.3.2 Winding temperature indicators shall be equipped with sets of electrically independent changeover contacts for alarm and trip purposes.
- 5.14.3.3 Alarm and trip contacts shall close at the temperature values specified in Table 1. Both sets of contacts shall open when the temperature has fallen by not more than 7°C.
- * 5.14.3.4 Where forced cooling or provision for forced cooling is specified in the Data Sheet, either the winding temperature indicator shall incorporate

another set of electrically independent contacts for control of the forced cooling equipment, or a second winding temperature indicator shall be fitted. The control contacts shall be adjustable to close between 50°C and 100°C for liquid immersed types and between 70°C and 180°C for dry-types, and to reopen when the temperature has fallen by 15°C to 30 °C. The nominal settings for contacts shall be as shown in Table 2.

The need for forced cooling of the insulation liquid of a transformer would be determined as part of the overall Power Systems design. See the commentary to section 6.1.1 below.

5.15 Ancillary Equipment Termination's

5.15.1 Transformer and reactor mounted ancillary equipment such as pressure relays or sensors, temperature relays or sensors, flow switches, and current transformers, which require external wiring, shall be wired to a marshalling box mounted on the side of the transformer or reactor and accessible from ground level. The marshalling box shall give a degree of protection of at least IP 55 to [IEC 529](#). Every contact of each relay, sensor or switch shall be wired out to the marshalling box, as shall every tapping of each current transformer.

5.15.2 Wiring to the marshalling box shall be carried out using 600/1000 V rated cables having a minimum of 2.5 mm² stranded copper conductors.

Armoured multicore cables would normally be expected for this service. However where the transformer would be weather protected, conduit connections should prove acceptable.

5.15.3 Current transformer terminals in the marshalling box shall be of the shorting type and unless otherwise specified shall be sized to terminate 6 mm² copper conductors.

It is expected that the cable used to interconnect the transformer mounted CT to the rest of the protection or indication circuit could be up to 6 mm².

5.15.4 Wiring to the marshalling box shall be weatherproof. Cable entries shall be either from the bottom or sides of the marshalling box. A blank, undrilled gland plate shall be provided at the bottom of the marshalling box for the purchaser's external cabling.

5.15.5 Where forced cooling, or on load tap changing equipment is provided, the associated control cabinet may also be used as the marshalling box for ancillary equipment termination's.

6. FORCED COOLING EQUIPMENT

6.1 General

- * 6.1.1 Any requirement for forced cooling, and whether this is to be fitted at the time of initial purchase or to be added at a later date, shall be as specified in the Data Sheet.

Forced cooling or provision for forced cooling should only be considered under the following circumstances:-

- (i) *Where it is anticipated that there could be a future plant load increase.*
- (ii) *Where transformers for use on a triple radial system could under certain operating conditions experience higher-than normal rated loads.*
- (iii) *Where a plant which usually runs as a base load has occasional periods of high load demand that would be outside the normal cyclic loading capabilities or the transformer or reactor.*
- (iv) *Where a seasonal high ambient temperature would cause transformers or reactors to be derated.*

- 6.1.2 If provision for forced cooling is specified, the manufacturer shall allow for this in the transformer design. The medium for forced cooling shall also be as specified in the Data Sheet.

In particular the transformer needs to have temperature control fitted and wired to the marshalling point. Further, the means of mounting and maintaining the fans/pumps needs to be considered together with the provision of cable boxes for the fan/pump power supply. Where required, the provision of local emergency stop push buttons shall be specified to satisfy any local safety requirements.

6.2 Forced Air Cooling

When forced air cooling is specified, this shall be by means of electric motor driven fans. All necessary air ducting and fan protective covers shall be provided and designed to prevent accidental contact with fan blades or other moving parts and to prevent the ingress of harmful matter.

The choice of forced cooling would be part of the overall Power Systems design.

6.3 Forced Liquid Cooling

Where forced liquid cooling is specified in the Data Sheet, this shall comprise either an integral cooling circuit, or a separate liquid cooling circuit. Both types of forced liquid cooling circuits shall be externally cooled by forced or naturally circulated air or water as specified in the Data Sheet.

- 6.3.1 It shall be possible to isolate and remove separate coolers without reducing the level of liquid in the main tank.

6.3.2 The circuit of each separate cooler shall be provided with the following:-

- (a) an isolating valve at the liquid inlet and outlet.
- (b) a liquid filling hole with screwed plug.
- (c) a combined filter and drain valve.
- (d) an in line flow switch in the inlet of the cooler complete with at least one set of changeover contacts.

6.3.3 Water cooled separate coolers shall be provided with an in line flow switch in the water inlet to the cooler in addition to the items listed in clause 7.3.3. The water inlet flow switch shall be provided with at least one set of changeover contacts.

6.3.4 It shall be possible to remove the pump and motor from both integral and separate liquid cooling circuits without having to draw off liquid from the main tank or the cooling plant.

6.4 Motors

* Unless alternative specification is given in the Data Sheets, motors shall comply with the requirements of [IEC 34](#) for general purpose, continuously rated, weatherproof machines, selected for reliable service under the ambient conditions noted in the Data Sheets.

In the interests of efficiency and economy, the provision of BP Group [GS 112-3](#) 'LV Motors' is not considered to be necessary for machines which may form part of the transformer manufacturers special purchase and which would not be expected to operate in a continuous manner except under unusual circumstances. It is expected that the transformer vendor would operate a quality control which would assure that good quality electrical machines form part of his supply. However where it is considered that higher integrity machines than those normally supplied by the transformer vendor is called for, or compatibility with other machines on the site should be a priority, the Data Sheets should be completed to require machines to conform to the requirements of BP Group [GS 112-3](#). Under these circumstances, a copy of BP Group [GS 112-3](#) should accompany the transformer specification together with any Data Sheet entries from BP Group [GS 112-3](#) which may be required.

6.5 Control Gear

* Motor starter gear will be provided by the purchaser.

7. NOISE

- * 7.1 Noise level limits for naturally cooled liquid-immersed transformers and reactors shall be as shown on Fig. 1 unless otherwise specified in the Remarks Section of the Data Sheet.

The noise levels detailed on Fig 1 are based upon common standards applied in the UK Electricity Supply Industry and reflect an optimum approach to the question of transformer noise applicable to the environmental concerns reflected by that business. Within the Oil Industry, noise would normally form part of an overall site specification or target. It would be unlikely that the transformer noise would be dominant in an overall assessment and therefore it is the contribution that the transformer gives to the total noise level that needs to be addressed. In order to ease that assessment and to avoid the need for the provision of specific data for each transformer on site, the standard noise levels given in Fig 1 should be followed. However it should be recognised that under most circumstances, noise limits for transformers may not be a factor which attracts significant importance and a manufacturers standard which differs from the values in Fig 1 may be acceptable (provided that the alternative noise levels do not reflect a tardy construction).

For some transformer applications, e.g. for Variable Speed Drives, the nature of the transformer load would affect the noise pattern of the transformer. For such applications the noise performance may be special for that transformer application.

- * 7.2 Noise level limits for naturally cooled enclosed or non enclosed dry type transformers and reactors shall be limited to 6 dB (A) in excess of those values given on Fig. 1 unless otherwise specified in the Remarks Section of the Data Sheet.

See commentary to 7.1 above for instances where differing sound levels could be specified. Dry type transformers may form an integral part of an equipment installation and this transformer specification may form part of a larger equipment supply specification in which case the question of noise may be associated with the overall performance of the equipment.

- 7.3 Where forced cooling methods are specified the noise level limits shall be subject to agreement between the purchaser and the manufacturer prior to placement of the order.

The ONAN performance of the transformer could be to the 'standard' performance requirements and the ONAF or OFAF would therefore be to the specific agreement. There are no specific guidelines for acceptability however it can be important that sound levels are determined at transformer purchase stage and subject to contractual agreement in order that confidence can be placed in figures which may form part of an environmental noise analysis.

- 7.4 Where the requirement for a noise test is specified in the Data Sheet this test shall be performed at the manufacturer's works in accordance with [IEC 551](#).

8. TESTS

- 8.1 Routine tests shall be performed on all completed transformers and reactors. For liquid-immersed transformers, routine tests shall be as detailed in IEC 76-1. For dry type transformers, routine tests shall be as detailed in IEC 726. For reactors and earthing transformers, routine tests shall be as detailed in IEC 289.
- * 8.2 Unless otherwise specified in the Data Sheet, the Rated Short Duration Power Frequency withstand voltage shall be selected from Table II of IEC 76-3, for all types of equipment.
- * 8.3 Type tests and special tests shall be performed on selected transformers and reactors. The tests to be carried out shall be identified and shall be formally agreed with the purchaser.

For liquid-immersed transformers the required tests should be selected from those detailed in IEC 76-1. Type tests for identical transformers will be acceptable. . For dry type transformers the required tests will be selected from those detailed in IEC 726. For reactors and earthing transformers the required tests will be selected from those detailed in IEC 289. The Rated Lightning Impulse Withstand Voltage shall be selected from List 1 of Table II IEC 76-3 unless otherwise advised elsewhere in this document. (See section 3.3).

NOTE: Where reference is made in IEC 289 to clauses in IEC 76, IEC 76-1 shall be taken as the reference document. Test clauses shall be cross referenced, where necessary, to the relevant clause of IEC 76-1.

- 8.4 Completed sealed tank transformers and reactors shall be filled with liquid and subject to a hydrostatic pressure test of 1 bar (g) without loss of pressure, for 24 hours.
- 8.5 Completed conservator type transformers and reactors shall be subjected to a hydrostatic pressure test of 0.3 bar (g) without loss of pressure, for 24 hours.

9. DOCUMENTATION

9.1 Data Sheet

All items in the Data Sheet designated 'To be completed by the manufacturer' shall be completed at the time of enquiry.

9.2 Tender Documentation

The manufacturer shall include with his tender a general arrangement drawing of the equipment on which the following information shall be included as a minimum:-

Overall dimensions
Base/skid dimensions
Lifting arrangements
Jacking points
Total weight (including liquid if applicable)
Cable entry positions
Volume of liquid (if applicable)
Location of ancillary equipment.

9.3 Certified Drawings

Subsequent to order and prior to despatch from the manufacturer's works a certified general arrangement drawing, a diagram of the winding connections and a drawing of the rating plate including the impedance voltage data, shall be forwarded to the purchaser from the manufacturer.

9.4 Test Documentation

On completion of tests and before despatch of the transformer from the manufacturer's works a full set of test documents shall be supplied to the purchaser by the manufacturer. The test documents shall include all of the test data for all tests agreed between the purchaser and the manufacturer in addition to the routine test data.

9.5 Final Documentation

In addition to the documentation requirements detailed in the order the manufacturer shall include in the transformer package when despatched one copy of each document listed below:-

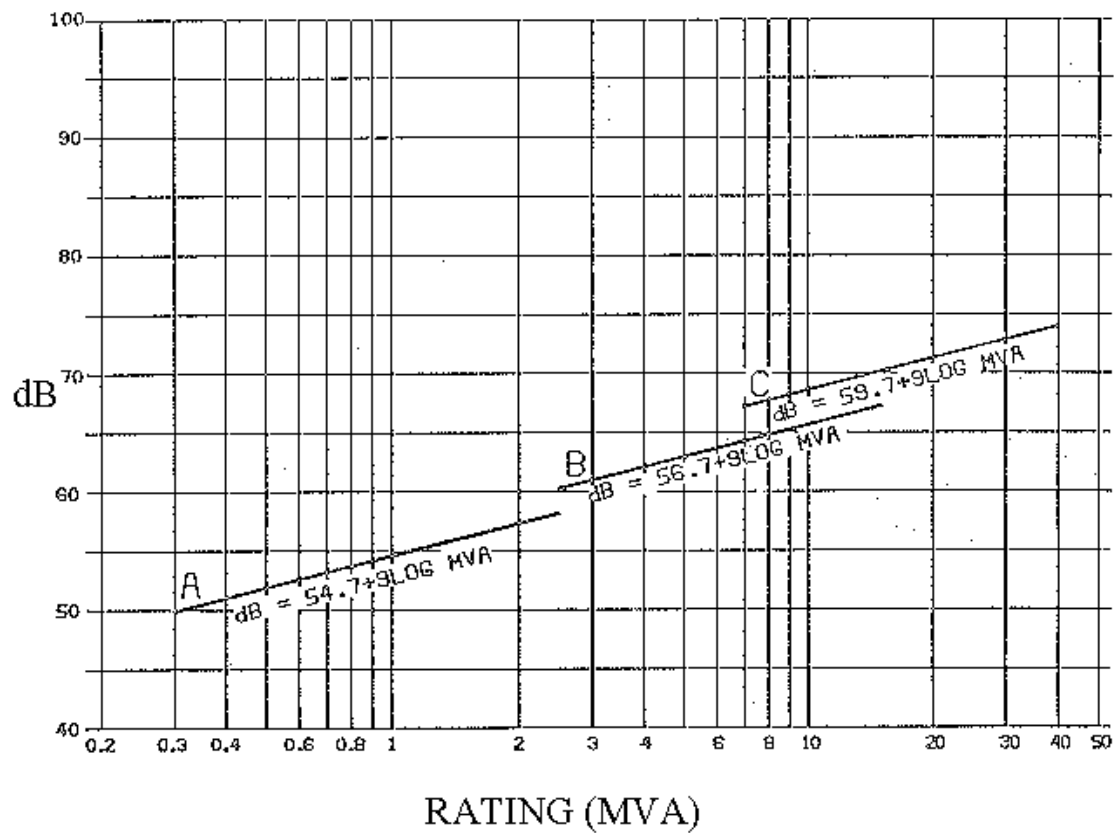
- (i) General Arrangement Drawing
- (ii) Test Certificates
- (iii) Installation and Commissioning Instructions
- (iv) Maintenance Instructions

TABLE 1
ALARM AND TRIP TEMPERATURE SETTINGS

ITEM	TYPE OF TRANSFORMER	INSULATION CLASS	ALARM °C	TRIP °C
Windings	Dry Type	A	100	115
		E	115	130
		B	120	135
		F	140	155
		H	165	180
		C	190	205
Windings	Liquid Immersed	A	105	120
Liquid	Liquid-Immersed	A	100	-

TABLE 2
FORCED COOLING NOMINAL TEMPERATURE SETTINGS

TYPE OF TRANSFORMER OR REACTOR	INSULATION CLASS	SWITCH-ON °C	SWITCH-OFF °C
Dry Type	A	85	60
	E	100	75
	B	105	80
	F	125	100
	H	150	125
	C	175	150
Liquid-Immersed	A	90	65



CURVE 'A' = 0.3 to 2.5 MVA, to 11KV
ONAN COOLED -
COOLING TUBES OR
TANK MOUNTED RADIATORS

CURVE 'B' = 2.5 to 15 MVA, TO 33KV
ONAN COOLED -
TANK MOUNTED RADIATORS

CURVE 'C' = 7 TO 40 MVA, TO 33KV
ONAN COOLED -
SEPARATE RADIATORS.

SOURCE: B.E.B.S. - T2 (1966)

FIGURE 1
NOISE LEVELS, 'A' WEIGHTING

DEFINITIONS AND ABBREVIATIONS**Definitions**

Standardised definitions may be found in the BP Group RPSEs Introductory Volume.

Abbreviations

IP	Ingress Protection
ONAN	Oil Natural Air Natural
ONAF	Oil Natural Air Forced
OFAF	Oil Forced Air Forced
U_m	Maximum value of highest voltage

LIST OF REFERENCED DOCUMENTS

A reference invokes the latest published issue or amendment unless stated otherwise.

Referenced standards may be replaced by equivalent standards that are internationally or otherwise recognised provided that it can be shown to the satisfaction of the purchaser's professional engineer that they meet or exceed the requirements of the referenced standards.

- = denotes an identical standard: the British Standard is identical in every detail with the corresponding international standard or standards, and is published with dual numbering.
- =?/ denotes a technically equivalent Standard: the British Standard is in all technical respects, the same as the corresponding international standard or standards; the wording and presentation may differ quite extensively.
- ± denotes a related standard: the British Standard covers subject matter similar to that covered by the corresponding international standard or standards.

Where a British Standard only is listed, no corresponding international standard exists.

International Standards

IEC 76 (± BS 171)	Power transformers
IEC 137	Bushings for alternating voltages above 1000V
IEC 214 (= BS 4571)	On load tap changers
IEC 289 (± BS 4944)	Reactors
IEC 296 (=?/ BS 148)	Unused insulating oils for transformers and switchgear
IEC 354	Loading guide for oil-immersed transformers
IEC 529 (= BS EN 60529)	Degrees of protection provided by enclosures
IEC 542 (= BS 5611)	Application guide for on-load tap-changers

IEC 551 (= BS 6056)	Measurement of transformer and reactor sound levels
IEC 606 (= BS 5953, Part 1)	Application guide for power transformers
IEC 616	Terminal and tapping markings for power transformers
IEC 726	Dry type power transformers

BP Group Documents

BP Group [GS 112-3](#) Low Voltage Induction Motors
(replaces BP Std 221)

NOTE: If there are differing requirements between an IEC Standard and an equivalent British Standard, the manufacturer shall bring this to the attention of BP and state the basis on which he will quote or has quoted.

APPENDIX C

INDENT/PURCHASE ORDER NUMBER To be completed in block capitals							
TO BE COMPLETED BY PURCHASER							
1	INSTALLATION SITE						
2	PLANT TAG NUMBER						
3	SERVICE CONDITIONS if exceeding IEC 76-1			ALTITUDE		m	
				MAX AIR TEMP		°C	
				MIN AIR TEMP		°C	
				AVERAGE DAILY AIR TEMP		°C	
				AVERAGE ANNUAL AIR TEMP		°C	
				COOLING WATER INLET TEMP		°C	
				SUPPLY VOLTAGE SYMMETRY			
				HARMONIC CONTENT			
4	EQUIPMENT DESCRIPTION			SERIES REACTOR		EARTHING TRANSFORMER	
				AUTO TRANSFORMER		POWER TRANSFORMER	
5	DUTY			DISTRIBUTION		UNIT GENERATOR	
				UNIT MOTOR			
6	TYPE			LIQUID-IMMERSED SEALED		LIQUID-IMMERSED CONSERVATOR	
				DRY TYPE ENCAPSULATED		DRY TYPE NON- ENCAPSULATED	
7	INSULATING LIQUID			MINERAL OIL		SYNTHETIC LIQUID	
8	LOCATION & INGRESS PROTECTION			OUTDOOR		INDOOR	
9	MAXIMUM RELATIVE HUMIDITY					% @ °C	
10	TYPE OF COOLING TO IEC 76-2 (TABLES I & II) OR IEC 726 (TABLES II & III)						
11	FREQUENCY & TOLERANCE			Hz		- % + %	
12	UNBALANCED LOAD			YES/NO			
13	LOAD REJECTION OVERVOLTAGE (GENERATOR TRANSFORMER)			%			
14	SYSTEM SHORT CIRCUIT APPARENT POWER IF GREATER THAN TABLE II OF IEC 76-5			MVA			
15	NUMBER OF PHASES						
16	NUMBER OF WINDINGS						
17	RATED POWER (NATURAL) (FORCED)			PRIMARY		SECONDARY	
				kVA		kVA	
18	RATED VOLTAGE			kV		kV	
19	HIGHEST VOLTAGE TO IEC 76-3 (RMS)			kV		kV	
20	RATED SHORT DURATION POWER FREQUENCY WITHSTAND VOLTAGE TO IEC 76-3 (RMS)			kV		kV	
21	RATED LIGHTNING IMPULSE WITHSTAND VOLTAGE TO IEC 76-3 (PEAK)			kV		kV	
22	SYSTEM EARTHING						
23	NEUTRAL TERMINAL			YES/NO		YES/NO	
24	WINDING CONDUCTOR			Cu		Cu	
25	REMARKS			NONE		ATTACHED	
Rev	Date	Remarks	By	App	DATA SHEET		
					SHEET 1 of 4		

INDENT/PURCHASE ORDER NUMBER To be completed in block capitals							
TO BE COMPLETED BY PURCHASER							

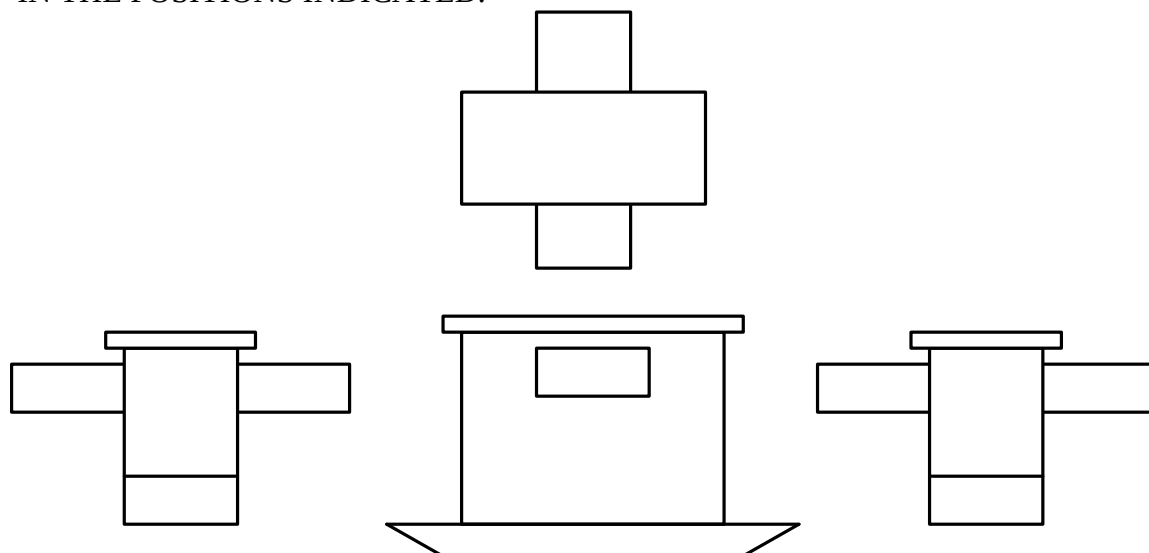


		PRIMARY	SECONDARY	TERTIARY
26	MAIN EXTERNAL TERMINATION DETAILS	EXPOSED BUSHINGS	EXPOSED BUSHINGS	EXPOSED BUSHINGS
		BUSDUCT	BUSDUCT	BUSDUCT
		CABLE BOX	CABLE BOX	CABLE BOX
27	CABLE BOX TYPE			
28	BUS DUCT TYPE			
29	CONDUCTOR MATERIAL	Cu/Al	Cu/Al	Cu/Al
30	CONDUCTOR SIZE			
31	NUMBER OF CABLES & TYPE			
32	CABLE STANDARD			
33	CABLE RATING	V	V	V
34	NUMBER OF CORES/CABLE			
35	NUMBER OF CORES/PHASE			
36	TAP CHANGER REQUIRED	YES/NO	YES/NO	YES/NO
37	TAP CHANGER TYPE	OFF CIRCUIT	OFF CIRCUIT	OFF CIRCUIT
		ON LOAD	ON LOAD	ON LOAD
		LINKS	LINKS	LINKS
38	TAPPINGS REQUIRED	- %	- %	- %
		+ %	+ %	+ %
39	WINDING CONNECTION OR SYMBOL TO IEC 76-4			
40	RATED VOLTAGE RATIO AT PRINCIPAL TAP & NO LOAD	PRIMARY/SECONDARY		PRIMARY/SECONDARY
41	IMPEDANCE VOLTAGE AT PRINCIPAL TAP & RATED CURRENT REFERENCE POWER	PRIMARY - SECONDARY - TERTIARY - PRIMARY		
		%	%	%
		kVA	kVA	kVA
42	REQUIREMENTS SPECIFIC TO IEC 289 (REACTORS)			
	RATED CURRENT (RMS)	A		
	RATED SHORT TIME CURRENT (RMS) & TIME	kA	s	
	IMPEDANCE AT RATED VOLTAGE & CURRENT	%		
	IMPEDANCE RANGE & METHOD OF ADJUSTMENT REQUIRED (ARC SUPPRESSION COIL)	% TO %		
		STEPPED	VARIABLE	
	REGULATING RANGE & METHOD OF ADJUSTMENT REQUIRED (SHUNT REACTOR)	kVAR TO kVAR		
		STEPPED	VARIABLE	
43	CURRENT TRANSFORMER REQUIRED	NO	YES - SEE ATTACHMENT	
44	ADDITIONAL FITTINGS	LIQUID TEMPINDICATOR		WINDING TEMP.INDICATOR
		PRESSURE/VACUUM INDICATOR		EARTH TERMINAL(S) 1/2
45	DRY TYPE ENCLOSURE TO IEC 726	ENCLOSED		NON-ENCLOSED
46	TYPE TEST(S) REQUIRED	YES/NO		
47	SPECIAL TEST(S) REQUIRED	YES/NO		
48	AUXILIARY SUPPLY VOLTAGE	VOLT	PHASE	Hz
49	SUNSHADE REQUIRED	YES/NO		
50	PAINT COLOUR			
51	REMARKS	NONE		ATTACHED
Rev	Date	Remarks	By	App
DATA SHEET				
SHEET 2 of 4				



INDENT/PURCHASE ORDER NUMBER

To be completed in block capitals

LAYOUTFITTINGS SHALL BE LOCATED APPROXIMATELY
IN THE POSITIONS INDICATED.

FITTING INDICATOR	FITTING	TICK POSITION SELECTED BY	
		PURCHASER	MANUFACTURE R
1	HV TERMINATION		
2	LV TERMINATION		
3	RATING PLATE		
4	LIQUID TEMPERATURE INDICATOR		
5	WINDING TEMPERATURE INDICATOR		
6	THERMOMETER POCKET		
7	NAME PLATE		
8	CONSERVATOR		
9	GAS AND LIQUID ACTUATED RELAY		
10	DIRECTION OF RELIEF EMISSION		
11	LIQUID DRAIN VALVE		
12	TAP CHANGER SWITCH		
13	ACCOMMODATION FOR NEUTRAL C.T.		
14	ACCOMMODATION FOR LINE C.T.(s)		
15	ANCILLARY EQUIPMENT TERMINAL BOX		
16	EARTHING TERMINALS		
17	LIQUID LEVEL GAUGE		
18			

Rev	Date	Remarks	By	App

DATA SHEET

SHEET 4 of 4

