

SECTION 2

DESIGN CRITERIA

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**SECTION 2
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1. SITE OPERATING CONDITIONS

Altitude of sites above sea level	Sea Level Coastal Region
Relative humidity	66 to 85%
Thunderstorms days per year	30
Earthquake loading for station equipment foundation and buildings design purposes	USA Uniform Building Code Zone 3
<u>Temperature (1977 - 97)</u>	
Average outdoor ambient shade temperature for design purposes	35°C
Absolute Max. Temp. (1 in 20 yrs)	32.2°C
Average Monthly Max. Temp.	31.0°C
Average Monthly Min. Temp.	22.5°C
Absolute Min. Temp (1 in 20 yrs)	21.1°C
<u>Wind Speed</u>	
Annual Max. Wind Speed (Non Hurricane) (1 in 50 yrs).	17.9 m/sec
Max. Hurricane Wind Speed.	56 m/sec
Design Wind Speed (1 in 50 yrs, 3 sec. gust)	56 m/sec.
Assumed Class B Ground Roughness	
Assumed Coincident Temperature for Design Wind Speed	22.0°C
Air Density at 22°C	1.133 kg/m ³

Rainfall Average Monthly (1977 - 97)

Jan	113 mm	May	108 mm	Sept	263 mm
Feb	61 mm	June	152 mm	Oct	257 mm
March	73 mm	July	209 mm	Nov	234 mm
April	70 mm	Aug	253 mm	Dec	121 mm

Buried Cables

For tendering and tender evaluation purposes, the following conditions shall be assumed for buried cables i.e. cables laid in the ground or in buried pipes or ducts.

Ground Temperature	20°C
Soil Thermal Resistivity	1.2°CW/M
Burial depth to top of 11 kV cables	800 mm
Burial depth to top of 66 kV cables	900 mm

1.1 General Design Information

Max. System Voltage	72.5 kV	12 kV
Nominal system voltage between phases	66 kV	11 kV
Rated short-circuit and through fault capability	6.3 kA for 3 sec.	16 kA for 3 sec.
Earthing of System	Solid	Earthing Transformer
System frequency	50 Hz	

D.C. Supplies

(a) Closing	125 V dc
(b) Tripping	125 V dc
Supply voltage for auxiliary equipment	415V 50 Hz, T.P.&N.
Supply voltage for auxiliary equipment	125 V dc max.
Initiating power supply for indications and alarms	125 V dc max.
Power supply for SCADA and supervisory equipment	50 V dc max.

1.2 Co-ordination of Substation Insulation

Minimum clearances -

(a) phase to earth	630 mm	120 mm
(b) phase to phase	630 mm	120 mm
(c) terminals of same phase	630 mm	120 mm
(d) section	3070 mm	2590 mm

Min. basic impulse withstand voltage:-

(a) Switchgear	325 kV	95 kV
(b) Transformer bushings	325 kV	95 kV
(c) Transformer windings	250 kV	95 kV
(d) Transformer neutral	75 kV	95 kV

The height from the ground of any working platform to any line fault of the equipment shall not be less than 2.45 metres plus the length of the insulator.

<u>Min. rated power frequency withstand voltage (1 min.):</u>		
(a) Switchgear	140 kV	28 kV
(b) Transformers	95 kV	28 kV
(c) Transformer neutral	38 kV	28 kV
Min. Creepage (outdoor insulators)	25 mm/kV	
Surge diverter rating	58 kV rms	10 kV rms
Maximum permissible discharge voltage at 10 kA	150 kV	35 kV

1.3 Minimum Factors of Safety for Outdoor Switchgear

Busbars or other connections based on elastic limit or 0.1% proof stress	1.5
Complete insulator units based on mechanical test	1.5
Insulator metal fittings based on elastic limit	1.5
Steel structures based on elastic limit of tension members and on crippling loads of compression members	1.5
Foundations for structures against overturning or up-rooting under maximum simultaneous working loadings	1.5

1.4 Outdoor Insulators and Bushings for OHL and Substations

(a) Nominal voltage between phases	66 kV	11 kV
(b) Rated voltage between phases	72.5 kV	12 kV
(c) Maximum impulse withstand voltage 1.2/50 wave	325 kV	75 kV
(d) One minute power frequency withstand voltage	140 kV	28 kV
(e) Minimum external creepage distance	25 mm	25 mm

The minimum creepage distance measured from the metal cap to the base over the surface of the insulator shed (expressed in millimetres per unit of rated voltage between phases) shall not be less than 25 mm per kV.

The minimum protected creepage distance shall not be less than thirty five per cent of the total creepage distance. The protected creepage distance refers to that part of the insulator which is protected against rain at right angles to the axis of the bushing. The use of "Anti-fog" or "Anti-pollution" type or other insulators with deep sheds or skirts are not accepted.

1.5 Minimum Clearances from Live Metal to Oil Pipework including Conservator and Pressure Relief Device

Rated system voltage	66 kV	11kV
Minimum Clearance	788 mm	150mm

Apart from the above, no phase or earth clearances are specified for transformers where an impulse voltage test level is specified.

1.6 Oil for Transformers

The preferred Transformer oil is Shell Diala - B or Texaco Rimula.

SECTION 3

**GENERAL TECHNICAL
REQUIREMENTS**

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GENERAL TECHNICAL REQUIREMENTS

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SECTION 3 GENERAL TECHNICAL REQUIREMENTS

Please note these are Standard Specifications as required by LUCELEC for Substation Plant and Civil Works and accordingly the scope may exceed the requirements of the scope of work.

1. APPLICATION OF REQUIREMENTS

The requirements of this section of the Specification apply to all equipment and materials and are supplementary to the detailed specifications. If the requirements specified herein are in conflict with those specified in the detailed specifications in the following sections, then the latter shall govern to the extent of such conflict.

2. STANDARDS AND CODES OF PRACTICE

2.1 Mechanical Plant and Equipment

Equipment shall be designed to the following acceptable standards valid at the time of Tender, except where a particular standard is laid down in the Specification, in which case the particular standard must be used.

- (a) The ISO Standards and Codes of Practice.
- (b) The British Standards and Codes of Practice.
- (c) National Standards comparable with the above.

2.2 Electrical Plant

Except where modified by this Specification equipment and materials shall be in accordance with IEC (International Electrotechnical Commission) and ISO (International Organisation for Standardisation Recommendations). If relevant IEC and ISO Recommendations are not available in any case or cases then relevant National Standards shall apply, if available, and such National Standards shall be proposed by the Contractor for approval for the purpose by the Engineer.

When IEC or ISO Recommendations or National Standards are referred to, the Edition shall be that current at the Date of Tender, together with any Amendments issued to that date.

Should the Contractor offer equipment complying with other National Standards these may be accepted subject to the satisfaction of the Engineer that the quantity, finish and performance of the equipment complying with such standards shall be comparable to that complying with IEC.

2.3 Copies of Standards

If requested by the Engineer, three (3) English language copies of the publications containing all standards and codes of practice proposed shall be supplied by the Contractor at his own expense within three (3) months of the Contract start date.

2.4 Insurance of Works

The whole of the Works shall be acceptable for insurance by Lloyds of London or another Insurance Company of similar standing subject to the approval of the Engineer.

2.5 Units of Measurement

The Contractor shall design in imperial or metric units. Contract drawings produced specifically for this Contract and plant manuals shall be in metric units.

The marking and Test Specification of safe working load values on lifting equipment shall be in metric units.

3. STANDARDISATION AND INTERCHANGEABILITY

The Contractor responsible for each major plant contract package shall provide maximum standardisation and interchangeability of equipment and shall minimize the number of spare part items required. During pre-contract discussions, the Contractor may be requested to standardise on certain manufacturer's equipment to simplify overall plant operation. Any deviation from using single manufacturer's equipment as specified shall be notified to the Engineer.

- (a) All standard frame motors of the same voltage shall be from a single manufacturer.
- (b) Motor starters of the same size shall be from a single manufacturer.
- (c) Instruments and controls for the same service shall be from the same manufacturer. The number of sizes and ranges of instruments shall be kept to a minimum consistent with meeting functional requirements.
- (d) All piping and plumbing speciality items shall be from the same manufacturer for the service intended (traps, expansion joints, sinks, faucets, showers, check valves, etc.).
- (e) All paints and protective coatings shall be from the same manufacturer.

The Contractor shall ensure that instruments, controls, pumps, motors, electrical equipment, etc. supplied by Subcontractors for subsystems are from the same manufacturer as similar equipment used in the balance of the Plant.

In order to facilitate interchangeability, the mirror handing of plant will only be accepted where the direction of rotation and the shape of components is unaffected thereby.

4. GENERAL DESIGN REQUIREMENTS

All plant and equipment shall be suitable for operation under the ambient conditions arising from their particular location in a substation, together with the climatic conditions at Site.

The Contract Works shall be designed to facilitate inspection, cleaning and repairs, and for the operation in which continuity of service is the first consideration. All apparatus shall be designed to ensure satisfactory operation under such sudden variations of load and voltage as may be met with under working conditions on the system and short-circuits, within the rating of the apparatus.

The design shall incorporate every reasonable precaution and provision for the safety of all those concerned in the operation and maintenance of the Contract Works and of associated works supplied under other Contracts.

Equipment shall be designed for reliable operation and ease of maintenance.

All material used shall be new and of the best quality and of the class most suitable for working under the conditions specified and shall withstand the variations of temperature and atmospheric conditions arising under working conditions without distortion or deterioration or the setting up of undue stresses in any part, and also without affecting the strength and suitability of the various parts for the work which they have to perform. No welding, filling or plugging of defective parts will be permitted without the sanction in writing of the Engineer. All components shall be new and shall be manufactured from sound materials, completely free from all visible imperfections such as cracks, flaws, blow holes, etc. No castings, forgings or other material will be accepted in a condition known to be faulty.

Corresponding parts liable to renewal shall be interchangeable. When required by the Engineer, the Contractor shall demonstrate this quality.

All apparatus shall operate without undue vibration and with the least practicable amount of noise.

Cast iron shall not be used for chambers of oil-filled apparatus or for any part of the equipment which is in tension or subject to impact stresses except where it can be shown that service experience has been satisfactory with the grade of cast iron and the duty proposed.

Operating boxes, kiosks, cubicles and similar enclosed compartments forming part of auxiliary equipment shall be adequately ventilated to restrict condensation. All contactor or relay coils and other parts shall be suitably protected against corrosion. Anti-condensation heaters of an approved type shall be provided inside each cubicle or where necessary each cubicle compartment. They shall be shrouded and located so as not to cause injury to personnel or damage to equipment. The thermostat shall be arranged to switch off the heater supply when the ambient temperature exceeds 30-35°C. Means shall be provided at each unit for isolating

the supply. A common switch with indicating lamp labelled "Cubicle heaters on" shall be mounted at a convenient point such that it will not require movement in the event of extension units being added.

All outdoor apparatus, including bushing insulators and fittings, shall be so designed as to avoid pockets in which water can collect.

The underside of all relevant tanks shall be ventilated in an approved manner to prevent corrosion.

All mechanisms shall, where necessary, be constructed of stainless steel, brass or gunmetal, to prevent sticking due to rust or corrosion.

All electrical connections and contacts shall be of ample section and surface for carrying continuously the specified currents without undue heating, and shall be secured by bolts or set screws of ample size, fitted with locking devices of approved type and material.

All taper pins used in any mechanism shall be of the split type. All rubbing or wearing surfaces shall be machine surfaced. Joints employing a gasket material shall be so constructed that the packing is maintained under sufficient compression in all parts, so that an efficient joint can be made without the use of jointing compounds. Gasket material shall be of the minimum thickness necessary and of approved composition.

All apparatus shall be designed to obviate the risk of accidental short-circuit due to animals, birds and vermin. Openings in ventilated enclosures shall be so constructed to prevent the entry of vermin and insects.

5. NUTS, BOLTS AND STUDS

All nuts, bolts, etc. shall be to an approved standard. Bolts or studs which are subject to high temperature and pressure shall be to an approved material specification with nuts of similar material. All fasteners shall be suitably protected from corrosion at all stages until finish painting is carried out.

Bolts and studs for electrical connections shall preferably be of brass M6 size. Alternatively size M5 may be used, but these must be of stainless steel, phosphor bronze or high tensile brass.

Nuts and pins shall be locked in position with lock nuts or lock washers, or other devices, if approved. Lock washers shall not be used above M24 size except when a spring type is specially approved.

No bolt or stud shall project through its nut by more than approximately 10 mm or four threads whichever is the less, except for terminals and relay stems.

Bolts, nuts and washers on outdoor equipment shall be of non-corroding material where they are in contact with non-ferrous parts in conductor clamps and fittings and elsewhere if specially required.

Suitable special spanners shall be provided for bolts and nuts which are not properly accessible by means of an ordinary spanner.

6. MATERIALS

6.1 Material Specification

All materials used must conform with the requirement of Sub-section 2 (Standards and Codes of Practice) and details of the materials proposed for all important plant items shall be submitted to the Engineer at the design stage and prior to manufacture.

Proprietary materials not covered by appropriate specifications will only be considered on submission of the necessary technical details to permit a full and complete appraisal of their suitability for the proposed use.

6.2 Material Condition

No material may be used in a metallurgical or physical condition significantly different from that assumed for design purposes. This requirement refers to all physical and mechanical properties of the material including deterioration of surface condition, up to the time of commissioning, by corrosion.

6.3 Material Substitution

Substitution of a specified material will only be accepted if the proposed material is satisfactorily demonstrated to the Engineer to be equal in all respects or superior to the original on which the design was based.

Recycling and/or reconstitution of solders, braze metals, white and bearing metals, tin, zinc, cadmium and similar materials is not permitted without the specific approval of the Engineer. In each case it is expected that virgin metals or their exact equivalent will be used.

6.4 Material Quality Control

All material forms including but not confined to forgings, castings, weldments and wrought products shall be free from flaws and defects to the standards necessary to comply with the requirements of the appropriate design code or specification, with the requirements of this Specification and with the functional requirements of their intended use.

Repairs to materials and/or components are not permitted without the full agreement of the Engineer and all planned operations which may affect the condition and/or properties of the material such as welding, brazing, manipulation

processes and heat treatments are subject to the full approval of the Engineer. In this respect, primary product forms such as tubes, pipes and rolled or forged sections heat treated by a supplier, tested and certified to the design specification requirements, may be considered as primary materials unless and until they are subjected to additional mechanical and/or metallurgical operations.

In all areas where the quality of the material, joint or component is determined by visual and/or non-destructive testing techniques and where the acceptable standards are not specified accurately and completely by the appropriate code or standard the proposed acceptance standards must be approved by the Engineer prior to the start of manufacture. It is the responsibility of the Contractor to determine all such areas and submit the necessary proposals to the Engineer so as not to delay the planned start of manufacture. Retrospective consideration of ambiguous or imprecise standards will not be given and in any dispute arising from such a situation the decision of the Engineer as to the acceptability of the material, joint or component will be final and irrefutable.

All materials, including welding and brazing consumables, shall be subject to an effective material identification and control system, following receipt from the material supplier, at all stages of manufacture, shipping and erection and the Engineer will, at his discretion, require demonstration of the system prior to approval being given. Demonstration will include the use of chemical and spectrographic checks on randomly selected components and it is expected that such checks will form an integral part of the Manufacturer's in-house quality assurance system.

6.5 Material/Component Supplier Approval

No material or component shall be obtained by a Contractor or his Subcontractors from any source which has not been previously audited by a responsible party and designated as an approved supplier. The Engineer may, at his discretion, require evidence that such audits have been satisfactorily made and/or evidence of the competence of the designated supplier to meet the necessary quality requirements.

6.6 Special Material Requirements

6.6.1 Aluminium and Aluminium Alloys

Aluminium, where its use is approved by the Engineer, shall be of high commercial quality. The composition, including the percentages and nature of impurities, shall be stated in the Schedules.

All aluminium alloys shall be of approved composition as stated in the Schedules.

Aluminium and alloy castings shall be sound and free from porosity.

6.6.2 Stainless Steels

Stainless steels may be of ferritic, martensitic or austenitic types depending on their application. Each material selected for a specific use shall be to the approval of the Engineer.

7. **CLEANING, PROTECTION AND PAINTING**

7.1 **General**

The protection of all items of plant, supporting metal work, structures, tanks, pipework, lifting tackle and other metallic items including bolts and fasteners is essential if the plant as a whole is to operate efficiently and in accordance with the design requirements.

While the philosophy of protection is to prevent deterioration by corrosion and is common to all applications, the specific requirements vary according to the materials involved, their function and the active corrodents to which they are exposed.

Having regard to the specific locations and functions of metallic items, all surfaces shall be either manufactured from materials with proven resistance to corrosion under the specific service environments or shall be fully protected by approved coatings, paints, electrochemical, or other approved means, from corrosion.

The selection and use of all materials, coatings and anti-corrosion measures is subject to the approval of the Engineer and detailed schedules of protection are required listing the surfaces concerned and the proposed protection. In addition to the summary schedules, the detailed procedures for preparation, application and testing of the protective materials and systems shall be submitted to the Engineer for approval. All such submissions will require full details from the Manufacturer of the protection giving composition and properties of protective materials.

Protection of all internal surfaces e.g. those washed by water, steam, oil and other operational fluids, if of the temporary type, shall be removed completely prior to plant commissioning or if of the permanent type, shall be suitable to withstand all normal and reasonable fault conditions during operation and service and shutdowns. Degradation products of all permanent protectives shall not be harmful to plant, protection or fluids used elsewhere in the systems.

Throughout cleaning, painting and protection work at Site, the Contractor shall ensure that all consumable items are delivered, stored and used strictly in accordance with the Manufacturer's instructions and the relevant approved schedules and specifications. The Contractor shall also ensure that during and on completion of Site work, all areas are left in a tidy, clean state and all paint drips, splashes etc. are removed.

All final painting shall be done to the Colour Code, the details of which will be advised during the Contract and all finishing paints shall be completely compatible with the paints used for protective purposes.

It is the responsibility of the Contractor to co-ordinate the protection proposals for Subcontractors plant and to ensure that the equipment from all Subcontractors is prepared and protected in accordance with the Specification and in a manner ensuring uniformity and compatibility of the protection. The number and type of systems proposed and the number of paint, coatings and protective material suppliers should be kept to an absolute minimum consistent with the purpose and particular application of the protection.

Protection of any surface shall not relieve the Contractor from providing adequate design corrosion allowances as required by the relevant design codes, specifications and/or functional duty of the plant.

7.2 Choice of Protection and Application

Painting, coating and protective systems shall be selected with proper regard for the function of the item, the preparation, the application requirements and the environment to be encountered during all stages of manufacture, shipping, temporary storage, erection and service.

All coatings and protectives which are required to withstand service fluids such as pipe, tank, pump, valve, waterbox and similar linings shall be applied in the works and prior to shipping. The Contractor shall satisfy the Engineer prior to acceptance of all such protection that repairs and joints can be adequately and properly made at Site to the standard of the factory applied coatings. In all such cases the use of flanged and bolted joints is preferred except where the service fluid might on leakage constitute a fire or explosive hazard e.g. lubricating oil systems. In the latter areas it is expected that pipework and items other than main tanks and submerged or washed major items will be constructed from corrosion resistant materials which will not require protection on internal surfaces.

Structural steelwork, lifting devices and tackle, handrails and similar items may be protected fully prior to shipping or may be suitably primed and finish painted at appropriate stages of erection and completion. In either case, protectives shall be selected to provide the necessary protection at all stages and such that repairs, overcoating and finishing can be carried out without loss of intercoat adhesion, protection properties (as with an aged anti-corrosion primer) or uniformity of coating thickness. Where items are shipped in a primed or otherwise unfinished condition it is expected that repair and overcoating will be carried out in a progressive manner as erection proceeds so that no undue deterioration of the primer, undercoats and finish coats occurs. Finish painted items must similarly be inspected and repaired as necessary throughout the erection programme to avoid the possibility of major repair and rectification work becoming necessary at any time.

Application of all paints and protectives may only be carried out under the conditions specified by the paint or protective manufacturer. Painting and protection work shall not be carried out in any way which is not strictly in accordance with the Manufacturer's instructions and/or to the satisfaction of the Engineer.

Washing of any surface prior to the application and/or overcoating of paint shall only be carried out with demineralised water or suitable approved solvent solutions.

Paints shall only be thinned and/or mixed in accordance with the Manufacturer's instructions and all paints, solvents, resins, hardeners and associated products shall be stored and used strictly in accordance with the Manufacturer's instructions and the applicable toxic, flammability and safety requirements for the particular products.

The Contractor is responsible for ensuring that all safety requirements are fully and completely implemented and for the provision of all necessary safety equipment to fully and completely protect personnel and plant.

The following minimum painting requirements shall apply to all ferrous parts unless the Contractor can show, to the satisfaction of the Engineer, that any alternative he proposes is in all respects equal or superior to the specified requirements:-

Apparatus

Painting

INTERNAL SURFACES

Oil filled chambers and tanks	One coat of oil resisting varnish or paint.
Kiosks and apparatus boxes for use <u>outdoors</u> .	Three coats of paint, the final coat being an anti-condensation finish white.
Cubicles, kiosks and apparatus boxes for use indoors.	Three coats of paints, the final coat being a white enamel.

Apparatus

Painting

EXTERNAL SURFACES

All ungalvanised surfaces other than nuts, bolts and washers which may be removed for maintenance purposes, for use outdoors.

At Works

- (a) One priming coat of corrosion inhibiting paint applied immediately after cleaning.
- (b) Two coats of non-glossy oil and weather resistant paint applied after inspection and testing and before despatch.

or

- (c) A dry powder application to the approval of the Engineer.

Exposed, ungalvanised nuts, bolts and washers which may be removed for maintenance purposes, for use outdoors.

One coat of oil and weather-resistant, non-fading paint applied.

At Site

One finishing coat of glossy oil and weather resisting, non-fading paint applied after erection is complete. For equipment despatched completely assembled, the final coat may be applied at the Works unless otherwise required by the Engineers.

Exposed, ungalvanised nuts, bolts and washers which may be removed for maintenance purposes.

One coat of oil and weather resistant, non-fading paint applied after erection.

Panels, cubicles, kiosks and apparatus boxes, for use indoors.

Three coats of paint, the colour and finish of the final coat to be the approval of the Engineer.

Successive coats of paint shall be easily distinguishable by shade or colour and shall be applied to a clean, dry and properly prepared surface. Each coat shall be compatible with the previous coat.

7.3 Preparation for Protection

All surfaces to be painted or coated shall be prepared to the requirements of the paint or coating manufacturer and shall in any case be fully equivalent in cleanliness to the Sa 3 Standard of SIS 055900 - 1967.

The surfaces profile shall be that necessary to provide maximum adhesion as advised by the protection manufacturer and shall be such as to avoid measurable thinning or non-uniformity of coating thickness.

All corners shall be radiused and all weld undercut, over- beading flow markings and like irregularities which may result in thinning or overstressing of the paint or coating shall be removed prior to blast or other approved cleaning process.

Particular care shall be taken prior to the application of any protective to ensure that the surfaces are free from chemical impurities and contaminants of any description. In all cases of reasonable doubt particularly at welds and crevices where alkaline deposits may concentrate, checks shall be carried out by approved methods to ensure freedom from contamination prior to the application of any paint or protective.

In general, it is expected that preparation for protection will involve either blast cleaning or chemical cleaning. Abrasives and/or chemical solutions shall be to the approval of the Engineer and neither shall leave any potentially harmful residues or other contaminants on the cleaned surfaces. Abrasives containing silica shall not be used for the cleaning of surfaces which will subsequently be exposed to condensate, boiler feed water or steam.

The use of an etch primer will normally be expected for the preparation and painting of galvanised steel or other non-ferrous metal surfaces.

If protection of cleaned surfaces is for any reason delayed such that the cleaned surface becomes contaminated either by 'in situ' corrosion or by deposition, the complete cleaning procedure shall be repeated. In the case of large items it may not be possible to complete protection within the necessary time to prevent deterioration of the cleaned surfaces. It is necessary in all such cases to clean only those surfaces which can be reasonably protected in the time available having proper consideration for the protective used, its curing time and the difficulties or problems associated with obtaining the required adhesion and continuity between already painted surfaces and newly painted ones.

Repair of multi-coat systems shall be avoided wherever possible and in all cases where such repairs are necessary, repairs and adjacent areas shall be subsequently overcoated with an additional full coat of the approved finishing paint to the Engineer's approval.

7.4 Storage and Mixing

The Contractor shall ensure that the storage of all paints is to the Manufacturer's recommendations and under no circumstances shall paint be used whose shelf life has been exceeded.

The mixing of two pack paints shall be strictly in accordance with the Manufacturer's recommendations.

7.5 Painting at Site

Where painting at Site is to be undertaken, the Contractor shall ensure that the prevailing climatic conditions meet the paint Manufacturer's requirements. Under no circumstances shall painting in adverse climatic circumstances be undertaken.

Items delivered to Site in a primed condition and intended to be overpainted at a subsequent date e.g. after erection, shall be maintained in a condition suitable for subsequent painting taking into account all reasonable Site conditions and problems. Pre-fabrication primers are not acceptable as protection for shipping and site storage.

The Contractor shall take all necessary measures to protect plant and equipment from mechanical damage and/or contamination with solvents, paint, abrasives, dust and other foreign materials during both preparatory work and the application of protective paints and coatings. In the event that damage and/or contamination occurs the Contractor is responsible, at his own expense, for full rectification to the Engineer's satisfaction.

7.6 Inspection

All stages of preparation, application and repair shall be subject to the Engineer's approval. Surface finish and condition prior to application of any protective, wet and dry film thickness checks and continuity checks shall be carried out by the Contractor. The Final Certificate will not be issued until all paintwork, protection, finishes, surfaces etc. satisfy the Engineer.

In addition to visual inspection it is expected that checks of paint dry film thickness, continuity and uniformity will be carried out by the Contractor, on all painted and protected surfaces and the equipment and procedures proposed should be detailed and submitted to the Engineer for approval.

7.7 Galvanising

7.7.1 General

Galvanising of iron and steel articles shall be carried out by the hot dip process and generally in accordance with an approved standard to give a minimum average coating weight in excess of 610g/m².

Galvanised finned tubing shall have a minimum average thickness of 70 microns. Other methods of depositing zinc coating such as sheradising, electroplating or metal spraying shall not be used unless specifically approved.

Surfaces which are in contact with oil shall not be galvanised or cadmium plated.

The identifying marks on any galvanised parts shall be stamped before galvanising is applied and shall be clearly legible afterwards.

Zinc coated fasteners such as nuts and bolts should be lubricated with beeswax or other suitable lubricant prior to fitting and tightening.

7.7.2 Preparation and Repair

The preparation for galvanising and the galvanising itself shall not adversely affect the mechanical properties of the coated material.

All fastenings which are used for regular inspection and maintenance must be treated by a zinc passivation process.

All possible welding, drilling, punching, cutting and bending of parts shall be completed and all burrs removed before galvanising is commenced. Small areas of galvanised coating damaged during transit and erection or by cutting and welding at Site shall be removed to the satisfaction of the Engineer. Such repairs to the coating will be made by use of either low melting point zinc alloy repair rods or powders made specifically for this purpose. If, in the opinion of the Engineer, the damage is local and can be repaired by applying a coat of galvanising repair paint, the damaged area shall be cleaned by wiping with clean rags saturated with mineral spirits or xylene followed by wire brushing. After wire brushing, the area shall be recleaned with solvent to remove residue and shall be given a minimum of two coats of zinc rich paint in accordance with the Manufacturer's instructions.

7.7.3 Protection of Galvanised Surfaces

If, on Site, any galvanised surfaces are to be externally visible, the Contractor shall take precautions to avoid wet storage staining of freshly galvanised articles during transport or storage.

7.8 Paint Colours

All outdoor switchgear transformers marshalling Kiosks and all internal panels cubicles and boxes shall be finished light grey to RAL 732.

The colours for other equipment are to be agreed with the Engineer.

8. INSULATING OIL AND GAS

Unless otherwise specified, sufficient oil or gas shall be supplied to fill all equipment provided under this Contract. The oil or gas shall be of appropriate type and suitable in all respects for use in the equipment when it is operated under the conditions laid down in this Specification.

9. PREVENTION OF ACIDITY

The design, and all materials and processes used in the construction of the equipment, shall be such as to reduce to a minimum the risk of development of acidity in the oil or gas.

10. CORONA AND RADIO INTERFERENCE

All equipment shall be designed so as to minimise corona or other electrical discharge and radio interference.

11. NAMEPLATES AND LABELS

11.1 General

All apparatus, plant and equipment shall be clearly and permanently labelled, to the approval of the Engineer, in English. Where labels are provided for making clear the method of operation of apparatus they shall be concise and preferably diagrammatic in form. They shall be of such a size as to be readable at normal operating positions.

Each item of plant or equipment covered by this Specification shall be supplied complete with an identification nameplate, clearly engraved or stamped with the Manufacturer's name, plant number and date, together with any other such information that will assist future maintenance and the purchase of spare parts.

Vessels which have been hydraulically tested at the Manufacturer's works must also have the test pressure and the date of test indicated on the plate.

Nameplates, labels and their fixing screws shall be of stainless steel or other corrosion resistant material. Where the use of vitreous enamelled labels is approved, the whole surface including the back and edges shall be properly covered and protective washers shall be provided front and back of the fixing screws.

Labels for similar equipment shall be of uniform appearance and size.

11.2 Warning and Danger Notices

Warning and danger notices shall have red lettering on a white background, and shall be in English.

11.3 Valve Nameplates

Identification discs of stainless steel or other approved material shall be provided on the handwheels of all valves and shall be suitably engraved to denote the duty or service for which the valve is installed. Large characters to identify the valves with the number or letter group appearing on the system diagram shall also be engraved prominently on the discs.

The nameplates shall incorporate the Colour Code corresponding to the service of the piping in which the valve is located.

11.4 Mandatory and Safe Conditions Notices

These notices shall be in accordance with "International Standards ISO/DIS/3864.3 1984 Safety Colours and Safety Signs".

11.5 Nameplates for Motors and Pumps

The nameplates shall include the designed duty and the maker's production number. Additional nameplates shall be fitted on h.v. motors stating lubrication details and lifting weights.

All anti-condensation heater terminal boxes shall have suitable warning plates.

11.6 Switchboards, Control, Relay and Distribution Panels

Each main switchboard panel, kiosk and marshalling box shall be adequately and permanently labelled at the front and at the rear with labels of two colour plastic material, matt or semi-matt finished. Labels shall have black lettering on a white background.

Circuit identification labels shall be provided at the front and at the rear of all units. An identical label shall be fitted to the front of all withdrawable moving portions and to the relevant fixed part.

All components such as switches, fuses, relays and other devices, whether mounted inside or on the surface of the compartments, shall have identifying labels which shall be related to the identifying references on the arrangement drawings and wiring diagrams.

For secondary fuses the current rating of the fuse link shall be shown on the label. Danger or warning labels shall comply with Clause 11.2 (Warning and Danger Notices). They shall not be mounted on removable parts.

So far as reasonably possible, labels and the lettering thereof shall comply with the approximate dimensions given below:-

<u>Equipment</u>	<u>Label Size</u> <u>mm</u>	<u>Lettering</u> <u>mm</u>
Main labels on panels, cubicles, kiosks, junction and control boxes and similar equipment	125 x 50	20 x 1.5
Control and changeover switches and similar items	70 x 30	12 x 1.5
Fuses and links	35 x 15	5 x 1
Relays and contactors	60 x 20	5 x 1

12. GUARDS AND PADLOCKS

12.1 Guards

Plate or mesh safety guards shall be provided for electrical apparatus and moving parts of machinery. The guards shall be of approved design and in accordance with approved National Standards.

The Contractor shall ensure that stationary points requiring access, such as lubricating and oil inspection points, are safe and outside the guards. Guards shall be designed so that they are secure but can be removed without disturbing other parts of the plant. Adjustment to machinery in motion shall be possible without the removal of guards.

12.2 Padlocks

Padlocks or other approved locking devices for circuit-breakers, isolating devices, control switches, valves, marshalling kiosks, cubicles, screened enclosures and other equipment shall be supplied under this Contract.

All padlocks and other locks shall be provided with two identical keys and two engraved, durable identification labels. It shall be impossible to open any lock with the key of any other lock provided under this Contract. Locks shall be provided in suites, provided with master key facilities.

Keys and locks shall be impressed with the Manufacturer's serial number.

Wall-mounting cabinets suitable for the accommodation of padlocks and keys while not in use shall be provided and mounted in approved positions.

The boxes and positions for locks and keys within the boxes shall be provided with durable identification labels.

13. SPARES

The Contractor shall complete the appropriate Schedules with a list of spares in addition to any specifically stated and provide unit prices for the spares which he recommends should be held in stock for the maintenance of the plant for at least 5 years of normal operation. The spares prices shall remain valid for at least six months after placing the contract or a reasonable time after the Contractor makes all necessary information available to determine the spares requirement. The Contractor shall state the latest date by which the spares must be ordered such that they can be delivered to Site prior to plant acceptance and commencement of operations. The delivery of the necessary spares shall be considered to be a condition for plant acceptance.

All spares must be delivered to Site suitably packed for long term storage and labelled for easy identification.

Packing shall be on individual items or sets basis where appropriate.

Labelling shall be such that spares can be correctly identified from references quoted in the operation and maintenance manuals provided.

14. CABLE DRUMS AND CABLE SEALING

Cable shall be supplied on strong non-returnable drums arranged to take a round spindle of a section adequate to support the loaded cable drum during installation and handling. The drum shall be lagged with strong closely fitting battens which shall be securely fixed to prevent damaged to the cable. Wooden drums shall be constructed of seasoned timber to prevent shrinkage of drums during shipment and subsequent storage on Site. Each drum shall be clearly marked in a manner which cannot be obliterated with the particulars of the cable including voltage, length, conductor size, number of cores, type of protective covering, section number, gross and nett weights, together with the direction for rolling.

The ends of the lead sheathed cables shall be sealed by plumbing cap or disc on the lead sheath. The ends of PVC sheathed cables shall be suitably sealed to prevent the ingress of moisture. The end of the cable left projecting from the drum shall at all times be securely protected against damaged.

15. PACKING FOR SHIPMENT

15.1 Containers, Packing Cases and Crates

Packing shall be such that it affords adequate protection to the enclosed materials against mechanical damage during transport to its final destination and transition from one to another.

Where shipment by container is intended the packing requirements stated below for non-containerised shipments shall apply for any part container loads.

Containers shall be of the fully enclosed weatherproof type (i.e. metal sides and roof) unless the size of plant to be shipped necessitates otherwise in which case the type of container and method of shipping shall be subject to approval.

For non-container shipments packings shall be stout close-boarded wooden cases of adequate thickness, suitably braced and banded and lined internally with water resistant material.

Certain types of outdoor equipment may be crated, provided that adequate protection of vulnerable parts is assured. All pipe flanges shall be fitted with wooden covers not less than 40 mm larger in diameter than the flange which shall be wired or bolted to the pipe. Steelwork sections and similar items may be bundled provided that the ends are adequately protected and the enclosing bands or wires are robust.

For full container shipments a degree of crating may still be required depending on the type of equipment involved and the Contractor shall state his intentions and obtain approval.

Adequate battens and braces shall be provided to prevent movement of equipment within the container. Where appropriate due to the weight or nature of the equipment pallet type bases shall be provided to assist in loading and off loading.

Indoor electrical equipment, whether shipped in containers or packing cases, must be enclosed in welded polythene envelopes inside the packing cases. The envelopes should be sealed and have sufficient desiccant inside to absorb the initial moisture content plus an allowance for leakage.

When in cases or crates or containers, all items shall be so secured that they are not free to move and cannot work loose in transport. If rotating parts are shipped within their bearings or mountings they must be adequately braced and restrained to prevent relative movement. Bags of loose items shall be placed in a supplementary case, each bag having stitched on to it a metal label indicating the number and nature of its contents. Where a filler material is used in a case to restrict movement or provide additional protection it must be inorganic and non-hygroscopic.

All surfaces liable to corrosion shall be thoroughly cleaned and special steps, adapted to the nature of the materials and the time interval between packing and unpacking, shall be taken to prevent corrosion. These steps may constitute the greasing of surfaces, the application of a protective coat, enclosure of the items in a hermetically sealed container, consisting of paper, cellophane, plastic or zinc, the addition of vapour phase inhibitor paper to the package, or other approved means.

Steps shall be taken to ensure that insulated materials cannot be damaged by moisture, moulds, insects or rodents. Items that include materials liable to be

damaged by moisture shall be packed in hermetically sealed containers in which silica gel, or some other approved dehydrant, has been inserted.

Cases shall be marked both with large lettering to show which side up the case is to be, and, if the contents are fragile, marked "FRAGILE" in large letters and the international wine glass symbol. In the case of container shipments individual crates or equipment on pallets shall also indicate any special handling or movement requirements or weight limitations. Packages shall be marked with their place of destination in such a way that rough handling or the effect of weather cannot remove or obliterate the marking. Each separate package shall be marked with the gross weight and for all lifts over two tonnes marks on the cases or equipment shall show where the weight is bearing and the correct positions for the slings.

The cases shall, whenever possible, be so packed that they can safely be placed any side uppermost and no reliance shall be placed on the ability of those who will handle the case to read written instructions or to understand pictorial ones. Cases that have to be slung in a certain way shall, as far as possible, be so constructed that they cannot conveniently be slung in any other way and packages shall preferably be so large that they cannot be easily rolled over or thrown about; thus when practicable small cases shall be crated together to form one larger unit. Crates shall be sufficiently strong to be capable of being slung from the outside even when provision is also made for slings to be attached direct to a major article inside.

Special steps shall be taken to guard against theft during transport. No small items, such as padlocks, nameplates and so forth, which could be torn off or unscrewed, shall be accessible. Cases, crates, barrels and drums shall be banded in such a manner as to obstruct the theft of any of the timber used for packaging, and the bands shall be so secured that they are not rendered ineffective by shrinkage of the wood.

A descriptive and fully itemised list shall be prepared of the contents of each packing case or container. A copy of this list shall be placed in a waterproof envelope under a metal or other suitable plate securely fastened to the outside of one end of the case or container and its position adequately indicated by stencilling. Where appropriate drawings showing the erection marking of the items concerned shall be placed inside the case or with the equipment in the container.

All packing cases shall remain the property of the Employer and the Contractor shall be responsible for them until handed over. The disposal of all packing cases shall be at the discretion of the Engineer.

15.2 Shipping Marks and Shipping

Each container, case or crate shall be clearly marked on two vertical faces with the following shipping mark:-

LUCELEC
LUC/18/SE4
LUCELEC

Letter sizes are to be a minimum of 100 mm and the diamond enclosing the Contract number shall have sides of length at least 700 mm and shall be coloured red.

Crated items shall not, without the express approval of the Engineer, be shipped as deck cargo and all protection and packaging for shipment is subject to inspection and approval by the Engineer. Notwithstanding such approval, it is the sole responsibility of the supplier to ensure that all items are packed in such a way as to ensure their complete safety and that of the shipping and handling authorities and their equipment.

15.3 Receipt and Storage at Site

All items, packing cases, containers and packages received at Site shall be recorded against the shipping schedule and immediately inspected for signs of damage. All signs of damage shall be investigated and the extent and nature of the damage recorded. The contents of each packing case, container or package shall be checked against the contents list and any discrepancies noted. Each item shall be carefully unpacked and checked for mechanical damage and/or damage to the corrosion protection. All such damage shall be recorded.

No item will be accepted for storage on Site until all mechanical and/or corrosion protection damage has been notified and rectified to the Engineer's satisfaction. It is emphasised in this respect that for damage which may affect the life or function of the component the Contractor must submit a full report to the Engineer describing the consequences of the damage and the proposed rectification procedures.

All plant and equipment to be stored out of doors shall be placed on timber or the equivalent so that it is out of contact with the ground and provided with adequate protection against weather. The Engineer may, if he considers it necessary, instruct the Contractor to carry out a repair or special cleaning process on any item on which the protection has been ineffective and/or which has been subjected to adverse storage conditions.

All items stored at Site shall be inspected on a regular basis and adequate records of inspection and corrosion protection rectification carried out shall be kept. All such records and the items in store will be subject to periodic audit and inspection by the Engineer who may require additional work to be carried out to either restore the condition of the item or to ensure that deterioration does not occur.

The cost of all recording, inspection and rectification shall be borne by the responsible supplier who is also responsible for any necessary insurance claims against shippers and/or other parties in respect of the damage to or loss of any item or component.

On withdrawal from store, each item or component shall be prepared for erection by removal of temporary shipping and site storage protection. Immediately prior to erection, inspection shall be carried out to ensure that all such protection has been properly and completely removed as necessary unless the protection is to be used for additional protection during erection. All such 'left on' protectives must be removed prior to commissioning the plant unless with the specific approval of the Engineer they will be removed during testing and/or commissioning without detriment to the plant or associated plant and equipment. All desiccants and vapour phase inhibitors must be removed prior to erection even though semi-completed systems and/or vessels may subsequently require re-protection by similar means to prevent deterioration during erection.

The Contractor shall be held responsible for, and make good, any and all damages due to improper preparation of goods for shipment or storage.

16. MAINTENANCE EQUIPMENT

16.1 Tools

The Contractor shall supply in steel boxes, complete with keys, a set of alloy steel spanners to fit every nut and bolt head on the plant supplied under this Contract, together with all special tools that may be required for erection, repair and maintenance of the equipment. Special tools shall be listed in Schedule D.

Suitable special spanners shall be provided for bolts and nuts which are not properly accessible by means of an ordinary spanner.

All tools shall be stamped in an approved manner for identification purposes and a corresponding key chart shall be supplied with the steel boxes.

16.2 Lifting Tackle

All lifting tackle, winches, jacks, rollers etc. required for installation of the plant shall be provided by the Contractor. Where items of plant need to be lifted in order to carry out regular maintenance or cleaning, lifting devices, to the approval of the Engineer, shall be provided.

17. FIRE PRECAUTIONS

All machinery, apparatus, connections, cabling and other works forming part of the Contract shall be so designed, arranged and be of such material as will minimise the risk of fire and any damage that might be caused in the event of fire. The Contractor shall be responsible for sealing in an approved manner all holes in floors, walls and roofs, through which the cables and pipes may pass and for

protecting the cables or pipes in an approved manner against mechanical damage or damage by fire.

18. PERMIT TO WORK SYSTEM

No work shall be carried out by any person on plant which is electrically charged from the Employer's systems or is operational or which has been taken over, or on the connections of plant to other plant which is so charged and/or operational or which has been taken over unless permission has been granted by Lucelec through the issue of a Permit to Work. If the Contractor is in doubt as to whether authorisation is required for any particular area of work he should consult the Engineer or his nominated representative for assistance.

The Contractor shall be responsible for requesting the issue of a Permit to Work from Lucelec via the Engineer outlining the work he proposes to do and giving the name of the Competent Person to which the Permit to Work should be issued. Applications shall be made at least 3 days before the intended work is due to start. The Contractor shall ensure that the plant and equipment covered by the Permit of Work meet his requirements and that the period of cover is also adequate.

When the application is approved by the Engineer and the Employer's representative at site, the necessary isolation will be carried out by the Employer and the Permit to Work will then be issued to the Competent Person. Lock-out keys (where applicable) for the Permit to Work will not be removed from the lock-out system until the relevant Permit to Work has been cancelled.

The Contractor shall supply to the Engineer for the Engineer's approval a list of Competent Persons in their or their Subcontractor's employment who are authorised to receive Permits to Work. When a Permit to Work is issued to a Competent Person he must sign that he understands the responsibilities and limitations imposed and to acknowledge receipt of the Permit to work and the keys, if any.

As soon as the work is completed or suspended, the Contractor must clear the Permit to Work by the Competent Person in charge of the work signing the appropriate section of the Permit to Work in the presence of the Engineer or his nominated representative.

The Competent Person as defined in Lucelec's Safety Rules is "A person recognised by Lucelec as having sufficient technical knowledge and/or experience to enable him to avoid danger and who may be nominated to receive and clear specified Safety Documents." Only those of the Contractor's work force qualifying under the above criteria will be allowed by the Engineer to assume the role of a Competent Person.

SECTION 4

**66 KV OPEN TYPE SWITCHGEAR
EQUIPMENT**

SECTION 4
66 KV OPEN TYPE SWITCHGEAR EQUIPMENT

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SECTION 4

66 kV OPEN TYPE SWITCHGEAR EQUIPMENT

1 GENERAL PARTICULARS

1.1 Type of Switchgear Equipment

The switchgear shall be of the outdoor type, of single busbar design as specified in Schedule 'G' and shall be suitable for operation under the climatic conditions existing at the sites.

1.2 Current Ratings

Unless otherwise approved the complete switchgear equipment shall be capable of carrying a through fault current equivalent to the specified kA breaking capacity of the circuit breakers for three seconds and shall also be capable of carrying continuously the rated currents specified without damage or overheating.

1.3 Clearances

The clearances and positions of apparatus including the access facilities shall permit safe maintenance of any section of the apparatus while the remaining sections are alive.

Arcing rings and co-ordinating gaps are not generally required as part of the scheme of substation insulation co-ordination. They may be fitted, however, when required for the co-ordination of circuit breaker internal and external insulation levels or for voltage grading purposes.

The height from the ground or working platform to any live part of the equipment which is not in an earthed screen enclosure shall be not less than 2.45 metres plus the length of the supporting insulator or the bushing insulator. When these clearances are not obtainable, earthed screen enclosures or partitions shall be provided which shall prevent approach to any live part. Access doors in such screens shall be provided with interlocks to restrict access unless the equipment is isolated and earthed.

1.4 Earthing

All metal parts other than those forming part of any electrical circuit shall be earthed to the earthing system. Any necessary terminals on any part of the equipment required for this purpose shall be provided by the Contractor.

1.5 Gas, Oil or Compound-filled Chambers

Suitable provision shall be made for the expansion of the filling medium in all gas, oil or compound-filled chambers and the chambers shall be so designed as to avoid the trapping of air or gases during the filling process.

The temperatures of any chamber which is to be compound filled shall, before filling, be such that the compound does not solidify during the filling process.

1.6 Joints for Oil-filled Chambers and Circuit breaker Tanks

All joints other than those which have to be broken shall be welded, and care shall be taken to ensure that the tanks are oil-tight. Defective welded joints shall not be caulked, but may be re-welded subject to the written approval of the Engineer.

All joints which have to be broken during normal maintenance shall be machine faced. Packing, if employed, shall be of an approved type and thickness. The spacing and size of bolts used in any of these joints shall be approved.

1.7 Oil Level Indication

Facilities shall be provided on oil circuit breakers and other oil containers such that an observer at ground level can see with certainty whilst the equipment is alive that it contains the required quantity of oil. A means, other than indication painted on the tank, shall be provided to indicate the oil level in each circuit breaker tank and other oil containers. All such oil containers of the removable type or having removable top plates shall have the oil level indicated both inside and outside. The inside level shall be the level attained by a normal operating quantity of oil when the tank or top plate is removed.

1.8 Insulating Compound

Insulating compound shall be of appropriate type. It shall not soften sufficiently to ooze out nor shall it become brittle under any conditions normally encountered during transport or in service.

Wherever practicable the operation of filling all apparatus shall be carried out at the Contractor's Works. The Contractor shall provide sufficient compound of the specified quality for all apparatus which has necessarily to be filled or topped up on Site.

1.9 Equipment Connected to Direct Current Circuits

All d.c. equipment, other than closing and tripping devices, shall operate satisfactorily between the limits of 20 per cent below and 10 per cent above normal operating voltage and over the complete range of operating temperature. Such equipment shall withstand a maximum voltage of 130 per cent for a period of 2 hours.

1.10 Auxiliary Switches and Contactors

With each circuit breaker, isolating device, and earthing device, there shall be supplied all necessary auxiliary switches, contactors and mechanisms for

indication, protection, metering, control, interlocking, supervisory SCADA and other services. Not less than eight spare auxiliary switch ways shall be provided with each circuit breaker and not less than four on all other devices. Each spare contact shall be readily changeable from normally open to normally closed and vice versa. All auxiliary switches shall be wired up to a terminal board on the fixed portion of the switchgear whether they are in use or not in the first instance, and shall be arranged in the same sequence on all equipments. Switches shall be provided to interrupt the supply of current to tripping and closing mechanisms of the circuit breakers directly the appropriate operation has been completed. All such switches and mechanisms shall be mounted in approved accessible positions clear of the operating mechanism, and shall be adequately protected. The contacts of all auxiliary switches shall be strong and shall have a positive wiping action when closing.

Contactors shall be of robust design and unless otherwise approved, shall be mounted in suitably ventilated weatherproof metal enclosures. Where the metal surface of the cubicle is close to the arcing area of a contactor it shall be covered with fireproof insulating material. Where two or more contactors are in the same cubicle they shall be separated by barriers of fireproof insulating material. All connections shall be insulated and so arranged or protected to prevent damage by arcing of the contactors. Discharge resistors shall be provided when required to prevent undue arcing during the operation of contactors.

1.11 Interlocking Gear

All circuit breakers, isolating devices, and earthing switches shall be provided with interlocking to prevent equipment being operated in an incorrect sequence. Interlocks shall be of the mechanical, electrical bolt or key operated type.

All mechanical interlocks shall be applied at the operating point at which hand power is used so that stress cannot be applied to parts remote from that point.

All electrical interlocks shall so function as to interrupt the operating supply, and an approved system of interlocks shall be provided which shall cover the emergency hand operation of apparatus which is normally power operated. Failure of supply or connections to any electrical interlock shall not produce or permit faulty operation. Electrical bolt interlocks shall be energised only when the operating handle of the mechanism is brought to the working position. Visible indication shall be provided to show whether the mechanism is locked or free. Means, normally padlocked, shall be provided whereby the bolt can be operated in emergency or a failure of interlock supplies.

Where key interlocking is employed tripping of the circuit breaker shall not occur if any attempt is made to remove the trapped key from the mechanism. Any local emergency tripping device shall be kept separate and distinct from the key interlocking.

All isolating devices shall be interlocked with associated circuit breakers and isolators in the same station so that it shall not be possible to make or break current on an isolating device unless a parallel circuit in that station is already closed.

Earthing switches shall be interlocked with their associated isolating switches so that it is impossible to close either switch without first opening the other.

2 66 KV CIRCUIT BREAKERS

2.1 General

Circuit breakers shall be designed and fully tested in accordance with IEC62271-100 and 60694.

Circuit breakers shall be suitable for the application of three-phase break-time delay - make break auto-reclosing and a dead time of less than 10 seconds will not be required normally for system operation.

Circuit breakers shall use SF6 gas conforming to IEC or other approved standard as the medium for arc quenching.

Circuit breakers shall operate on the principle of a self generating gas pressure within the interrupter for arc extinction, e.g. puffer type.

A lockout feature shall be incorporated to prevent operation of the circuit breaker whenever the gas pressure falls to a value below which it would be incapable of performing in accordance with its rated duty. Gas monitors shall be temperature compensated.

An alarm feature shall also be incorporated to give indication of falling gas pressure prior to lockout of the circuit breaker.

Suitable facilities shall be included for gas sampling and for draining and replenishing the gas volume for maintenance. Absorption of moisture and the decomposition products of arcing or discharge in the gas shall be achieved by integral filters.

2.2 Circuit breaker Operating Mechanisms

The circuit breaker operating mechanism shall be power operated and of the type specified. Operation will normally be from a remote or supervisory position but facilities shall be provided for operation locally by electrical release and by direct manual release from stored energy devices when the circuit breaker is isolated for maintenance. It shall be possible to padlock each local control function in the open position. Operation counters shall be fitted to all circuit breaker mechanisms.

The mechanism and its control scheme shall be such that, in the event of an electrical tripping pulse being applied to the circuit breaker during the closing

stroke, or of the mechanism failing to latch in the closed position, the circuit breaker shall open fully and in such a manner as to be capable of interrupting its rated breaking current.

The mechanism and its control scheme shall be such that the mechanism shall not make repeated attempts to close the circuit breaker when the control switch is held in the CLOSE position in the event of failure to latch on the first closing attempt or in the event of a trip signal being given to the circuit breaker.

The electrical closing and tripping devices, including direct acting solenoid coils and solenoid operated valves, shall be capable of operation over the ambient temperature range when the voltage at their terminals is any value within the voltage range specified and in addition over the range of all operating conditions of the batteries and chargers supplied under this Contract.

The circuit breaker may be driven by a single mechanism coupled to the three phases.

Where separate operating mechanisms are provided for each phase approved means shall be provided to ensure simultaneous operation of the three phases. Mechanisms shall be designed to minimise the possibility of making or breaking one or two phases only. Provision shall be made for automatic tripping of the circuit breaker or for a remote alarm indication in the event of any phase falling out of synchronism.

2.2.1 Spring Operated Mechanisms

Spring operated mechanisms shall be arranged for motor charging but means shall be provided for charging by hand. No electrical or mechanical operation of the mechanism during this process shall endanger the operator or damage the equipment.

When fully charged the spring mechanism shall have sufficient stored energy to permit the operating sequence O-C-O to be performed following the loss of supply to the charging motor.

A mechanical indicating device shall be provided to indicate the state of the spring. The indication shall be visible with the doors of the mechanism cabinet closed. An auxiliary switch shall give the remote indication of "spring discharged".

2.2.3 Hydraulic Operating Mechanisms

Hydraulic operating mechanisms shall incorporate individual (unit) oil pumps for each circuit breaker and unit storage using compressed gas accumulators.

There shall be sufficient energy stored in the accumulators for at least two CO operations when the pressure of the hydraulic fluid is at pump start setting.

Low pressure alarms and lockout facilities shall be provided to warn of low accumulator pressure conditions.

The hydraulic mechanism, pipework and accumulator shall preferably be of a design where it is not possible for the compressed gas in the accumulator to leak into the hydraulic fluid. Means shall be provided for bleeding the hydraulic circuit of air or gas.

Means shall be provided for detecting loss of nitrogen or other accumulator gas and in the event of excessive loss all hydraulic operations of the circuit breaker shall be blocked. Alarm contacts shall be provided to indicate this condition and also any excess running time of the pump motor.

Manual or d.c. motor driven standby facilities shall be provided to recharge the accumulators in the event of a failure of the pump or its voltage supply. The design of the mechanism, pipework and accumulator shall be such as to ensure minimum loss of oil pressure and operating pressure range shall be such as to requires infrequent pump operation to compensate for losses. Provision shall be made at larger installations to prevent all pumps within a substation from starting together following the restoration of pump supply voltage or busbar fault tripping.

2.3 Local Control Unit

Each circuit breaker shall be provided with a local control panel located in an approved position. A local/remote changeover switch shall be provided to prevent local and remote control functions from being in operation simultaneously. To render the circuit breaker safe for maintenance it shall be possible to prevent any external protection tripping and control functions by isolation links in the local control panel and remote relay panel.

Local manual release facilities shall be provided for closing and tripping the circuit breaker. The operation of both releases shall be subject to lock-out if insufficient stored energy is available. Local manual releases shall be provided with locking off facilities.

Sufficient electrical terminals shall be provided for the termination and interconnection of all cabling associated with remote and supervisory control, alarms, indications, protection and local ring main supplies.

Hydraulic/pneumatic and SF6 auxiliary equipment necessary for the correct functioning of the circuit breaker shall be located in a separate cubicle compartment.

2.4 Circuit breaker Maintenance

All arcing contacts, and other parts affected by operation or heavy duty shall be readily replaceable. Adequate facilities shall be provided to permit the inspection and maintenance of contacts, valves and other components.

3 DISCONNECTORS AND EARTHING SWITCHES

Disconnectors and earth switches shall comply with requirements of IEC 62271-102 and other relevant IEC standards if not otherwise required in these Specifications.

Disconnectors shall be arranged to permit safe maintenance of substation equipment. Isolating switches shall be arranged for operation while the equipment is alive, and will not be required to break current other than the charging currents of open busbars and connections (including circuit breaker bushings).

The minimum total length of air gap between terminals of the same pole with the isolator open shall be designed to provide an impulse voltage withstand level not less than 15 per cent in excess of that specified for the insulation of the substation to earth.

Disconnectors and earthing switches shall unless otherwise specified be arranged for manual operation from ground level.

Where required the operating mechanism shall be of motor operated type with facility for emergency manual operation. Emergency manual operating device shall be placed at readily accessible position. Emergency manual operation must be possible in the event of failure of electrical supplies and it shall render electrical operation inoperative (mechanically disconnected). The motor shall be of maintenance free type.

It must be possible to mechanically block and padlock the disconnector in either operational position.

Operating mechanism shall be complete with local/remote/selector switch an open (neutral) close control switch.

Electrical bolt interference interlocks shall be provided and energised in the case of hand operation, only when the operating handle of the hand mechanism is brought into the working position. Visible indication shall be provided, normally locked, whereby the bolt can be operated in the event of loss of auxiliary supplies.

Disconnector mechanisms shall be so designed that the disconnectors cannot be opened by forces due to currents passing through it, and shall be self-locking in both the "open" and "closed" positions. The mechanism shall open and close all three phases simultaneously.

Service conditions require that disconnectors shall remain alive and in service without being operated and without maintenance for periods of up to two years. In such conditions the contacts will be expected to remain capable of carrying their rated load and short-circuit currents without overheating or welding. After such periods the maximum torque required at the operating handle to open them should be within the capabilities of one man (i.e. approx. 340 Nm).

When made of steel or malleable iron, operating boxes, handles, rods, tubes and other fittings for outdoor equipments shall be galvanised.

When the disconnector moves from the open to closed position the auxiliary switch contacts shall be set to give break before make with the sequence complete before the main contacts reach the pre-arcing position. A set of contacts shall be provided for remote signalling of the disconnector position, the signalling of the open position shall not take place until the disconnector has reached a stable open position.

4 BUSBARS AND CONNECTIONS

Busbars and busbar connections shall be of electrolytic copper. The busbars may consist of either stranded conductors or tubes. Approved non-ferrous metal spacers shall be used for stranded conductors having hollow cores.

Material used for busbars, busbar connections, and their supports, whether insulated or otherwise shall not be stressed beyond two fifths of its elastic limit or its proof stress, whichever is applicable. Satisfactory provision shall be made for expansion and contraction of busbars and busbar connections with variation in temperature.

The maximum permissible temperature of unprotected, bare busbars or busbar connections when carrying rated current shall be 75°C.

All busbar connections shall be kept as short and as straight as possible. The design of connections to busbars and other equipment shall be such as to permit easy dismantling for maintenance purposes. The busbars shall be so arranged that they may be extended in length without difficulty.

All clamps, and fittings necessary for attaching the busbars and busbar connections to their insulated supports, together with all connectors, terminals and accessories required for attaching the connections to the busbars, switchgear, transmission lines and power transformer bushings shall be provided. Where dissimilar metals are connected approved bi-metal clamps shall be provided to prevent electrochemical action or corrosion. Stranded copper connections shall be tinned at clamping points and if of the hollow pattern shall be supported against crushing at such points by sweating solid or plugging. The open ends of all tubes shall be fitted with end caps.

Busbar supports shall be designed and constructed so that resonant vibrations are eliminated or reduced to negligible proportions.

Overhead conductors carried by substation structures shall be erected with such sags and tensions that the maximum loading of the structures is not exceeded when the conductors, at minimum temperature, are subjected to maximum transverse wind pressure on the whole projected area. Copies of the conductor sag charts shall be submitted to the Engineer for approval.

5 CURRENT TRANSFORMERS

Current transformers shall be of outdoor, oil immersed multi core hermetically sealed type.

They shall comply with IEC 60044-1 and other relevant IEC standards if not otherwise required in these specifications.

Current transformers shall be suitable for the operation of protective gear, instruments and/or metering equipment and the design characteristics shall be to approval.

Current transformers shall have an output rating adequate to cater for all the burden connected to them. They shall have sufficient rating, terminal voltage and accuracy class for the satisfactory operation of their associated equipment. The Contractor shall be responsible for taking into account lead and all other burdens.

The primary windings shall not, without special approval, have a short time current rating less than that specified for the associated circuit breaker. Windings shall be capable of carrying the rated primary current for a period of one minute with the secondary winding open circuited.

The current transformer particulars as specified in IEC 60044 shall be given in an accessible plate mounted external to the current transformer.

Current transformer secondary circuits shall be complete in themselves, and shall be earthed at one point only, through links situated in an accessible position. Each separate circuit shall be earthed through a separate link, suitably labelled. The links shall be of the bolted type have M6 nuts and provision for attaching test leads.

The earth links for protective and instrument current transformer secondary circuits shall be mounted inside the relay panels. Earth links for metering current transformer secondary circuits shall be mounted at the switchgear.

Magnetisation curves of each type of current transformer shall be submitted for approval.

6 VOLTAGE TRANSFORMERS

Voltage transformers shall be suitable for the operation of protective gear, voltage regulating equipment instruments and/or metering.

Voltage transformers not intended for tariff metering shall be of the outdoor capacitor (i.e. CVT) type.

CVTs shall comply with the requirements of IEC 60186 and associated standards.

Except for tariff measuring VTs, the standard secondary arrangement shall be with two outputs each capable of simultaneous supply at rated burden at Class 1.0 (metering) or class 3P (protection). Secondary output voltage shall be $110/\sqrt{3}$ V.

When a polarising source voltage is required for directional overcurrent or directional earth fault protection a broken delta connected residual voltage winding shall be provided.

Where specified capacitor voltage transformers shall be provided with coupling facilities for use with H.F. power line carrier equipment with provision being made for the mounting of line traps and connection of carrier equipment.

Capacitor voltage transformers shall be designed to minimise the possibility of ferro-resonance occurring.

Voltage transformers shall be in accordance with IEC 60186 with a rated voltage factor of 1.2 and Class 1.0 accuracy. Transformers for protective duty shall be accuracy Class 3P.

All voltage transformers shall have an output rating adequate to cater for the burdens connected to them.

For single phase voltage transformers, both ends of each secondary winding shall be brought out to insulated links. For three phase voltage transformers, each phase end shall be brought out to fuses and the neutral of the secondary winding shall be brought out to insulated links. Where a residual winding is required the open delta shall be brought out to insulated links. The fuses and links shall then be brought out to insulated terminals located in a terminal box.

Secondary fuses shall be provided in the terminal box such that they can be removed with the equipment alive and shall be labelled to indicate their function.

For single phase units separate earth links for each secondary winding shall be provided. Each of the neutral leads shall be connected together at a single point and earthed as close as possible to the voltage transformer.

Secondary circuits of voltage transformers shall not be paralleled.

Magnetisation curves for each type of voltage transformer shall be submitted for approval.

7 SURGE ARRESTERS

Surge arresters shall be of the metal-oxide, gapless type.

The design of equipment shall be in accordance with the requirements of IEC60099-1, IEC: 60099-4 and any additional requirements of this Specification.

The surge arresters shall be designed to incorporate a pressure relief device to prevent shattering of the blocks/or housing, following prolonged current flow or internal flashover. They shall be designed to ensure satisfactory operation under the atmospheric conditions given in the Schedules, and under such sudden variation of voltage as may be met with under working conditions on the system.

Where surge arresters form part of an overall contract for the engineering of a station and the supply of equipment, the positioning of the arresters relative to other equipment shall provide protection to the other equipment according to the requirements of IEC 60099. Insulation coordination studies shall be carried out to demonstrate these requirements and issued to the Engineer for approval.

The porcelain insulators and fittings shall be in accordance with the relevant items of the section of this Specification - Insulators, Bushings and Fittings.

The Contractor shall state if grading rings are provided. Such rings shall be of an approved type, size and material and shall be attached in an approved manner.

Surge Counters

Surge counters shall be provided and shall be operated by the discharge current passed by the surge arrester. Surge counters shall be of the electro-mechanical type and designed for continuous service, they shall be provided with a facility for continuously monitoring the leakage current.

Internal parts shall be unaffected by atmospheric conditions on Site. Alternatively, a weatherproof housing to IP 55 shall be provided as part of the Contract and this shall be designed to allow the recording device to be read without exposing the internal parts to the atmosphere.

The surge counter shall be connected in the main earth lead from the diverter in such a manner that the direction of the earth lead is not changed or its surge impedance materially altered. A bolted link shall be provided so that the surge counter may be short circuited and removed without taking the arrester out of service.

SECTION 5

**11 KV INDOOR METAL-ENCLOSED
SWITCHGEAR**

SECTION 5

11 KV INDOOR METAL-ENCLOSED SWITCHGEAR

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SECTION 5

11 KV INDOOR METAL-ENCLOSED SWITCHGEAR

1 TYPE OF SWITCHGEAR

The switchgear shall comprise an extensible air insulated metal clad switchboard of single busbar design suitable for indoor use and shall be constructed in accordance with IEC 60298 unless otherwise specified.

Only designs employing vacuum circuit-breakers will be considered.

2 RATINGS

Each complete switchgear unit shall have the current rating and short circuit rating specified in the Schedules.

The rated short-circuit making capacity shall apply when the circuit-breaker is being closed in the "service" location and also with the equipment arranged for busbar and circuit earthing.

The rated duration of short-circuit for the complete switchgear equipment shall be 3 seconds at a current not less than the rated short-circuit capacity specified.

3 GENERAL CONSTRUCTION

A switchgear unit shall preferably comprise two main portions, a fixed portion housing the busbars, current transformers, relays and instruments and a moving portion comprising a carriage complete with circuit-breaker. Designs employing fixed vacuum or SF6 gas circuit-breakers having incorporated internal isolation facilities may also be considered. The principles of at least metal-enclosed segregation of compartments shall apply throughout the design.

Separate switchgear units shall be assembled to form a complete flush fronted switchboard which shall be readily extensible at either end.

Where specified in Schedule 'G' a relay and instrument compartment shall be located at the front of each switchgear unit and shall be provided with a hinged door for access to the internal wiring and terminals. Gaskets shall be used to provide close sealing. The height of the instrument panel above floor level shall not exceed 2000 mm. All panels constituting a complete switchboard shall be the same height.

Bolted-on rear and top covers shall be designed to gain access to individual circuits without exposing other circuits which may be alive.

4 PRIMARY BUSBARS AND CONNECTIONS

Primary busbars and connections between the several pieces of apparatus forming the equipment of a cubicle shall be of electrolytic copper.

Primary busbars shall be contained in a separate compartment within the switchboard and access shall be possible only by means of bolted-on sheet steel covers which shall clearly be marked "Busbars". Busbars and busbar connections shall not be exposed when covers and doors are opened for access to the remainder of the switchgear.

Each phase conductor of the primary busbars, including all through joints and tapping connections shall, in addition to being spaced at such intervals to give the necessary air clearance for the voltage rating, be completely insulated in an approved manner. Taping will not be accepted.

Primary busbars, connections and their supports shall be of an approved type and shall be capable of carrying the short-time current associated with their short-circuit ratings for a period of 3 seconds.

Where busbar supports etc., use insulation of moulded or resin bonded material they shall have a durable anti-hygroscopic surface finish with high anti-tracking properties.

The connections from busbars in individual units shall have a continuous current rating of not less than that of the equipment comprising the unit.

At all points where connections or joints occur, the busbars and connecting pieces shall be tinned or silver-plated. The resistance of any length of conductor containing a joint shall not be greater than that of an equal length without a joint. Clamps, where used, shall be phosphor bronze and all bolts for joints shall be of high tensile steel.

Primary busbars and connections shall be clearly marked and shall be displaced for standard phase sequence Red (R), Yellow (Y), and Blue (B) or equivalent counting from front to rear, top to bottom or left to right as viewed from the switching device operating mechanism side. Busbars shall be readily extensible and on duplicate busbar equipment without shutdown of the complete switchboard or without taking existing circuits out of service.

5 CIRCUIT-BREAKERS

Circuit-breakers shall be vacuum type.

The moving portion of each circuit-breaker unit shall consist of a three-pole circuit-breaker with operating mechanism, primary and secondary disconnecting devices, auxiliary switches, position indicators and the necessary control wiring, all

mounted on a substantial steel framework. This framework and all metal parts of the moving portion apart from current carrying parts, shall be solidly earthed via the fixed portion. The earthing of the moving portion shall be to the approval of the Engineer. Means of registration shall be provided so that circuit-breakers may be readily placed and secured in the correct position in the fixed portion.

Circuit-breakers of the same current and voltage rating shall be fully interchangeable one with another. Means shall be provided to prevent circuit-breakers from being placed into fixed housings of different ratings. This device shall also prevent damage to isolating and other contacts.

The fixed and moving contact systems shall comprise both main and arcing contacts, all parts of which shall be easily dismantled and replaced.

5.1 Vacuum Circuit-breakers

Circuit-breakers employing the vacuum interrupting principle shall incorporate vacuum bottles of declared and established manufacture. Each interrupter shall be capable of individual adjustment for correct operation and easily removed for maintenance or replacement. Full instructions for monitoring the state of vacuum and contact life shall be provided to the approval of the Engineer.

6 OPERATING MECHANISMS

The circuit-breaker mechanism shall be either of the motor wound spring type or spring assisted manual closing type as called for in Schedule 'G'. The circuit-breaker shall be capable of closing fully and latching against its rated making current.

Facilities shall be provided where necessary for maintenance purposes to permit manual slow closing and slow opening of the circuit-breaker. It shall not be possible to use this facility when the circuit-breaker is in the service or earth positions. Such manual operations shall be easily accomplished by one person. In the case of designs utilising portable jacking devices, a sufficient number of them shall be included in the special tools at each substation so that circuit-breakers of any rating at that substation may be manually operated.

In the event of a spring breaking, it shall still be possible to open the circuit-breaker or switch safely, and it shall also not be possible to start to close the circuit-breaker.

Motor wound spring operated mechanisms shall have the following additional features:-

- (a) If the circuit-breaker is open and the springs charged, the circuit-breaker can be closed and then tripped.

- (b) If the circuit-breaker is closed and the springs charged, there shall be sufficient energy to trip, close and then trip the circuit-breaker.
- (c) Mechanical indication shall be provided to indicate the state of the spring. This indication shall be clearly visible from the front of the breaker. In addition, suitable contacts shall be provided which may be used for remote indication.
- (d) Motor charged mechanisms shall be provided with means for charging the springs by hand, and also a shrouded push button for releasing the springs. An electrical release coil shall also be provided.
- (e) Under normal operation, motor recharging of the operating spring shall commence immediately and automatically upon completion of each circuit-breaker closing operation. The time required for spring recharging shall not exceed 30 seconds.
- (f) It shall not be possible to close a circuit-breaker, fitted with a motor charged closing mechanism, whilst the spring is being charged. It shall be necessary for the spring to be fully charged and the associated charging mechanism fully prepared for closing before it can be released to close the circuit-breaker.

All circuit-breaker operating mechanisms shall be fitted with an electrical shunt trip release coil, and in addition, a mechanical hand tripping device.

The electrical tripping and closing devices shall be suitable for operation from a power supply as specified and shall operate satisfactorily with their coils at the maximum site ambient temperature over a voltage range as specified in IEC standards.

All operating coils for use on the d.c. supply shall be connected so that failure of insulation to earth does not cause the coil to become energised.

Tripping and closing circuits shall be provided with a fuse in each pole on each unit and shall be independent of each other and all other circuits.

Auxiliary switches shall be provided in circuit-breaker tripping circuits to interrupt the tripping supply as soon as the circuit breaker has completed the tripping operation, and to interrupt the closing supply as soon as the circuit-breaker has completed the closing operation.

Locking facilities with padlocks shall be provided so that the circuit-breaker can be prevented from being closed when it is open and from being manually tripped when it is closed. These facilities shall not require the fitting of any loose components prior to the insertion of the single padlock required. It shall not be possible, without the aid of tools, to gain access to the tripping toggle or any part of

the mechanism which would permit defeat of the locking of the manual trip. It shall not be possible to lock mechanically the trip mechanism so as to render inoperative the electrical tripping.

7 ISOLATING DEVICES AND SHUTTERS

All circuit-breakers shall be connected to their associated busbars and cables through isolating devices of an approved design which shall be suitable for operation whilst the busbars or feeder circuit are live.

The design shall be such that it is impossible for the isolating devices to be opened by forces due to current in the primary circuit and shall be interlocked with the circuit-breaker so that it is impossible to make or break current with the isolating device. Attempted isolation shall not trip the circuit-breaker.

When isolating devices do not form an integral part of the circuit-breaker equipment, they shall be provided with padlocking facilities in both the open and closed positions and this should not adversely affect the impulse withstand capability of the switchgear.

When isolation is effected by withdrawal of the circuit-breaker, provision shall be made for positively locating the circuit breaker in the service, isolated and, when fitted, earth positions. Stops shall be provided to prevent over-travel and each position shall be clearly indicated.

Preferably, a mechanical selector mechanism shall be utilised such that when a particular position is selected it is impossible to select the circuit-breaker in any other position.

Isolating devices shall incorporate self-aligning contacts, the fixed contacts of which shall be such that access can readily be obtained for maintenance purposes.

Metal shutters shall be provided to completely shroud fixed isolating contacts of the circuit-breaker busbar and feeder circuits in drawout switchgear. These shutters shall be opened and closed automatically by the movement of the circuit-breaker carriage and shall prevent access to fixed isolating contacts when the circuit-breaker is withdrawn. They shall not adversely affect the impulse withstand capability of the switchgear.

The shutters for fixed isolating contacts connected to busbars and cables shall have independent operating mechanisms. All shutters shall have painted labels indicating whether they are busbar or circuit shutters. Those for the busbars shall be red, and those for the circuit shall be yellow.

To facilitate testing, a device shall be provided for fixing, but not locking, shutters in an open position. The device shall be arranged so as to be cancelled by the moving portion, to ensure that the automatic feature of the shutter is restored.

Self-aligning plug and socket isolating devices of an approved design shall be provided for all auxiliary circuits. The position of these devices shall be such that individual circuits on different units are in the same relative physical positions.

8 INTERLOCKING GEAR

Maintenance and safety interlocks shall be of the mechanical or key operated type and shall be provided to prevent the following operations:-

- (a) Isolation or selection of a circuit when the circuit breaker is closed. Attempted isolation or selection shall not trip the circuit-breaker.
- (b) The closing of the circuit-breaker unless the movable portion is correctly plugged in or isolated from the equipment, or selector isolators are fully open or closed.
- (c) The closing of the circuit-breaker in the "service" or "earth" location without completing the appropriate auxiliary circuits.
- (d) The application of an earth to busbars until all circuit-breakers which can feed the busbars are locked open.
- (e) The withdrawal or replacement of the movable portion unless the circuit-breaker is isolated and in the appropriate position.

When key interlocking is employed, any attempt to remove the trapped key shall not cause closing or opening of the associated equipment.

Where a circuit-breaker or other switchgear is fitted with means for mechanical or electrical operation, interlocks shall be provided so that it is impossible for the electrical and mechanical devices to operate simultaneously.

The earthing devices shall be provided with interlocks to ensure correct operation in conjunction with the associated circuit breaker.

In the case of circuit-breaker earthing, the electrical tripping of the circuit-breaker shall be rendered inoperative during earthing operations both when closing and when closed in the earthed position. It shall not be possible to return to the service position and close the circuit-breaker until the electrical tripping is again operative.

9 LOCKING FACILITIES

In addition to any requirements already specified the following padlocking facilities shall also be included:-

- (a) Selector mechanisms on circuit-breaker in both isolated and service positions.

(b) Safety shutters on primary contact isolating orifices in closed position.

All cubicle access doors, other than those which are interlocked with a switching device shall be provided with an integral type locking facility.

10 EARTHING AND EARTHING DEVICES

All metal parts, other than those forming live parts of an electrical circuit, shall be connected in an approved manner to a hard drawn, high conductivity copper earth busbar which shall run the full length, and be bolted to the main frame, of the switchboard. At the position where joints occur, the earth busbar shall be tinned. The earth busbar shall be rated to carry currents equal in magnitude and duration to that associated with the short circuit rating of the equipment.

The design and construction of the equipment shall be such that all metal parts, other than current carrying parts, of withdrawable equipment are earthed before the primary connections are made.

Metal case supports and bases of all instruments, relays or other associated components mounted on the switchgear shall be connected to the earthed busbar by conductors of not less than 2.5 mm^2 cross-sectional area.

When components are provided for mounting separately, each shall be provided with an earthing terminal not less than 30 mm^2 cross-sectional area.

Earthing devices shall be provided on all circuit-breaker units whereby the circuit can be earthed. With the circuit earthed, shutters over unearthed fixed main isolating contacts shall be closed.

Busbar earthing facilities are to be provided on selected circuits of each switchboard section. The circuit to be to the approval of the Engineer.

Where earthing is effected through the circuit-breaker, it is preferred that the facilities shall be integral in the design and construction of the switchgear, and that the devices for circuit earthing be provided for each circuit. Should separate devices be offered for earthing, the operational requirements and features listed above shall be applicable but the scheme shall be subject to the approval of the Engineer.

Feeder and busbar earthing devices shall have a short-circuit rating equal to that of their associated circuit-breaker.

Padlocking facilities shall be provided for the purpose of preventing inadvertent earthing.

Labelling shall be provided to show whether the equipment is prepared for "SERVICE", "BUSBAR EARTH" or "CIRCUIT EARTH". Such indication shall be visible from the front of the equipment at all times.

In addition to the main provision for earthing, the design of the unit shall be such that a temporary earth can be applied to each equipment for the purpose of permitting work on the unit (e.g. for cleaning of insulators, or to release a circuit-breaker for maintenance) after earthing the circuit with the prescribed fault making earthing device. Such temporary earths shall be capable of being applied to each of the phases separately.

11 TESTING FACILITIES

All circuit-breaker units shall be provided with facilities to enable applied high voltage tests to be carried out.

Provision shall also be made for temporarily completing the auxiliary circuits when the circuit-breaker is isolated and withdrawn, to enable the functioning of the circuit-breaker to be tested.

When current transformers and protective relays are fitted, facilities shall be provided for primary and secondary injection tests to be carried out, such that wires and connections need not be disconnected for the tests.

12 MECHANICAL INDICATION

Positively driven mechanical indicating devices shall be provided on all equipment to indicate the following:-

Circuit-breaker "OPEN" or "CLOSED"

Circuit-breaker in "SERVICE", "ISOLATED" or "EARTHED" position.

Circuit-breaker "SPRING CHARGED" or "SPRING FREE"

13 AUXILIARY SWITCHES

Positively driven auxiliary switches shall be provided on all circuit-breakers and isolators for local and remote indication, control and interlocking. Auxiliary switches shall be provided for remote indication of the state of the spring charge mechanism.

Auxiliary switches shall be strong, have a positive wiping action when closing and shall be mounted in an accessible position clear of operating mechanisms.

They shall be designed to make, break and carry, without undue heating, the current of their associated circuit or a current of three amperes d.c., whichever is the higher.

Not less than four spare auxiliary switches shall be provided with each circuit-breaker and not less than two with each isolator. Each spare contact shall be readily changeable from normally open to normally closed and vice versa. All auxiliary switches shall be wired up (via secondary disconnecting devices if on withdrawable equipments) to a terminal board on the front of the fixed portion, arranged in the same sequence for each individual unit of the same type.

14 ANTI-CONDENSATION HEATERS

Anti-condensation heaters of an approved type shall be provided inside each cubicle or where necessary in each cubicle compartment. They shall be shrouded and located so as not to cause injury to personnel or damage to equipment. Unless otherwise specified the heaters shall be individually switched, with a lamp to indicate 'cubicle heaters on'. The heaters shall operate from a specified single phase a.c. supply.

15 CURRENT TRANSFORMERS

Current transformers shall be suitable for the operation of protective gear, instruments and/or metering equipment and the design characteristics shall be to the Engineer's approval.

Current transformers shall have an output rating adequate to cater for all the burden connected to them. They shall have sufficient rating, terminal voltage, accuracy class and overcurrent performance where applicable, for the satisfactory operation of their associated equipment. The Contractor shall be responsible for taking into account lead and all other burdens.

All current transformers and auxiliary transformers shall be of the low reactance type and, unless otherwise approved, current transformers shall be of the bar-primary design unless approved in specific cases where low ratio CTs are involved and the protective gear is suitable.

The primary windings shall not, without special approval, have a short time current rating less than that specified for the associated circuit breaker. The secondary windings of each set of current transformers shall be capable of being open circuited for one minute with the primary winding carrying the rated current.

Multi ratio current transformers should be tapped on the secondary side and not on the primary side unless otherwise approved by the Engineer.

All current transformers shall be installed with the P1 terminals adjacent to the busbars. The polarity of the primary and secondary windings of each current transformer shall be clearly indicated and in addition labels shall be fitted in a readily accessible position to indicate the ratio, class and duty of each transformer.

The current transformer particulars as specified in IEC 60044 shall be given on an accessible plate mounted external to the current transformer.

All connections from secondary windings shall be brought out and taken by means of separate insulated leads to a terminal board mounted in an accessible position. Where multi ratio secondary windings are required, a label shall be provided at the secondary terminal board clearly indicating the connections required for each ratio. The connections and ratios in use shall be shown on all diagrams of connections.

Current transformers for instrumentation or metering shall have their secondary windings earthed at the switchgear. The secondary windings of current transformers for protection shall be earthed at the panel which accommodates the associated relay. The earth connection shall be made via a removable link.

The characteristics of current transformers used for protective gear circuits shall include the following requirements:-

(a) For overcurrent protection:-

They shall not saturate, change ratio or produce harmonic voltages in the secondary winding which will affect the accuracy of the relay with primary currents up to 15 times rated full load current.

(b) For earth fault protection and balanced forms of protection:-

When connected as in service they shall not produce spill currents in excess of half the minimum operating current of the relay but provide stable conditions with primary currents up to 15 times rated full load.

Current transformers for tariff metering shall not be used for any other purpose. Current transformers for statistical metering may also be used for other instruments and protection.

Current transformers shall be air-insulated and be installed on that side of the switching device (circuit-breaker etc.) electrically remote from the busbar. They shall be mounted in the fixed portion of the switchgear with a method of securing in position such that undue mechanical pressure cannot be exerted on the transformer windings.

Magnetisation curves of each type of current transformer shall be submitted for approval.

Each current transformer shall have a certified maximum rating (CMR) of at least 1.2 times the rated current.

Where current transformers have to be supplied on this Contract for mounting in apparatus provided under other Contracts, the Contractor supplying the current

transformers shall be responsible for making all necessary arrangements with the other Contractors and for keeping the Engineer informed.

16 VOLTAGE TRANSFORMERS

Voltage transformers shall be suitable for the operation of protective gear, voltage regulating equipment instruments and/or metering and shall be of the wound type.

Voltage transformers shall be in accordance with IEC 60186 with a rated voltage factor of 1.2.

Voltage transformers shall be capable of carrying continuously without injurious heating 50% burden above their rated burden. The rated primary voltage of voltage transformers shall be the appropriate nominal system voltage.

Unless specified otherwise, voltage transformer primary windings shall be connected to the circuit side of the current transformers remote from the busbars so as to be included in the protected zone of the associated feeder.

The primary of a single phase voltage transformer shall be connected across Red and Yellow or A and B phases, unless otherwise approved.

Red and Yellow phases shall be used in a synchronising scheme, unless otherwise approved.

Voltage transformers shall be capable of being connected and disconnected from the equipment whilst in service. Facilities for padlocking in the service position shall be provided. Where isolation is carried out by withdrawal, a set of shutters, capable of being padlocked, shall be provided to cover the stationary isolating contacts. The shutters shall operate automatically by positive drive actuated by movement of the voltage transformer assembly.

The primary windings shall preferably be connected via renewable fuses with current limiting features which shall be readily accessible with the circuit alive and the secondary windings through fuses and links, labelled to indicate their function and phase colour, to the appropriate circuits.

For single phase voltage transformers, both ends of each secondary winding shall be brought out to insulated links. For three phase voltage transformers, each phase end shall be brought out to fuses, and the neutral of the secondary winding shall be brought out to insulated links. The fuses and links shall then be brought out to insulated terminals located in a terminal box.

The primary and secondary fuses shall be capable of being removed and replaced when the circuit-breaker is closed in the service position. Isolation of the primary fuses for this purpose shall be carried out, preferably by withdrawing the entire

voltage transformer assembly. Additionally, it shall be possible to remove secondary fuses whilst the voltage transformer is padlocked in the service location.

For single phase units, separate earth links for each secondary winding shall be provided. Each of the neutral leads shall be connected together at a single point and earthed as close as possible to the voltage transformer.

Voltage transformer secondary windings shall be earthed at the switchgear through a link which can be removed for insulation testing. The earthing of voltage transformers shall be to approval.

Voltage transformers shall be designed so that saturation of the core and dangerous over-heating arising there from shall not occur when 1.73 times normal voltage is applied to each winding for a period of 15 minutes.

Secondary circuits of voltage transformers shall not be paralleled.

Magnetisation curves for each type of voltage transformer shall be submitted for approval.

The ratio and phase angle errors of voltage transformers shall not exceed the permissible limits prescribed in the relevant Standard and shall be capable of meeting the following additional requirements from 5% rated primary voltage to 90% rated primary voltage:-

- Voltage error - not exceeding + 3%
- Phase angle error - not exceeding + 120 minutes

SECTION 6

**POWER TRANSFORMERS AND
EARTHING TRANSFORMERS**

SECTION 6

POWER TRANSFORMERS AND EARTHING TRANSFORMERS

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SECTION 6 TRANSFORMERS

1. TYPES OF TRANSFORMERS AND OPERATING CONDITIONS

1.1 Types of Transformers and Operating Conditions

All transformers shall be oil-immersed and shall each be provided with conservator vessels and shall be suitable for outdoor installation in bunded enclosures.

Transformers with forced cooling shall be capable of remaining in operation at full load for 10 minutes after failure of the oil and/or water circulating pumps or blowers without the calculated winding hot spot temperature exceeding 150°C.

Transformers fitted with two coolers must each be capable of dissipating 50% of the losses at full rated output and shall be capable of remaining in operation for 20 minutes in the event of failure of the oil and/or water circulating pumps or blowers associated with one cooler without the calculated winding hot spot temperature exceeding 115°C.

Where transformers are designed for forced oil or air-blast cooling, but are initially supplied only with natural oil cooling, provision shall be made for adding the cooling plant at a later date, if required to increase the output of the transformers.

1.2 Reference Documents

Transformers shall comply with the latest edition of the following :-

- IEC 60076-1 -Power transformers, General.
- IEC 60076-2 -Power transformers, Temperature rise.
- IEC 60076-3 -Power transformers, Insulation levels, dielectric tests and external clearances in air.
- IEC 60076-5 -Power transformers, Ability to withstand short circuit.
- IEC 60076-10 -Power transformers, Determination of sound levels.
- IEC 60137 -Insulated bushings for alternating voltages above 1000 V.
- IEC 60214 -On-load tap-changers.
- IEC 60354 -Loading guide for oil-immersed power transformers
- IEC 60529 -Degrees of protection provided by enclosures
- NEMA TR1 -Transformers, regulators and reactors [for audible sound levels

2. CONTINUOUS MAXIMUM RATINGS AND OVERLOADS

Equipment shall comply, as regards rating, temperature rise and overload, with the appropriate requirements of IEC 60076.

All equipment except where stated below shall be capable of operating continuously without injurious heating at full rated output at any ratio, irrespective of the direction of flow of power and with the voltage of the untapped winding maintained at the rated voltage.

Transformers having tapping ranges extending not more than 10% below the nominal voltage shall operate on the principal tapping without exceeding the limits laid down for temperature rise. On other tappings they shall operate continuously without injurious heating.

Transformers with tapping ranges extending more than 10% below the nominal voltage shall meet the temperature rise limits specified on all tappings on which the rated current is not more than 90% of the maximum rated current on the lowest voltage tapping. On other tappings they shall operate continuously without injurious heating.

If the system has an earthed neutral the manufacturer shall take into account any change of impedance per phase due to the zero sequence component resulting from unsymmetrical currents.

3 ELECTRICAL CONNECTIONS

Transformers and reactors when specified in the schedules shall be designed such that connection to the high voltage switchgear shall be via circular copper busbar suitable for the rating of the equipment.

Transformer and reactor l.v. connections and the h.v. and l.v. connections of earthing transformers shall be subject to the approval of the Engineer.

The reactors shall be erected on anti-vibration mountings such that mechanical isolating from surrounding structure is achieved.

Transformers shall be connected in accordance with the Group Symbol specified.

When specified, tappings shall be provided to give an alternative ratio of transformation. When operated on this tapping, the transformer shall give full rated power, as specified.

Transformers with alternative ratios of transformation shall be capable of withstanding the voltage tests specified, for the most severe condition.

Terminal bushing insulators when provided shall be mounted on transformer tanks so that the l.v. connections can be taken away horizontally clear of all obstacles.

4 DUTY UNDER FAULT CONDITIONS

Except where modified below, it is to be assumed that the amount of generating plant simultaneously connected is such that normal voltage will be maintained on one side of any transformer when there is a short-circuit between phases or to earth on the other side. Any transformer may be directly connected to an underground or overhead transmission line and switched into and out of service together with its associated transmission line.

All transformers shall be capable of withstanding for three seconds without damage an external short-circuit between phases. Transformers without tertiary windings shall be capable of withstanding for three seconds, without damage, a short-circuit between one phase and earth.

Transformers with tertiary windings shall be capable of withstanding for three seconds without damage any external short-circuit to earth with the neutral points on both h.v and l.v windings directly connected to earth.

Transformers directly connected to generators (generator step-up transformers) shall, under exceptional circumstances, due to sudden disconnection of the load, be capable of operating at a voltage approximately 35% above normal rated voltage for a period not exceeding one minute.

5 FLUX DENSITY

Unless otherwise agreed, the magnetic circuit shall be of cold rolled grain oriented sheet steel and the maximum flux density shall not exceed 1.7 T when the voltage applied to any tapping is not in excess of that for which the tapping was designed.

6 VIBRATION AND NOISE

Noise levels shall be measured in accordance with IEC 60551. The maximum acceptable level is 85 dB.

Anti-vibration mountings shall be fitted between the tank and the transformer plinth for transformers with ratings of 20MVA and above.

7 SUPPRESSION OF HARMONICS

The equipment shall be designed with particular attention to the suppression of harmonic voltages, especially the third and fifth, so as to eliminate wave form distortion and any possibility of high frequency disturbances, inductive effects or of circulating currents between the neutral points at different transforming stations reaching such a magnitude as to cause interference with communication circuits.

8 TOLERANCES

The admissible tolerances for no load current, component and total losses, voltage ratio and impedance voltage shall be as given in IEC 60076.

9 MAGNETIC CIRCUIT

The design of the magnetic circuit shall be such as to avoid static discharges, development of short-circuit paths within itself or to the earthed clamping structure and the production of flux components at right angles to the plane of the laminations which may cause local heating.

The design of the magnetic shielding, if required, shall be such as to minimise the effect of the return flux path penetrating the container wall without undue reduction in the overall reactance or increase in tank size.

Where the magnetic circuit is divided into packets by cooling ducts parallel to the plane of the laminations or by insulating material above 0.25 mm thick, tinned copper strip bridging pieces shall be inserted to maintain electrical continuity between packets.

The magnetic circuit shall be earthed through a link as specified below. With the link removed the magnetic circuit shall be insulated from all structural parts so as to withstand the tests specified and shall subsequently be earthed.

10 MECHANICAL CONSTRUCTION OF CORES

Care shall be exercised in the selection, treatment and handling of the core steel to ensure that as far as possible laminations are flat and the finally assembled core is free from distortion. Particular care shall be taken to secure even mechanical pressure over the laminations, to prevent subsequent settling of the core and to reduce noise and vibration during operation.

All parts of the cores shall be of robust design capable of withstanding any shocks to which they may be subjected during lifting, transport, installation and service.

All structural members of the assembled cores shall be of steel. All castings shall be fettled and structural steel adequately cleaned and painted before being built into the structure. Any non-magnetic or high resistance alloy used shall be subject to approval.

Adequate fitments shall be provided to enable the core and windings to be lifted.

Suitable accommodation, attached to the transformers, shall be provided for the storage of any removable portions of the lifting arrangements.

Adequate provision shall be made to prevent movement of the transformer relative to the tank during transport and installation or while in service.

The supporting framework of the cores shall be so designed as to avoid the presence of pockets which would prevent complete emptying of the tank through the drain valve, or cause trapping of air during filling.

11 WINDINGS - GENERAL

All windings for system highest voltages of 72.5 kV and below shall be fully insulated.

Tappings shall be arranged at such positions on the windings as will preserve, as far as possible, the electromagnetic balance at all voltage ratios, but shall also be positioned with due regard to the impulse voltages which may be impressed on the windings.

The insulation of windings and connection shall be free from insulating composition liable to soften, ooze out, shrink or collapse during service.

The stacks of windings shall receive adequate shrinkage treatment before final assembly.

The coil clamping arrangement and the finished dimensions of any oil ducts shall be such as will not impede the free circulation of oil through the ducts.

No strip conductor wound on edge shall have a width exceeding six times its thickness.

The coils shall be mounted in such a manner as to reduce any magnetic imbalance between each of the windings liable to induce circulating flux in the windings and surrounding metal work.

12 BRACING OF WINDINGS

The windings and connections shall be braced to withstand shocks which may occur during transport, or due to switching and other transient conditions during service.

Coil clamping rings, if provided, shall be of steel or of suitable insulating material built up from flat laminations. Axially laminated material other than bakelised paper shall not be used. Where bakelised paper rings are used with the layers of paper lying in an axial direction, the rings shall only be relied upon to provide the major insulation between the windings and earth provided the creepage voltage stress obtained by dividing the full line voltage by the creepage distance to earth does not exceed 200 kV/m.

Any metal pieces in contact with laminated rings shall be so designed and secured that they do not weaken the electrical or the mechanical properties of the rings.

If the winding is built up of sections or disc coils, separated by spacers, the clamping arrangements shall be such that equal pressures are applied to all columns of spacers. All such spacers shall be securely located, shall be of suitable material and shall receive adequate shrinkage treatment before assembly.

13 INTERNAL EARTHING ARRANGEMENTS

All metal parts with the exception of the individual core laminations, core bolts and associated individual clamping plates shall be maintained at some fixed potential.

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

- (a) By connection through vertical tie-rods to the top structure.
- (b) By direct metal-to-metal contact with the tank base, maintained by the weight of the core and windings.
- (c) By a connection to the top structure on the same side of the core as the main earth connection to the tank.

The magnetic circuit shall be earthed to the clamping structure at one point only through a removable link placed in an accessible position beneath an inspection opening in the tank cover. The connection to the link shall be on the same side of the core as the main earth connection and taken from the extreme edge of the top yoke in close proximity to the bridging pieces referred to above.

Magnetic circuits having an insulated sectional construction shall be provided with a separate link for each individual section and the arrangement of the connections shall be subject to approval. Where oil ducts or insulating barriers parallel to the plane of the laminations divide the magnetic circuit into two or more electrically separate parts the ducts or barriers shall be bridged and the magnetic circuit shall not be regarded as being of sectional construction.

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

All the earthing connections with the exception of those from the individual coil clamping rings shall have a cross-sectional area of not less than 80 mm². Connections inserted between laminations may have the cross-sectional area reduced to 20 mm² where in close thermal contact with the core.

14 TANK CONSTRUCTION

The tanks shall be complete with all accessories and shall be designed so as to allow the complete unit in the tank and filled with oil, to be lifted by crane or jacks,

transported by road, rail or water without over-straining any joints and without causing subsequent leakage of oil.

The main tank body excluding tap changing compartments, radiators and coolers shall be capable of withstanding a vacuum of 70 kN/m² less than atmospheric pressure when empty of oil.

Unless otherwise approved, tanks shall be constructed of mild steel plate, the minimum thickness of which shall be 6 mm for the sides and 10 mm for the bottom where the longer sides have a horizontal length up to but not exceeding 1.8 metres. For a horizontal length in excess of 1.8 metres the minimum side plate thickness shall be 10 mm and the minimum bottom plate thickness 13 mm.

Where the design of the tank is such that the bottom plate will be in direct contact with the surface of the foundations the above minimum bottom plate thicknesses shall be increased to 18 mm and 25 mm respectively.

Air-cooled reactors shall be supplied complete with metal tank surround to protect the windings from external damage. This tank shall be mounted outside the distance required for minimum clearance of metallic parts and be constructed and erected in the approved manner and as covered by the requisite sections of the Specification.

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

Unless specifically approved detachable underbases shall not be used.

Where the base is of a channel iron construction it shall be designed to prevent retention of water.

Tank stiffeners shall be continuously welded to the tank and designed to prevent retention of water.

Wherever possible the tank and its accessories shall be designed without pockets wherein gas may collect. Where pockets cannot be avoided pipes shall be provided to vent the gas into the main expansion pipe. The vent pipes shall have a minimum inside diameter of 18 mm except for short branch pipes which may be 6 mm minimum inside diameter.

All joints other than those which may have to be broken shall be welded. Caulking of defective welded joints will not be permitted. Such defective joints may be re-welded subject to the written approval of the Engineer.

The under surfaces of the bases shall be specially treated with an approved preservative composition before the transformers are finally lowered on to the concrete foundations.

15 TANK LIFTING AND HAULAGE FACILITIES

Each tank shall be provided with:-

- (a) Lifting lugs suitable for lifting the equipment complete with oil.
- (b) A minimum of four jacking lugs, in accessible positions to enable the equipment complete with oil to be raised or lowered using hydraulic or screw jacks. The minimum height of the lugs above the base shall be:-
 - (i) Up to and including 10 tonnes weight - 300 mm.
 - (ii) Above 10 tonnes weight - 500 mm.
- (c) Horizontal plates with 50 mm diameter draw holes drilled therein shall be fitted adjacent to each corner of rectangular tanks at not more than 750 mm from the base to permit the tank to be hauled in any direction or slewed. On round ended tanks the draw holes shall be located approximately on the diagonals of the rectangle formed by the overall boundaries of the tank. At least 100 mm free working space shall be provided above and below each draw hole.

As an alternative to draw holes, rope fairings may be provided at each corner at not more than 750 mm above the base to enable a hawser to be placed round the tank for haulage purposes.

16 TANK COVER

Each tank cover shall be of adequate strength, and shall not distort when lifted. Inspection openings shall be provided as necessary to give easy access to bushings, for changing ratio or winding connections or testing the earth connections at the link board. Each inspection opening shall be of ample size for the purpose for which it is provided, and at least two openings, one at each end of the tank, shall be not less than 450 mm by 360 mm.

The tank cover and inspection covers shall be provided with lifting arrangements. Unless otherwise approved inspection covers shall not weigh more than 25 kg each.

The bolt holes in all cover plates shall be provided with washers which will prevent the collection of moisture in the bolt hole.

The tank cover shall be fitted with pockets for a thermometer and for the bulbs of the winding temperature indicators. Protection shall be provided where necessary for each capillary tube.

The thermometer pocket shall be fitted with a captive screwed cap to prevent the ingress of water.

The pockets shall be located in the position of maximum oil temperature at full rated power and it shall be possible to remove the instrument bulbs without lowering the oil in the tank.

17 CURRENT TRANSFORMER ACCOMMODATION

When specified in Schedule 'G', provision shall be made for mounting current transformers in the terminal housings, and this shall include approved terminal boxes, conduit and wiring or cables for the secondary connections which on each transformer shall be terminated in main marshalling kiosk near ground level.

When specified in Schedule 'G', provision shall be made for the mounting of current transformers in the neutral earth connection of the high or low voltage windings of main or earthing transformers. On main transformers the current transformers shall be mounted external to the main tank. On earthing transformers or where disconnecting link boxes are provided the transformers shall be mounted in the link boxes.

On transformers with outdoor terminal bushings facilities shall be provided for mounting an external tank leakage current transformer.

18 AXLEZS AND WHEELS

If specified in Schedule 'G', units are to be provided with wheels and the axles shall be of such dimensions and so supported that under any service conditions they shall not deflect sufficiently to interfere with the movement.

All wheels shall be detachable and shall be made of steel. The bearings shall be either bronze bushed or of the roller or ball type.

If wheels are required to swivel, they shall be arranged so that they can be turned through an angle of 90° when the tank is jacked up clear of the rails or floor. Means shall be provided for locking the swivel movements in positions parallel to and at right angles to the longitudinal axis of the tank.

19 CONSERVATOR VESSELS, OIL GAUGES AND BREATHERS

A conservator complete with sump and drain valve shall be provided in such a position as not to obstruct the electrical connections and having a capacity between highest and lowest visible levels of not less than 7 per cent of the total cold oil volume in the transformer and cooling equipment. The minimum indicated oil

level shall be with the feed pipe to the main tank covered to not less than 12 mm depth of oil and the indicated range of oil levels shall correspond to average oil temperatures of from minus 10°C to plus 80°C.

If the sump is formed by extending the feed pipe inside the conservator vessel, this extension shall be for at least 75 mm. The conservator shall be designed so that it can be completely drained by means of the drain valve provided, when mounted as in service.

One end of the conservator shall be bolted into position so that it can be removed for cleaning purposes.

Two oil gauges of approved type shall be provided, preferably one at each end of the conservator. At least one gauge shall be of the direct reading prismatic or reflex type. Float operated oil gauges shall be of the magnetic type. See also clause 35 for tap changer requirements. Gauges shall be provided with low oil level alarm contacts for each alarm station.

Where it is necessary to fit two or more gauges of the prismatic type at one end in order to cover the full expansion range, they shall be so disposed that the oil level is in view at all parts of the range.

The oil level mark on the gauges shall be to approval.

Taps or valves shall not be fitted to oil gauges.

The oil connection from the tank to the conservator vessel shall be arranged at a rising angle of from 3 - 7 degrees to the horizontal and shall consist of pipes having inside diameters not less than 75 mm.

A valve shall be provided at the conservator to cut off the oil supply.

Each conservator vessel shall be fitted with a breather suitable for the high humidity that prevails at site. Normally the dehydrating agent shall be silica gel and designed so that:-

- (a) The passage of air is through the silica gel.
- (b) The external atmosphere is not continually in contact with the silica-gel.
- (c) The moisture absorption indicated by a change in colour of the tinted crystals can be easily observed. At least 25 per cent of the total quantity of silica gel crystals shall be tinted.
- (d) All breathers shall be mounted at approximately 1.4 metres above ground level.

20 FILTER AND DRAIN VALVES, SAMPLING DEVICES AND AIR RELEASE PLUGS

Each unit shall be fitted with the following:-

- (a) One 50 mm valve at the top and one 50 mm valve at the bottom of the tank mounted diagonally opposite to each other for connection to oil circulating equipment.
- (b) A drain valve together with such arrangements as may be necessary within the tank to ensure that the tank can be drained of oil as far as practicable.
- (c) A drain valve fitted to each conservator.
- (d) A robust sampling device at top and bottom of the main tank. The sampling devices shall not be fitted on the filter valves specified under (a) above.
- (e) Flanged type air release plugs.

All valves opening to atmosphere shall be fitted with blank flanges.

21 VALVES

All valves up to and including 100 mm shall be of gunmetal. Larger valves may be of gunmetal or may have cast iron bodies with gunmetal fittings. They shall be of the full way type with internal screw and shall be opened by turning counter-clockwise when facing the handwheel.

Means shall be provided for padlocking the valves in the open and closed positions. Provision is not required for locking individual radiator valves.

Every valve shall be provided with an indicator to show clearly the position of the valve.

All valves shall be provided with flanges having machined faces.

22 PRESSURE RELIEF DEVICE

A pressure relief device shall be provided of sufficient size for rapid release of any pressure that may be generated within the tank, and which might result in damage to the equipment. The device shall operate at a static pressure of less than the hydraulic test pressure for transformer tanks. Means shall be provided to prevent the ingress of rain or dust.

Contacts for trip initiation shall be provided on operation of the device.

Unless otherwise approved the relief device shall be mounted on the main tank and if on the cover shall be fitted with a skirt projecting 25 mm inside the tank to prevent gas accumulation.

If a diaphragm is used, it shall be of approved design and material and situated above maximum oil level. If the device is mounted below top oil level it shall be of the resetting type.

One of the following methods shall be used for relieving or equalising the pressures in the pressure relief device:-

- (a) An equaliser pipe connecting the pressure relief device to the conservator, or
- (b) The fitting of a silica gel breather to the pressure relief device, the breather being mounted in a suitable position for access at ground level.

Loss of oil on operation of the relief device shall be contained within the transformer oil retaining area.

23 EARTHING TERMINALS

Earthing terminals shall be adequately dimensioned to receive the subsidiary earthing conductors. Provision shall be made at positions close to each of the bottom four corners of the tank for bolting the earth terminals to the tank structure to suit local conditions. A similar terminal shall be fitted to the tank cover.

24 RATING, DIAGRAM AND PROPERTY PLATES

The following plates shall be fixed to the transformer tank at an average height, where possible, of 1.5 metres above ground level:-

- (a) A rating plate bearing the data specified in IEC 60076 as applicable. Ratings under site ambient conditions shall also be stated.
- (b) A diagram plate showing the internal connections and also the voltage vector relationship of the several windings and in addition a plan view of the transformer giving the correct physical relationship of the terminals. When links are provided for changing the transformer group symbol and/or ratio, then means shall be provided for clearly indicating the group symbol and/or ratio for which the transformer is connected. The transformer ratio shall be indicated for each tap.
- (c) A plate showing the location and function of all valves and air release cocks or plugs. This plate shall also warn operators to refer to the Maintenance instructions before applying vacuum treatment.

The above plates shall be of stainless steel or of other material capable of withstanding continuous outdoor service.

25 JOINTS AND GASKETS

Oil resisting synthetic rubber gaskets may be used, subject to approval, provided they are of the limited compression type.

26 COOLING PLANT - GENERAL

Radiators and coolers shall be designed so that all painted surfaces can be thoroughly cleaned by hand and subsequently painted on Site by suitable brushes or sprays.

Radiators and coolers shall be so designed as to avoid pockets in which moisture may collect.

The cooling arrangements of all transformers, other than water cooled units, having ratings of 30 MVA and above, shall be such that failure of one part of the cooling plant will not result in the loss of more than 50 per cent of the total forced cooling capacity.

27 RADIATORS CONNECTED DIRECTLY TO THE TANK

Radiators connected directly to the tank shall be detachable and shall be provided with machined or ground inlet and outlet branches. Plugs shall be provided at the top and bottom of each radiator for draining and filling.

Valves shall be provided on the tank at each point of connection to the tank.

28 COOLERS

Where separate radiator banks are provided, the conservator vessels shall be mounted thereon.

All coolers shall be suitable for mounting on a flat concrete base.

Valve mountings shall be provided on the tanks of all equipment other than water cooled units to enable all the cooling equipment to be located at either end of the tanks. The mountings not in use shall be blanked off without valves.

The oil circuit of all coolers shall be provided with the following:-

- (a) A valve at each point of connection to the tank.
- (b) A valve in the main oil connection at the bottom of each cooler.

- (c) Removable blanking plates to permit the blanking off of the main oil connection to the top of each cooler. The blanking plates, when not in use, shall be bolted to some suitable structure on the equipment.
- (d) A drain valve at the lowest point of each cooler.
- (e) A thermometer pocket fitted with a captive screwed cap on the inlet and outlet oil branches of each cooler.
- (f) Machined flanges on all items.
- (g) A 50 mm filter valve at the top and bottom of each cooler.
- (h) On all air cooled coolers which have no natural oil circulation rating, a differential pressure gauge across the oil inlet and outlet of the cooler, marked to indicate correct oil circulation shall be provided. Where natural oil circulation coolers are not provided in addition to such coolers, an oil flow indicator, with electrical contacts, is to be fitted. These contacts shall comprise one pair normally open.
- (j) Flanged air release plugs.

In addition, the following are to be provided only with water cooled oil coolers:-

29 OIL PIPING AND FLANGES

The necessary oil piping shall be provided for connecting each equipment to the coolers and oil pumps and for any equalising connection when more than one unit is connected to any oil cooling equipment. The oil piping shall be with machined flanged joints. Cast iron shall not be used.

An approved expansion piece shall be provided in each oil pipe connection between the equipment and the oil coolers.

Drain valves shall be provided in order that each section of pipework can be drained independently.

30 PUMPS

Each forced oil cooler shall be provided with a motor driven oil pump of the submerged motor type. It shall be possible to remove the pump and motor from the oil circuit without having to lower the level of oil in the transformer or coolers and without having to disturb the pump foundation fixing. The pump shall be capable of dealing with the maximum output and head which may occur in service and with the varying head due to changes in the viscosity of the oil.

31 BLOWERS AND DUCTS

The blowers for use with oil coolers, or for air blast cooling, shall be motor driven and shall be suitable for continuous operation out of doors and capable of dealing with the maximum output and head required in service.

The blowers shall be capable of withstanding the stresses imposed when brought up to speed by the direct application of full line voltage to the motor.

The blowers shall be complete with all necessary air ducting. The blowers, air ducting and coolers shall be designed so that they operate with a minimum of noise or drumming. In order to reduce the transmission of noise and vibration the blowers shall be either mounted independently from the coolers, or, alternatively, an approved form of anti-vibration mounting shall be adopted. It shall be possible to remove the blower complete with motor without disturbing or dismantling the cooler structure framework.

Blades or runners fabricated to form hollow sections shall not be used.

Unless otherwise approved, blades shall be of galvanised steel.

The ducts and casings shall be made of galvanised steel not less than 2 mm thickness, suitably stiffened by angles or tees.

Galvanised wire mesh guards with a mesh not greater than 25 mm shall be provided to prevent accidental contact with the blades. Guards shall be provided over all moving shafts and couplings.

32 COOLER CONTROL

Each motor or group of motors shall be provided with a three-pole electrically-operated contactor and with control gear of approved design both for starting and stopping the motor by hand and also automatically from the contacts on the winding temperature indicating device. Overload and single phasing protection shall be provided but no-voltage releases shall not be fitted. This equipment shall be accommodated in the marshalling kiosk.

Where small motors are connected in groups, the group protection shall be arranged so that it operates satisfactorily in the event of a fault occurring on a single motor.

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

The control arrangements shall be such that motors totalling more than 15 kW shall not be started simultaneously when the cooling plant motors are started automatically, or by hand by means of a single switch operation.

Where blowers and oil pumps are provided, the connections shall be so arranged as to allow the motors or groups of motors to be started up and shut down either collectively or individually.

33 VOLTAGE CONTROL

Where specified in Schedule 'G', each transformer shall be provided with voltage control equipment of the tap changing type or other approved apparatus for varying its effective transformation ratio whilst the transformers are on-load and without producing phase displacement. The voltage control equipment shall be designed so that it may be easily adapted to operate by automatic control.

Equipment for local and remote/supervisory electrical and local hand operation shall be provided and shall comply with the following conditions:-

- (a) It shall not be possible to operate the electric drive when the hand-operating gear is in use.
- (b) It shall not be possible for any two electric control points to be in operation at the same time.
- (c) Operation from the local, remote or supervisory control switch shall cause one tap movement only unless the control switch is returned to the off position between successive operations.
- (d) All electrical control switches and the local operating gear shall be clearly labelled in an approved manner to indicate the direction of tap changing.
- (e) The local control switches shall be mounted in the marshalling kiosk.

In the above context "local" means at the transformer marshalling kiosk, "remote" the first stage of control away from the unit i.e. the AVC panel and "supervisory" means the System Control Centre.

The equipment shall be so arranged as to ensure that when a tap change has been commenced it shall be completed independently of the operation of the control relays or switches. If a failure of the auxiliary supply during a tap change or any other contingency would result in that movement not being completed, approved means shall be provided to safeguard the transformer and its auxiliary equipment. Electrical and mechanical means shall also be provided to prevent damage to the tap changing mechanism when end of travel has been reached.

Apparatus of approved type shall be provided for each transformer:-

- (a) To give indication mechanically at the transformer and electrically at the remote control point, of the number of the tapping in use on the transformer. The numbers shall range from 1 upwards, the lowest number

representing the tapping position corresponding to the maximum number of winding turns, i.e. the plus per cent position, and the highest number representing the tapping position corresponding to the minimum number of winding turns, i.e. the minus per cent position.

- (b) To give an indication at the remote/supervisory control point that a tap change is incomplete.
- (c) Full supervisory control facilities are to be provided. A selector switch located at the local point is to be provided to transfer control to the remote/supervisory points and at the remote point a further selector switch will transfer control to the supervisory point.

All indicating devices shall operate correctly at any voltage between the limits of 85 per cent and 115 per cent of nominal value.

The tap changing switches and mechanism shall be mounted in oil tanks or compartments mounted in an accessible position on the transformer tank and shall be supported from the main tank or its base. "Drop down" tanks which necessitate the provision of pits in the foundations shall not be used unless otherwise approved.

Any "drop-down" tanks associated with the tap changing apparatus shall be fitted with guide rods to control the movement during lifting or lowering operations. The guide rods shall be so designed as to take support of the associated tank when in the fully lowered position. Lifting gear fitted to "drop-down" tanks shall include an approved device to prevent runaway during lifting and lowering operations.

Any enclosed compartment not oil filled shall be adequately ventilated. A metal-clad heater shall be provided in the driving mechanism chamber and connected in parallel with the heater in the marshalling kiosk.

The oil in those compartments of the main tap changing apparatus which do not contain contacts used for making or breaking current shall be maintained under conservator head by means of a 50 mm inside diameter pipe connection from the highest point of the chamber to the conservator. This connection shall be controlled by a suitable valve and shall be arranged so that any gas leaving the chamber will pass into the gas and oil actuated relay.

It shall not be possible for the oil in those compartments of the tap change equipment which contain contacts used for making or breaking current, to mix with the oil in the main transformer or to mix with the oil in the compartments containing contacts not used for making or breaking current. This requirement shall not apply where mercury or vacuum switches are used to make and break current.

When a conservator is provided and used to maintain oil level in compartments which contain contacts used for making and breaking current, it shall be clearly separate from the main transformer conservator. Two oil gauges shall be provided. One shall be of the prismatic type and the second one of the magnetic type shall be fitted with contacts for initiation of a low oil level alarm to each alarm station. A silica gel breather shall be fitted to each such conservator.

Each compartment in which the oil is not maintained under conservator head shall be provided with an oil gauge of approved design.

Limit switches shall be provided to prevent over-running of the mechanism and shall be directly connected in the circuit of the operating motor. In addition a mechanical stop, or other approved device shall be provided to prevent over-running of the mechanism under any condition.

Limit switches may be connected in the control circuit of the operating motor provided that a mechanical declutching mechanism is incorporated.

Thermal devices or other approved means shall be provided to protect the motor and control circuits. All relays, switches, fuses, etc., shall be mounted in the marshalling kiosk and shall be clearly marked to indicate their purpose. Switches for the initiation of a tap change shall bear the inscription "Raise Tap Number" or "Lower Tap Number".

The a.c. control circuits shall operate at 110 V single phase to be supplied from a transformer having a secondary winding of 55-0-55 V with the centre point earthed through a removable link mounted in the marshalling kiosk.

Tripping contacts associated with any thermal devices used for the protection of tap changing equipment shall be suitable for making and breaking 150 VA between the limits of 30 volts and 250 volts a.c. and d.c. and for making 500 VA between the limits of 110 and 250 volts d.c.

The whole of the apparatus shall be of robust design and capable of giving satisfactory service without undue maintenance under the conditions to be met in service, including frequent operation.

A device shall be fitted to the tap changing mechanism to indicate the number of operations completed by the equipment.

A permanent legible lubrication chart shall be fitted within the driving mechanism chamber.

After installation and commissioning tests, the terminals of the operating motor shall be clearly and permanently marked with numbers corresponding to those on the leads attached thereto.

Means shall be provided for ensuring that the tapping or other switches are making full contact. When such contact is made it shall be possible to lock the apparatus at any setting.

When two or more transformers are to be operated in parallel at the same substation, means shall be provided to ensure that the voltage control equipment is automatically synchronised before and while the transformers are operated in parallel.

This feature shall operate irrespectively of whether the voltage control equipment is operated by the remote electrical operating gear or automatically. It must also be possible to operate the voltage control equipment for each transformer, independently, whether on load or for test purposes, and to obtain independent indications.

34 AUTOMATIC VOLTAGE CONTROL

Where specified in Schedule 'G', approved means shall be provided for automatically maintaining within adjustable limits a pre-determined voltage at the lower voltage busbars to which the transformer is connected.

Unless otherwise specified, the equipment shall be suitable for control of up to three transformers and shall be so designed that where control of less than three transformers is initially required it shall be possible to extend the facilities to cover up to three transformers at a later date.

In addition to the methods of voltage control already specified the following alternative methods shall be provided:-

- (a) Automatic Independent Remote. It shall be possible to select remote or local electrical (non-automatic) control, or automatic independent remote control for each transformer irrespectively of the method of independent control selected for any of the other associated transformers.
- (b) Automatic parallel control in one group or two independent groups. It shall be possible to select any transformer for either group and also select any transformer in a group for master control. Provision shall be made for more than two transformers in a group.

Local control shall be so arranged that it is necessary to have the remote selector on a non-automatic position and the Local/Remote Supervisory changeover switch in the marshalling kiosk positioned on "Local" before operation is possible. If the remote selector switch is on any other position the Local/Remote switch shall be inoperative. Under these conditions the Local switch shall have overriding control.

A voltage regulating relay of an approved type designed to operate from a nominal energising pressure of 110 volts shall be provided for each transformer. The no-load

voltage level of the relay shall be adjustable between 90% and 110% of the nominal energising voltage independent of other adjustments. Unless otherwise specified the sensitivity of the relay shall be suitable for pre-determined adjustment at any value between the transformer tap step percentage and 1.5 times the transformer tap step percentage. The relay shall be insensitive to frequency variation within reasonable limits.

Associated with the voltage regulating relay shall be provided a time delay relay, the setting of which shall be adjustable between the limits of 10 and not less than 120 seconds.

Approved means shall be provided either at the remote control point or at a supervisory point, for selection of adjustment in the balancing voltage to give load shedding facilities, together with means for restoration. Unless otherwise specified three stages shall be provided, each stage representing a 5% reduction in load.

When specified in Schedule 'G', provision shall be made on the tap changer for an additional set of tap position contacts to be provided for use in conjunction with the supervisory control scheme.

Compounding (line drop compensation) equipment shall be provided when specified in Schedule 'G'. Provision shall be made, within the tapping range, for voltage compounding to a maximum of 15% resistance and 15% reactance in suitable steps, with separate adjustment for each component. It shall be possible to reverse the reactive component by means of a changeover switch or links. Unless otherwise specified, the current transformer for the compounding shall be provided and mounted inside the main transformer tank and shall be rated for a nominal secondary current at full load of 5 amperes.

Approved means either by switch or links, shall be provided for each transformer, to give complete isolation of all supplies at the remote control point without preventing the operation of tap changers on the other transformers.

An out-of-step device shall be provided for each transformer which shall be arranged to prevent further tap changing if after a definite time interval any transformer in one pair or group operating on "parallel control" is one tap out of step. The device shall not operate under any control arrangement other than parallel control.

A device shall also be provided for each transformer to render the automatic voltage control inoperative if the control voltage falls below 80% of the nominal value with means of restoration of the automatic control with the application of at least 85% of the normal energising voltage. Unless otherwise specified the apparatus shall stay at the tap in use at the instant when the automatic voltage control is rendered inoperative.

The following additional apparatus of an approved type shall be provided for each transformer.

- (a) To give after a suitable interval indication by means of an illuminated lamp at the remote control point when the units of a pair or group of transformers arranged to operate in parallel are operating at different taps. Where several groups are controlled from one operating room separate indication shall be provided for each group.
- (b) A voltage failure indicating lamp at the remote point to give indication of a partial or complete failure of the voltage transformer supply to the voltage regulating relay. The alarm shall be operative only when the transformer l.v. circuit-breaker is closed and when the tap changer is on automatic control. The tap changer shall remain on the position at which it stands when the alarm is given, until such times as the control voltage is restored.
- (c) A circuit voltmeter suitably scaled to read l.v. volts.

The "out-of-step" alarm and "V.T. Fail" alarm shall also operate a common flag relay indicating "Voltage Control Faulty" and an audible alarm given by a buzzer which is common to the temperature alarms, and transformer gas and oil actuated relay.

A remote control panel shall be provided complete with all relays, instruments, control switches and wiring. Unless otherwise agreed a separate control panel shall be provided for each transformer.

35 TEMPERATURE INDICATING DEVICES AND ALARMS

Transformers shall be fitted with a dial type oil temperature thermometer with maximum pointer and one set of normally open switch contacts which close at a predetermined setting to initiate an alarm when called for in the schedules.

All equipment shall be provided with a device for indication of winding hottest-spot temperature, (W.T.I), having a dial type indicator and a pointer to register the maximum temperature reached. These devices shall incorporate two normally open, electrically separate sets of switch contacts which close at pre-determined settings, one of which shall be used to initiate an alarm and the other to initiate tripping of a associated circuit- breaker.

Transformers having or being suitable for mixed or forced cooling, shall have an additional set of normally open switch contacts on the winding temperature indicator to control automatically the forced cooling plant, or give cooler failure alarm.

The temperature indicators shall be housed in the marshalling kiosk.

The electrically separate alarm and trip switch contacts of winding temperature indicators and the alarm contacts of oil temperature indicators shall be adjustable to close between 60°C and 150°C and re-open when the temperature has fallen by not more than 7°C. For transformers without natural cooling, the third set of contacts on the winding temperature indicator shall also close within this range of temperatures to give a cooler failure alarm.

The electrically separate switch contacts used to control cooling plant motors of mixed cooled transformers shall be adjustable to close between 50°C and 100°C and re-open when the temperature has fallen by any desired amount between 15°C and 30°C. The electrically separate cooler control switch contacts shall be connected in parallel with corresponding contacts on other indicators.

All contacts shall be adjustable to a scale and shall be accessible on removal of the cover. Alarm and trip circuit contacts shall be suitable for making or breaking 150 VA between the limits of 30 volts and 250 volts a.c. or d.c. and of making 500 VA between the limits of 110 and 250 volts d.c. Cooler motor control contacts shall be suitable for operating the cooler motor contactors direct, or, if necessary, through an interposing relay.

The winding temperature indicators shall have their corresponding switch contacts paralleled.

The temperature indicators in the marshalling kiosk shall be so designed that it shall be possible to move the pointers by hand for the purpose of checking the operation of the contacts and associated equipment. It shall not be possible to operate the trip contacts without removing the temperature indicator cover.

The working parts of the instrument shall be made visible by the provision of cut-away dials and glass-fronted covers.

Connections shall be brought from the devices to terminal boards placed inside the marshalling kiosk.

Terminals, links, and a moving iron ammeter shall be provided in the marshalling kiosk for each W.T.I. for:-

- (a) Checking the output of the current transformer.
- (b) Disconnecting the bulb heaters from the current transformer secondary circuit to enable the instrument to be used as an oil temperature indicator.

Information shall be included in the maintenance instructions in the form of either a graph or table, showing the relationship between current injected into the heater coil and the corresponding indicator reading for:-

- (a) Operating at full rated output and an oil temperature of 60°C.

- (b) Unenergised and an oil temperature of 15°C.

Where specified, means shall be provided to indicate at a remote point, by a direct wire electrical system, the dial pointer reading of winding temperature indicators. The electrical transmitting equipment shall be integral with and housed in the winding temperature indicator case.

Oil flow failure alarms shall be provided where appropriate.

The following equipment shall also be supplied:-

- (a) An electrical drop flag indicating device for connection in series with each set of alarm contacts provided on the temperature indicating devices and the gas and oil-actuated relays.
- (b) An alarm system, illuminated signal and audible warning device for use in conjunction with the alarm contacts of the temperature indicating device, gas and oil-actuated relays and flow meters. These shall be arranged so that the audible warning device may be switched out of circuit, leaving the illuminated signal in operation as long as the contacts of the initiating devices remain closed. The audible alarm circuit shall be restored automatically when the contacts of the indicating device open.

36 GAS AND OIL-ACTUATED RELAYS

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

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

To allow gas to be collected at ground level, a pipe approximately 5 mm inside diameter shall be connected to the gas release cock of the gas and oil-actuated relay and brought down to a point approximately 1.35 metres above ground level, where it shall be terminated by a cock.

A machined surface shall be provided on the top of each relay to facilitate the setting of the relays and to check the mounting angle in the expansion pipe and the cross-level of the relay.

A straight run of pipework shall be provided for a length of five times the internal diameter of the pipe on the tank side of the gas and oil-actuated relay and three times the internal diameter of the pipe on the conservator side of the gas and oil-actuated relay.

The surge float contacts shall close at a rate of steady oil flow between the following limits. As far as possible the limits shall also be met when the relay is subjected to oil surge conditions produced by rapid opening of a lever operated gate valve.

<u>Oil Pipe Connection</u>	<u>Operational Limits for Relay</u>
<u>Internal Diameter</u>	<u>Rising angles of 1° to 9°</u>
<u>mm</u>	<u>Steady Oil Flow</u>
	<u>(mm/s)</u>
25	700 - 1300
50	750 - 1400
75	900 - 1600

The gas collection contacts shall operate within the angle limits specified for tests.

The design of the relay mounting arrangements, the associated pipework and the cooling plant shall be such that mal-operation of the relays shall not take place under normal service conditions.

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

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

- (a) If the two conservators are connected to the transformer by a common oil pipe, one relay shall be installed in the common pipe.
- (b) If the two conservators are piped separately to the transformer two relays shall be installed, one in each pipe connection.

Connections shall be brought from the relay to terminal boards inside the marshalling kiosk.

37 DRYING OUT

All equipment shall be dried out at the Manufacturer's works and the transport and method of erection thereof so arranged that unless otherwise approved they may be put into service without further drying out on Site. The method of drying out and the arrangements for transport and erection shall be subject to approval. Any subsequent drying out which may be necessary after taking over will generally be carried out on Site, and the Contractor shall submit to the Engineer for their

approval details of the method which he recommends. These details shall be incorporated into the Maintenance Instruction Manual.

38 TRANSPORT

Shipping arrangements shall be subject to approval.

Irrespective of the actual method approved for transport to the individual sites, all equipment shall be suitable for transport in oil unless otherwise approved.

Where shipping under nitrogen is agreed make up bottles shall be provided and proposals for monitoring gas pressure agreed.

All bushings, insulators, conservator vessels and breathers, radiators, wheels or other external parts may be removed for this purpose provided that they can be replaced on Site without necessitating drying out.

The Contractor shall be responsible for ascertaining the methods and limitations of transport to site and designs affected by these factors shall be subject to agreement.

39 ERECTION

The completely assembled equipment shall be designed to withstand any of the following vacuum treatments:-

- (a) Vacuum of 50 kN/m² applied to tank and cooling equipment when empty of oil.
- (b) Vacuum of 70 kN/m² applied above oil level to tank and cooling equipment when full of oil.
- (c) Vacuum of 70 kN/m² applied to tank only when empty of oil.

Clear instructions shall be included in the Maintenance Instructions regarding any special precautionary measures (e.g. strutting of tap changer barrier or tank cover) which must be taken before the specified vacuum treatments can be carried out. Any special equipment necessary to enable the equipment to withstand the treatment is to be provided with each unit. The maximum vacuum which the complete equipment filled with oil can safely withstand without any special precautionary measures being taken shall also be stated in the Maintenance Instructions.

After the equipment has been erected and completely filled with oil at Site adequate steps shall be taken in order to exhaust as far as possible all air which may be trapped within the tank and pipework.

Special care shall be taken not to injure galvanised or other specially treated surfaces during erection and also to prevent or remove any rust streaks or foreign

matter deposited on galvanised surfaces during storage or transport or after erection.

40 OIL HANDLING AND STORAGE EQUIPMENT

40.1 General

Where specified, oil handling and storage equipment shall be provided for the transformers. The equipment shall include filtering equipment, pumps, piping, valves and all necessary connections for handling oil. Oil handling and storage equipment shall include a single tank with two compartments for clean and dirty oil and each compartment of capacity 6,000 litres.

This equipment shall be mounted on a trailer having wheels with pneumatic tyres, automatic brakes and a canopy for weather protection. Accommodation shall be provided on the trailer for the clean and dirty oil pumps for carriage for the flexible hoses and power cables. The storage tank shall be air tight and oil tight and shall be suitable for containing insulating oil. The tank shall be of welded steel construction with a minimum thickness of 10 mm.

The tank shall be complete with the under mentioned fittings.

- (a) A connection at the bottom of each tank, of 76 mm diameter steel pipe projecting 76 mm above the bottom of the tank, complete with flange for connection to the oil handling system. A separate drain valve shall be provided to permit complete drainage.
- (b) Direct reading oil level indicator designed so as to show oil level or contents at any position from "tank full" to "tank empty". Indicator tubes shall be protected and of transparent oil-resisting plastic.
- (c) Built up type manhole 600 mm diameter with bolted cover plate.
- (d) Access ladder to manhole, if required.
- (e) Oil sampling device to permit samples of oil to be drawn at ground level.
- (f) Oil sealed overflow and vacuum relief device on each dirty oil tank.
- (g) Silica gel breather on clean oil compartment, capable of passing the flow of air when the compartment is being filled or emptied at the maximum rate and also capable of drying the air passing through the breather with variation in the oil quantity due to change of temperature.

The system shall be designed to avoid air locks and means shall be provided for the removal of entrapped air.

40.2 Oil Pumps

Pumps shall be capable of dealing with the maximum output and head which may occur in service and with the varying head due to changes in the viscosity of the oil. Special attention shall be paid to the design of the glands to prevent leakage. Valves shall be provided on the inlet and outlet of each pump, and by-pass valves shall be provided to limit the pressure rise on the delivery side of each pump to a safe value when the oil flow is restricted at a point away from the delivery valve.

A duplex oil strainer or self cleaning filter shall be fitted on the suction side of the dirty oil pump.

The pumps shall be complete on a stand with two lengths of flexible hose of the type specified.

40.3 Valves

All valves shall be of gunmetal or carbon steel, and shall be opened by turning counter-clockwise when looking down on the handwheel. Every valve shall be provided with an indicator to show clearly the position of the valve and means shall be provided for locking the valve in the open or closed position. All valves shall be provided with flanges having machined faces or shall be screwed to suit union couplings. All valves shall be clearly labelled.

40.4 Oil Filtering Equipment

The type of filter used should be of the vacuum type. The surface temperature of any heaters used must not be excessive and the temperature of the oil must not be raised above 80°C.

The filtering equipment shall be mounted on a road trailer having wheels with pneumatic tyres, automatic brakes, and a canopy for weather protection. Accommodation shall be provided on the trailer for carriage of the flexible hoses, and power cable supplying the filter plant.

40.5 Flexible Hose

Flexible hoses shall be provided with bolted type flanges for direct connection to the valve flanges on the main equipment, or provided with female unions suitable for connection to adapter plates bolted to the valve flanges on the main equipment.

Flexible connections shall be by means of smooth bore nitrile lined hose or flexible metallic type hose. Externally armoured hose is not acceptable.

40.6 Power Cable

Suitable flexible power cable shall be provided wound on a drum mounted on the trailer and complete with plug to suit the socket outlets in the substation building specified elsewhere. The length of cable shall be sufficient to connect the filtration plant to the nearest socket outlet.

Similar cable drums with adequate length of cable complete with plugs shall be provided for clean and dirty oil pumps. Required number of socket outlets of appropriate ratings near the transformers shall be provided to take the supply to the pumps and to the oil filtering equipment.

SECTION 7

**INSULATORS, BUSHINGS AND
FITTINGS (SUBSTATION)**

SECTION 7
INSULATORS, BUSHINGS AND FITTINGS (SUBSTATION)

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SECTION 7

INSULATORS, BUSHINGS AND FITTINGS (SUBSTATION)

1 MATERIAL

Porcelain insulators shall be sound, free from defects and thoroughly vitrified so that the insulation is not dependent upon the glaze. The glaze shall be smooth, hard, of uniform shade and shall completely cover all exposed parts of the insulator. The insulators shall be unaffected by the atmospheric conditions due to weather, proximity to the coast, fumes, ozone, acids, alkalis, dust or rapid changes of temperature.

Paper insulators shall be of approved design and method of manufacture and shall retain their insulating characteristics in service. Special precautions shall be taken to exclude moisture from paper insulation during manufacture and assembly. The surfaces of all paper insulators shall be finished with approved non-hygroscopic varnish which cannot be easily damaged.

Toughened glass insulators shall be sound and free from defects or blemishes which might adversely affect their life. All exposed glass parts shall have a smooth surface. All locations where glass insulators are to be used shall be identified.

2 ELECTRICAL DESIGN

The maximum total creepage distance shall be as stated in the Design Criteria and the protected creepage distance over the external surface of bushings and insulators shall not be less than 35% of the total surface creepage distance. The protected creepage distance refers to that part of the insulator which is protected against rain at right angles to the axis of the bushing. For post insulators comprising standard units, the above requirements shall, unless otherwise specified, be met by the addition of an approved number of additional units to the normal assembly.

3 MECHANICAL DESIGN

The strength of insulators shall be such that, when supporting the maximum working load as in service, the factor of safety shall be not less than 2.5.

They shall be secured in an approved manner with suitable clamping plates. They shall not engage directly with metal but shall be mounted with suitable interposing materials. All joint surfaces of porcelain shall be accurately ground. Where cement is used as a fixing medium, the method and materials used shall be approved.

The design shall be such that stresses due to expansion and contraction in any part of the insulator and fittings shall not lead to the development of defects.

The design of all insulators shall be such as to permit easy cleaning.

4 SUSPENSION AND TENSION INSULATORS

Suspension and tension insulators shall consist of toughened glass or porcelain units with ball and socket fittings. Tension insulators shall consist of single strings unless otherwise specified.

Disc insulators, together with their metal fittings shall comply with the requirements of IEC 60383. Their mechanical characteristics and dimensions shall comply with IEC 60305, whilst the ball and socket couplings, retaining pins and locking devices shall comply with IEC 60120 and IEC 60372.

The individual units of both suspension and tension insulator sets shall be identical and interchangeable.

Retaining pins or locking devices for insulator units shall be of phosphor bronze or other approved tough material.

They shall be so formed that when set and under any conditions, nothing but extreme deformation of the retaining pin or locking device shall allow separation of the insulator units or fittings or shall permit accidental displacement of the retaining pins or locking devices. Their design shall be such as to allow for easy removal or replacement of insulator units or fittings without removal of the insulator sets from the structures. Retaining pins or locking devices when in position shall be incapable of rotation.

5 POST TYPE INSULATORS

Post insulators shall be dimensioned in accordance with IEC 60273 and tested in accordance with IEC 60168. They shall comprise fully interchangeable units of either the pedestal or solid core cylindrical type and shall be designed so that they can be used either upright or inverted. Where appropriate they shall match the units in an existing substation.

6 BUSHING INSULATORS

Bushings may employ solid, liquid or gaseous mediums as the primary means of insulation with the medium declared in the technical schedules or clearly indicated on drawings submitted for approval. Bushing design shall be such as to prevent internal discharge over the full range of test and working voltages. Where necessary the insulation shall be graded by condenser layers or other approved methods. For outdoor installation the bushings shall include a porcelain weathershield. Where presence of humidity or pollution may cause deterioration of the primary insulation any annular space between the weathershield and primary installation shall be fitted with an approved secondary insulation media. Means shall be provided to ensure maintenance of the correct fluid level and level gauges shall be such as to give reliable indication to an observer at ground level with the equipment live. Any fluids within the bushing shall not enter into contact with those in the remainder of the equipment.

Where specified in the schedules, provision shall be made to accommodate any current transformers specified and the bushing shall preferably be so arranged that it can be removed without disturbing the current transformers, secondary terminals and connections or pipework. Suitable lifting arrangements shall be provided.

Bushing flanges shall not be of a shape which may trap air. Outdoor bushing insulators and fittings and their mounting arrangements shall be designed so as to avoid pockets in which water can collect.

SECTION 8

**POWER CABLES, AUXILIARY
CABLES AND ACCESSORIES**

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SECTION 8

**POWER CABLES, AUXILIARY
CABLES AND ACCESSORIES**

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SECTION 8

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SECTION 8

POWER CABLES, AUXILIARY CABLES AND ACCESSORIES

1 CROSS-LINKED POLYETHYLENE (XLPE) INSULATED POWER CABLES

1.1 General

All XLPE insulated power cables and accessories shall be designed for the rated voltages stated in the Schedules. Where the system voltage is above 60 kV, the cables shall have an approved lead alloy sheath or corrugated copper sheath with an extruded anti-corrosion MDPE sheath overall. For other system voltages, the cables shall have metallic screens or armour and be MDPE sheathed overall according to the specified designs.

Where specified, cables shall be wire armoured on approved bedding and finished overall with an extruded MDPE sheath.

Where the system voltage is above 60 kV, the cables and accessories shall be manufactured and tested in accordance with the latest edition of IEC 60840 and amendments, subject to variations and additions stated in this Specification. For other system voltages, the cables and accessories shall be manufactured and tested in accordance with the appropriate part of the latest edition of IEC 60502 and amendments, subject to variations and additions stated in this Specification.

1.2 Conductors

Conductors shall be of stranded construction consisting of high conductivity aluminium or copper. The conductor shall be clean, uniform in size, shape and quality, smooth and free from scale, spills, splits, sharp edges and other harmful defects, and shall comply with the requirements of IEC 60228 where applicable.

Where joints are permitted in individual wires, formed into a conductor, they shall be made in the manner prescribed in the appropriate Standard and the frequency shall conform to the limiting dimensions stated therein. No joints shall be made in the conductor after it has been formed.

1.3 Conductor Screening

Conductor screening shall be employed at rated voltages above 1.8/3.0 kV and shall consist of a layer of extruded semi-conducting material having a smooth even surface in intimate contact with the cable insulation and the conductor, but easily strippable from the conductor and insulation.

1.4 Extruded Insulation

The materials used in the manufacture of compounds for insulation shall be mixed together and processed under such conditions of cleanliness as to ensure a stable product with the required physical and electrical characteristics suitable for prolonged use without deterioration in service under the environmental and operational conditions on Site.

1.5 Core Screening

Core screening shall be employed at rated voltages above 1.8/3.0 kV for cables and shall consist of a non-metallic semi-conducting part and a metallic part.

The non-metallic part shall consist of a layer of extruded semi-conducting material having a smooth even surface in intimate contact with the core insulation. Core screens of 6/11 kV cables shall be of the 'strippable' type.

The metallic part shall consist of a layer of copper tape applied over the semi-conducting layer on each individual core of multi-core cables. For single core cables the metallic part may consist of plain copper wires and a counter-helix of plain copper tape.

1.6 Identification of Cores

The cores of multi-core cables shall be identified by numbers or colours as follows:-

		Number	Colour
2-core cable	-	0 (ZERO)	BLACK
	-	1 (ONE)	RED
3-core cable	-	1 (ONE)	RED
	-	2 (TWO)	YELLOW
	-	3 (THREE)	BLUE
4-core cable	-	0 (ZERO)	BLACK
	-	1 (ONE)	RED
	-	2 (TWO)	YELLOW
	-	3 (THREE)	BLUE

The numbers shall be indelibly printed continuously on the whole length of the individual core.

1.7 Inner Covering and Fillers

The inner covering shall be extruded PVC. The fillers shall be of a non-hygroscopic nature, and shall not adhere to the conductor insulation or core screen.

1.8 Metallic Layers

The metallic layer for twin, three and four-core cables shall be "metallic armour" consisting of a single layer of galvanised round steel wires. The metallic layer for single core cable shall be "metallic screen".

The metallic layer shall surround the cores "collectively".

1.9 Lead and Lead Alloy Sheathing

Where specified the lead shall be new and of approved origin and purity.

The sheathing shall be of uniform thickness and homogeneous construction, reasonably close fitting, seamless and free from defects, porosity and inter-crystalline fracture.

The composition of the sheathing and its thickness shall be suitable for resisting fatigue due to vibration and the construction shall be capable of withstanding the external and internal mechanical stresses likely to be encountered during manufacture, testing, transport, installation and service without puncture or fracture.

1.10 Corrugated Copper Sheathing

Where specified corrugated copper sheaths shall be constructed from pure copper. The corrugations shall be helical and designed to give flexibility and stability of shape. Welded seams shall be non porous and free of ripples.

1.11 Metallic Sheath Bedding

The metallic sheath of 66 kV XLPE cables shall be bedded on tapes providing electrical continuity between screen and sheath and designed to absorb thermal expansion of the insulation and prevent longitudinal water penetration in the event of cable damage.

1.12 Outer Sheath

The protective outer sheath shall be extruded MDPE and the sheath shall be coloured black with the type of the cable embossed i.e. Electric cable 66kV.

An outer graphite coating shall be applied to the outer covering of 6,350/11,000 V cables and above to serve as an electrode for the voltage test specified under Test Requirements.

1.13 Sealing and Drumming

Immediately after the Works Tests both ends of every length of cable shall have a metal cap fitted over the end and plumbed to the sheath. Other cables shall be sealed by enclosing the ends in approved caps, which shall be tight fitting and adequately secured to prevent ingress of moisture.

The ends of factory lengths of cable shall be marked "A" and "Z", "A" being the end at which the sequence of core numbers is clockwise and "Z" the end at which the sequence is anti-clockwise.

The end which is left projecting from the drum shall be protected against damage.

The cable drums shall be arranged to take a round spindle and be lagged with strong closely fitting battens so as to prevent damage to the cable. Each drum shall bear a distinguishing number, either printed or neatly chiselled on the outside of one flange.

Particulars of the cable, i.e. voltage, length, conductor size, number of cores, finish, section and length number, gross and nett weights, shall be clearly shown on one flange of the drum. In addition the words "Running End "A"" or "Running End "Z"" shall be marked on the flange and the direction for rolling shall be indicated by an arrow.

All cables and accessories shall be carefully packed for transport and storage on Site in such a manner that they are fully protected against all climatic conditions, particular attention being paid to the possibility of deterioration during transport to the Site by sea or overland and to the conditions prevailing on the Site.

Wooden drums shall be suitably constructed to avoid trouble due to shrinkage, rot and attack by insects.

Drums, crates, cases, etc., for maintenance spares shall be non-returnable.

1.14 Current Carrying Capacity and Design Parameters

The maximum continuous current carrying capacity and maximum permissible continuous conductor temperature, and the factors for determining such rating and temperature shall be based on IEC 60287 and subsequent amendments, and all conditions on Site. Due account shall be taken of the layout and proximity of adjacent power cable circuits when considering the cable size and ratings.

The Contractor shall confirm that the cable size specified is adequate for the required circuit ratings and adequate for the short-circuit requirements specified. The Contractor shall produce calculations and information to verify that the cable size and the method of installation are satisfactory.

Immediately after the Contract is awarded the Contractor shall carry out at his own expense moisture content, water table level, soil thermal resistivity tests and such other tests as he may consider necessary, sufficiently in advance before manufacture of any cable to satisfy himself that the conditions on Site and his proposed arrangement of cables and method of installation are such that the maximum current carrying capacity can be maintained. If the Contractor considers that the conditions and the proximity to other power cables, spacings and method of installation are likely to reduce the maximum current carrying capacity below the declared value, he shall immediately notify the Engineer as to what the maximum current carrying capacity would be under these conditions and the action he proposes to taken to ensure that the declared value is maintained and he shall not proceed with the work on that portion of the route affected until the Engineer has given permission.

When establishing the cable size the following factors shall be considered: -

- (a) Short circuit capacity
- (b) Maximum permissible continuous conductor temperature
- (c) Any special operating conditions.

1.15 Cable Joints

Before manufacture commences the Contractor shall submit drawings showing the types of joint boxes proposed for each of the cables included in the Contract that, by reason of the length or nature of their route, will require straight through joints. The joint boxes shall be constructed of approved materials and shall be watertight, free from sharp points or ridges, thoroughly clean internally and designed to retain the filling medium and/or cable compound at all times without leakage. The metal sheathing of the cables shall be plumbed to the joint box and the armouring wires (if any) shall be efficiently clamped at a point between the body of the box and the wiped joint of the sheath. Suitable connections shall be provided for exhausting, filling or pressure filling the joints and for testing the sealing of the filling ports as may be required. The design shall be submitted to the Engineer for approval.

All cable joints shall have the metallic sheathing of the cables plumbed to the joint sleeves and efficiently bonded to armouring wires and/or outer box by means of a copper bond having a resistance not greater than the combined resistance of an equal length of armouring and/or metallic sheath.

For mechanical considerations the copper bond shall have a sectional area of not less than 95 mm².

Joint boxes shall be installed as directed and where they are laid direct in the ground they shall be protected by an outer box of approved design and filled with compound. Each joint and its outer box shall be permanently labelled in an

approved manner and the marking shall include the serial number of the joint and if single core cable, the phase colour.

Joint boxes used with cables provided with anti-corrosion protective coverings shall be insulated from earth so as to provide means for testing the soundness of the outer coverings after completion of the installation.

No joint shall be made in a single drum length of cable or within 3 metres of a bend without the written consent of the Engineer. The position of all joints shall be approved.

Where three-core cables are required to terminate with single core cables, trifurcating boxes of approved design shall be installed.

The Contractor shall submit drawings showing designs of trifurcating joint and splitter boxes suitable for use with the cables to be terminated with these accessories.

1.16 Cable Sealing Ends and Terminal Boxes

Detailed drawings showing the types of cable sealing ends, terminal boxes and glands proposed for the installation shall be submitted at the time of Tendering.

All cable sealing ends and terminal boxes shall be designed with jointing faces below compound level which will ensure the retention of the filling medium and/or cable compound under operating conditions and exclude the entry of air, dust or moisture. Cable sealing ends and terminal boxes designed for use with fluid or semi-fluid filling media shall have flanged joints, the faces of which shall be machined. The fixing bolt centres for the flanged joints shall not exceed 100 mm.

All sealing ends and terminal boxes shall be fitted with screwed taper or stepped brass wiping glands which shall be insulated, where required by the Engineer.

An earthing strip shall be provided on all boxes terminating metallic sheathed cables and combined armour and earthing clamps shall be fitted to all boxes terminating armoured cables.

The external dimensions, fixing details and terminal arrangements for all sealing ends and terminal boxes shall be agreed with the Engineer.

Sealing ends and terminal boxes shall be provided with all necessary fittings, including external flexible connections as required. The design of flexible connections shall be to approval. Drain plugs shall be of ample size to permit the filling medium to be removed. The contact faces of the cable sockets shall be thoroughly cleaned, the lugs shall be placed in the most suitable positions and arranged as required to avoid unnecessary bending of cable cores inside the box.

Provision shall be made for earthing the body of the box, and for expansion of the conductors in the box. Provision shall also be made for the expansion of the filling medium and arrangements made to prevent the formation of air spaces when filling.

1.17 SF6 Gas-immersed or Oil-immersed Cable Sealing Ends

The Contractor shall provide satisfactory evidence, or carry out a programme of Type Tests, to demonstrate that the complete sealing end assembly is gas and oil tight under all conditions of maximum operating and transient pressures and pressures attained during testing of connected equipment.

At terminations the cable supporting steelwork may be required to be totally self-supportive and designed to avoid imposing excessive thrust forces under any service condition on the associated plant. Cable supporting steelwork at SF6 switchgear may also be required to be clad in a lightweight metallic material suitably finished or painted to the Engineer's requirements.

1.18 Sealing End Oil Expansion Tanks - XLPE Cables

Where oil expansion tanks are required for XLPE cable sealing ends the design of tank, necessary support and proposed location shall be stated in the Tender together with the oil specification and monitoring requirements.

1.19 Porcelain Insulators

All porcelain insulators used in the manufacture of cable sealing ends, terminal boxes and joints shall be sound, free from defects and thoroughly vitrified so that the glaze is not depended upon for insulation. The glaze shall be smooth and hard and where required for outdoor service shall be of a uniform shade of brown. The glaze shall completely cover all exposed parts of the insulator.

The insulators and fittings shall be unaffected by atmospheric and climatic conditions, ozones, acids or alkalis, dust deposits or rapid temperature changes likely to arise when operating in the Site conditions and shall be designed so as to facilitate cleaning.

The porcelain shall not engage directly with hard metal and where necessary, an approved resilient material shall be interposed between the porcelain and the end fittings. All porcelain clamping surfaces in contact with gaskets shall be accurately ground and free from glaze. All fixing material used shall be of approved quality and shall not enter into chemical action with the metal parts or cause fracture by expansion during service. Where cement is used as a fixing medium, the thickness of cement shall be as small and even as possible and proper care shall be taken to centre and locate the individual parts correctly during cementing.

The Contractor shall state in Schedule 'D' the maximum working loads for each design of cable sealing end.

1.20 Heat Shrink Terminations

Heat shrink tubing and moulded parts shall be flexible, flame retardant, polyolefin-based material of electrical insulating quality, and shall be obtained from an approved manufacturer. They shall be suitable for use indoors or outdoors in the conditions prevailing on Site.

Each part shall bear the Manufacturer's mark, part number and any other necessary markings to ensure correct identification for use on the correct size and type of cable. Each set of parts shall be packed as one unit with full and complete installation instructions and clearly marked to show the application.

The material shall reduce to the predetermined size and shape when heated above 120°C. The components shall also be provided with an internal coating of hot melt adhesive compound which shall not flow or exude at temperatures below 85°C.

Heat shrink terminations shall only be employed where specified in the Schedules.

1.21 Jointing Instructions

As soon as possible after the commencement of a contract and before materials are despatched, copies of the jointing instructions applicable to the joints, sealing ends and terminations to be supplied shall be submitted in English to the Engineer for approval, together with details of the physical and electrical characteristics of the filling medium proposed. Where a contract is for supply only, each set of jointing or terminating materials shall include a copy of the relevant approved jointing instructions.

Jointing instructions must be complete in every detail and for paper cables include Hot Oil Tests to ensure moisture is not present in the materials or cable before jointing is commenced.

2 AUXILIARY CABLES AND ACCESSORIES

2.1 General

All PVC insulated multi-core auxiliary cables shall be 600/1000 Volt grade with stranded copper conductors. They shall conform to all the applicable requirements of this Specification dealing with the construction of power cables unless otherwise specified hereunder.

All auxiliary cables shall be PVC sheathed, galvanised steel wire armoured and PVC sheathed overall unless otherwise specified.

2.2 Core Identification

The method adopted for core identification shall be to the Engineer's approval.

2.3 Oversheaths

PVC oversheaths shall be embossed in conformity with the requirements of the section on Power Cables, with the legend 'ELECTRIC CABLE-AUX'.

2.4 Sealing and Drumming

The sealing and drumming of these cables shall be in accordance with the requirements for Power Cables and Accessories. (Item 1.13).

2.5 Termination of Auxiliary Cables

The ends of each cable shall be terminated in brass compression- type cable glands of the correct size, which shall secure the cable inner sheath and ensure effective electrical continuity between the cable armouring wires and the metal enclosures on which the cable is terminated. Cable glands fitted on outdoor equipment shall also incorporate suitable compression seals to secure the outer sheath and shall be so designed and fitted that water cannot enter the cable or the equipment via the cable termination.

At all rising terminations, the cable inner sheath shall pass through the gland to terminate approximately 6 mm above the gland.

Where multi-core cables provided under this Contract connect with plant and equipment supplied under another Contract, the cable contractor shall leave sufficient lengths of tails to connect up to the terminal boards. The Contractor shall also strip, insulate, ring through and identify the tails with temporary tags, and shall provide, fit and install the cable glands in accordance with the requirements specified above.

The plant contractor shall be responsible under another Contract for drilling the gland plates on Site, re-checking the individual cores, fitting numbered ferrules, crimped terminations and finally connecting up the tails.

2.6 Identification of Auxiliary Cables

All auxiliary cables shall be identified below the gland at each end and at approved positions by means of bands on which shall be engraved the number and size of cores, the type of cable and the destination. The bands shall be made of material proof against corrosion, damp and mechanical damage.

3 INSTALLATION OF CABLES, ACCESSORIES AND ANCILLARY EQUIPMENT

3.1 General

The installation and handling of the cable shall be undertaken at all times by adequate staff suitably trained and supplied with all the necessary plant, equipment and tools. The arrangement of the cables and all methods of laying shall be approved by the Engineer and shall be planned to provide an orderly formation, free from unnecessary bends and crossings, which will permit the removal of any one cable without undue disturbance to adjacent cables.

Every precaution shall be taken to ensure that cables and accessories are not installed in a manner or under conditions likely to cause electrolytic or other corrosive action or damage to or be detrimental to the performance of the cable during operation.

Where required by the Engineer, the combustible outer coverings of cables installed within buildings shall be removed and, if required, the cables shall be protected against fire in an approved manner. Cables passing through floors shall be installed in the manner specified and where required shall be sealed in bushes employing fire resisting materials to minimise the risk of spreading fire.

Before commencing work on any part of the Site the Contractor shall ascertain that each cable route has been approved by the Engineer, and where applicable, the local and statutory authority or other bodies and persons concerned and that wayleaves in such cases have been obtained and notices served.

3.2 Depth of Laying

For cables laid direct in ground, the depth of burial from ground surface to centre of cable, to centre of duct, or to centre of trefoil group of cables or ducts shall be 0.9 m for 66 kV, 0.8 m for 11 kV and 0.5 m for 600/1000 V cables except where they are laid in the same trench with 11 kV cables when the depth shall be 0.8 m.

Any variations from the specified depths shall be approved.

3.3 Excavation of Trenches

The exact location of each trench shall be approved on Site. Trenches shall be kept as straight as possible and each trench shall be excavated to approved formation and dimensions and shall have vertical sides which shall be timbered where necessary so as to avoid subsidence and damage.

The bottom of each trench shall be firm and of smooth contour. The Contractor shall take reasonable precautions to prevent damage to the highway or ground surface from a slip or breaking away of the sides of the trench.

The trench excavation and filling in shall be so executed that all walls, roads, sewers, drains, pipes, cables, structures, places and things shall be reasonably secure against risk of subsidence or injury and shall be carried out to the satisfaction of the authorities concerned.

Where trenches pass from a footway to a roadway or at other positions where a change of level is necessary, the bottom of the trench shall rise or fall gradually. The rate of rise or fall shall be approved.

The Contractor shall deal with and dispose of water so as to prevent any risk of the cables and other materials to be laid in the trenches being detrimentally affected. He shall provide all pumps and appliances required and shall carry out the necessary pumping and baling.

Unless otherwise agreed, provision shall be made during excavation and until interim restoration has been completed, for reasonable access of persons and vehicles to property or places adjacent to the route.

When the excavations for trenches have been accurately executed, notice shall be given by the Contractor to the Engineer. Laying of cables or building of structures shall not be started until the Contractor has obtained the Engineer's sanction to proceed with the work.

The use of explosives shall not be permitted for excavation works without the approval of the Engineer. The Contractor shall observe such regulations as may be in force regarding the storage and use of explosives, safety of personnel and other precautions to which the Employer may be subject.

3.4 Excavated Materials

The materials excavated from each trench shall be placed so as to prevent nuisance or damage to adjacent hedges, trees, ditches, drains, gateways, and other property or things. Excavated material shall be stacked so as to avoid undue interference with traffic. Where, owing to traffic or for reasons of safety or other considerations, this is not permissible, the excavated material shall be removed from the Site and returned for refilling the trench on completion of laying; surplus material shall be disposed of by and at the cost of the Contractor.

In order to facilitate the re-use of excavated materials for road foundations and surfacing, the excavated material shall be separated into hard road material, soil and other materials. All excavations carried out in Substations shall be executed in a manner which provides for the separation and storage of the top surfaces and subsequent reinstatement layer by layer to provide the same construction on completion thereof as existed prior to commencement of excavation works.

3.5 Methods of Laying

Cables shall be laid direct in the ground in trenches excavated therein and shall be protected with covers of reinforced concrete or earthenware. Cables shall also be drawn into pipes or ducts or laid in formed trenches or troughs or on racks or supported in trays or cleats as required by the Engineer.

Where cables are laid in formed trenches the rates quoted for installation shall include for the removal and replacement of the trench covers and for the provision of temporary protective covers on the trenches where they cross access ways.

Where three single core cables are laid direct in the ground or in formed trenches or supported in cleats or racks and form one three-phase circuit, they shall be laid spaced apart or in flat or triangular formation touching depending on the rating and permissible standing voltage unless otherwise agreed, the apex of the triangle being uppermost. In order to maintain a triangular formation the three cables shall be tied together with tarred rope when buried or secured by brass binders or other approved means at intervals of one metre. Where transposition is required the relative position of the three cables shall be changed at joint positions.

Unless otherwise approved auxiliary cables shall be laid under the same covers as the power cables, where the latter are laid direct in the ground. Where power cables are laid otherwise than direct in the ground the auxiliary cables may be laid separately in an approved manner.

After any cable has been laid and until the whole of the cables to be laid in the trench have been covered with their protective covers, no sharp or heavy metal tools, such as spades or fencing stakes or rollers, shall be used in the trench or placed in such a position that they may fall into the trench. Rollers used during the laying of cables shall have no sharp projecting parts liable to damage the cables.

3.6 Cables Laid Direct

Unless instructed to the contrary by the Engineer, the Contractor shall lay cables direct in the ground in the following manner: -

80 mm of earth riddled through a screen having a mesh not greater than 12 mm square shall be placed to form a bed for the cable.

After the cables have been laid they shall be covered with additional riddled earth well punned over and around the cables to a level of 100 mm above the top of the uppermost cable. Mechanical punners shall not be used for this work. In each layer where protective covers are required they shall be carefully centred over the cables forming each circuit, each cover being closely interlocked with the adjacent covers throughout the length of the cable.

The covers shall be of adequate width to protect the cables and provide a minimum overlap on each side of 50 mm.

Where in the opinion of the Engineer, the soil on Site is unsuitable for riddling or back filling, the Contractor shall arrange for the importation of material with suitable thermal properties which shall be of approved type and quality.

Where more than one horizontal layer of cables is laid, the level of the upper layers of cable shall be gauged from the level of the finished bottom of the trench and marked on the side of the trench at frequent intervals before the installation of the lower layers, to ensure that the correct vertical spacing is maintained.

The Contractor shall be solely responsible for ascertaining whether the soil is chemically active and for taking special precautions to protect the cables against chemical action. The Contractor shall take precautions to avoid electrolytic and/or electro chemical action occurring in situations where the cable and accessories are likely to be installed in close proximity to other dissimilar metals in the presence of moisture.

3.7 Pipes and Ducts

The materials and construction of pipes and ducts shall be approved. Pipes and ducts into which cables are to be drawn shall have nominal internal diameters not less than those stated in Schedule 'D'. Where single core cables are individually drawn into separate pipes, non-metallic pipes shall be used.

Care shall be taken to make the bends of pipe or duct lines as easy as practicable and in no case of a radius less than is specified in Schedule 'D'. Where approved, split pipes may be used on bends, the pipes being fitted round the cable after laying.

For routes inside the Employer's property and particularly within buildings, pipes and ducts will be supplied and installed by the Employer unless otherwise stated.

3.8 Laying of Pipes and Ducts and Drawing in Cables

All pipes and ducts shall be laid and jointed in approved manner. Non-metallic pipes and ducts shall when specified, be surrounded by 80 mm of concrete and ducts provided for groups of three single core cables forming three-phase circuits shall be of the single way or trefoil type to suit the cable system unless otherwise approved.

After pipes and ducts have been laid they shall be thoroughly cleaned. A mandrel of diameter slightly less than the pipe or duct shall be drawn through. After the mandrel has been drawn through the pipes, a draw wire of galvanised steel shall be left in each pipe or duct if required by the Engineer, to facilitate the drawing in of cables. The duct ends shall be sealed temporarily to prevent the entry of foreign

matter. The pipes and ducts shall be cleaned again immediately before the cables are drawn in.

Where required by the Engineer, duct seals shall be provided to prevent the entry of water or vermin into buildings or cable tunnels. The design of duct seal shall, unless otherwise approved, consist of two impregnated wooden plugs fitted around the cable for compressing a mastic compound within the duct by means of pressure applied to steel bolts fixed between the wooden plugs and secured at the extremities by nuts and washers. The bolts, nuts and washers shall be galvanised.

3.9 Joint Bays

The Contractor shall submit drawings of the layout and construction of joint bays which shall be designed with concrete rafts and formed so as to enable jointers to carry out their work efficiently and expeditiously. The method of securing and supporting cable joints and cables, also the bonding and earthing thereof, shall be detailed on the drawing. The details shall be approved by the Engineer.

Joint bays shall be shuttered to prevent subsidence and damage and during jointing shall be adequately covered with tents or other waterproof sheeting suitably supported. Proper precautions shall be taken to ensure temperature and humidity conditions suitable for jointing operations.

3.10 Timber Left and Built-in

Where required for the security of the Works or adjacent buildings or structures, timber installed for the support of trenches, joint bays, heading, tunnels etc., shall not be withdrawn but shall be left in position. All timber left in on the instructions of the Engineer shall be paid for in accordance with the rates quoted for work at time and material rates or at rates to be agreed.

3.11 Filling in and Reinstatement

Filling in of trenches shall not be commenced until the Engineer has inspected and approved the cables and accessories in situ. Such inspection shall not be unreasonably delayed.

All excavations made (whether for the purpose of cable laying or trial holes) shall be back filled in 150 mm layers, the earth in each layer being well rammed and consolidated and sufficient allowance made for settlement.

The Contractor shall be responsible for the permanent reinstatement of the upper levels, which shall be carried out to the satisfaction of the Engineer and the Authorities concerned.

3.12 Cable Markers

Cable markers shall be provided and installed at positions defined by the Engineer to mark the location of cables and joints. The design of marker, inscription and method of installation shall be approved by the Engineer.

3.13 Concrete and Mortar

Unless otherwise approved, concrete shall consist, by volume, of one part of slow-setting Portland Cement, two parts of sand and four parts of gravel or broken stone and shall be thoroughly mixed. Gravel, broken stone and sand shall be clean and free from salt, ligneous, earthy, organic or other impurities. Sea-shore sand, unwashed pit sand or unwashed gravel shall not be used. All gravel or broken stone shall be of approved grading and shall be screened through a mesh of not more than 50 mm square, but shall be retained by a mesh 5 mm square. All sand shall be screened through mesh of not more than 2.5 mm square. Water shall be clean and free from salt, acid or lime in solution.

Cement mortar for pipe jointing shall consist of one part of Portland cement and two parts of clean river or pit sand, and for brickwork one part of Portland cement and four parts of clean river or pit sand. Concrete or mortar shall be placed in position within 30 minutes of mixing.

3.14 Brickwork

All bricks used shall be of approved type and shall comply as regard size with BS.3921. Brickwork shall be of English bond, no four courses rising more than 25 mm above the same laid dry.

All joints shall be thoroughly flushed so that they are completely filled and shall be weather pointed as the work proceeds.

3.15 Steelwork

Mild steel for the fabrication of cable supports shall be free from blisters, scales, laminations or other defects. Fabrication shall be carried out by means of bolting and welding. Riveting shall not be used unless specially approved.

All cable supporting steelwork shall be galvanised.

3.16 Cable Supports and Cleats

The design of cable support for installation within cable tunnels shall consist of steel members spaced at 2 metres centres on horizontal and 1 metre centres on sloping sections of the tunnel, and secured to the walls by means of bolts either cemented in position or expanded into cored holes, or Unistrut type metal inserts provided and cast into walls by the Civil Contractor. Each support shall have

bolted to it a number of steel brackets spaced at the intervals agreed with the Engineer and designed to support and retain trays constructed of galvanised sheet steel 2 mm thick before galvanising to carry the weight of the cables, plus space for an additional quantity of future cables not less than 25% by weight and dimensions in excess of the cables installed under this Contract and an additional load of 100 kg at the extremity without distortion. The trays shall be designed with raised edges to retain the cables and shall incorporate an interlocking feature so as to prevent movement between supports. Sheet steel trays shall accommodate cable cleats at 4 metre spacing to support 11 kV single core cables in trefoil with the trefoil group of cables laid in sinusoidal formation as shown on the drawings issued with this Specification.

The trefoil group of cables shall be bound together at 1 metre intervals with stainless steel or brass binders to maintain the cables in trefoil formation under short-circuit conditions.

All auxiliary and small power cables laid on trays in the sloping section of the cable tunnel shall be securely cleated to the tray every two metres.

The design of support for situations where trays are not required shall in general consist of a metal rack within which is contained one or more pairs of impregnated wood or porcelain cleats shaped to suit the formation of the cables. When single core cables are installed the cleats shall be so designed as to permit the cables to be laid in close trefoil formation. Metal cleats may be employed for this purpose but in such cases approved sheet insulation shall be provided between the lead sheaths and the cleats. The spacing of cable supports shall be approved by the Engineer.

3.17 Sunshields

Sunshields shall be provided around the exposed 11 kV and 66 kV cables in the Switchyard. These shall consist of 150 mm PVC split ducts secured with non-magnetic fastenings around each cable, with a 50 mm space allowed at ground level and the top left open to allow adequate air flow between cable and inside of the sunshield.

3.18 Earthing and Bonding

At the ends of each power and auxiliary cable the lead sheathing and armouring (if any) shall be bonded together and the sheathing connected to the main earth bar or other earthing system by means of medium drawn copper strip of 95 mm² minimum section.

All connections to the main earth bar shall be made with a single branch unless otherwise approved.

All joints shall have the surfaces tinned to prevent oxidation and shall be riveted and soldered, or where specially approved, bolted and soldered or welded.

Single core 11 kV and 66 kV cables shall have their lead sheaths bonded together and connected to earth at both ends. The connections shall be made to the sealing end baseplate, and the connections shall be removable to permit testing of the extruded PVC oversheaths.

3.19 Reinforced Concrete Cable Covers

Reinforced concrete cable covers shall be precast and constructed in good quality cement with aggregate not exceeding 9.5 mm nominal size. The covers shall be efficiently compacted in the mould with the exposed face struck off level and have the ends designed to provide an interlocking facility to resist lateral displacement after installation.

Reinforcement shall be provided by suitably spaced longitudinal bars of not less than 4.8 mm diameter with transverse wires of minimum diameter 2.6 mm. Reinforcement shall extend to within 25 mm of the end and sides of the cover and shall have a minimum surround of 12 mm of concrete, and be constructed to a nationally recognised specification.

3.20 Bi-metal Connectors

Where the connections from outdoor sealing ends are in steel cored aluminium the connection shall be bi-metal employing a compression sleeve over the aluminium conductor and incorporating a weatherproof joint to a copper pin or gunmetal palm as appropriate.

The design is to have proven service life on a national overhead line system and will be subject to the approval of the Engineer.

3.21 Route Marker Tapes

Cable route marker tapes for use during installation shall be continuously installed 300 mm directly above the cable or cable covers.

The tape shall have a thickness not less than 0.1 mm gauge, shall be 150 mm wide and manufactured from high-grade polyethylene pigmented in bright colours.

The following warning message shall be continuously printed in a contrasting colour in characters not less than 20 mm high specially protected against deterioration and fading.

CAUTION CAUTION CAUTION

CHECK ELECTRIC CABLE BELOW

The tape shall be supplied in rolls of approximately 400 metre length on stout reels suitably crated for shipment.

Tapes shall be in the following colours:-

66 kV cables - Blue tapes with black lettering

Up to 11 kV and control cables - Yellow tapes with black lettering

3.22 Tests During Laying

During the progress of the laying the Contractor shall, as required by the Engineer, subject the cable on completed portions of the route to the voltage tests specified.

3.23 Route Plans

During the progress of the Contract Works the Contractor shall record on a set of route plans and cross section drawings of an approved form, such particulars as will allow an accurate reference to be made in the case of any fault or projected modification. These records shall show, amongst other data, the exact position of every joint, cable box, earth electrode and connections thereto and also particulars of the cables and the position of all obstructions revealed during the course of excavations.

SECTION 9

STATION EARTHING

SECTION 9
STATION EARTHING

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**SECTION 9
STATION EARTHING**

1 BASIS OF DESIGN

The design of the earth mat shall be based on the maximum fault level of the system.

It shall take into account the special requirements for Outdoor Type or GIS substations in respect of 'step' and 'touch' potentials and shall be generally in accordance with the guidelines for earthing IEEE 80.

2 EARTHING SYSTEM

The earthing system shall comprise a network of buried copper earthing conductors forming a main earth grid with connection to all items of electrical plant, steel structures and other metalwork inside the substation perimeter fence.

The "main" earth grid and the "branch" connections from the grid to all high voltage equipment shall consist of copper having a suitable cross sectional area. "Subsidiary" earth connections to items such as panels, kiosks, lighting columns, shall be earthed by copper having a cross section area not less than fifty per cent of the "main" connections.

The earthing system shall be designed to minimise the dangers from step, touch and transferred potentials which can occur under maximum fault conditions. The Contractor, shall submit calculations in support of his design.

The main earth grid shall encompass as large an area as possible within the substation fence and shall be laid at a depth not less than 500 mm. The separating distance between the main earth grid and any items connected to it, and the fence shall be at least 2 metres.

Loops shall be provided in approved positions on earth bars for the attachment of portable earths.

When specified sets of three earthing clips, connections and insulated operating poles of an approved design, and capable of being attached and disconnected by an operator from a safe position, shall be provided at each station for earthing temporarily any portion of the switchgear or plant which has to be made dead for cleaning or maintenance.

3 EARTH ELECTRODES

Where necessary to reduce the overall earth resistance, earth electrodes shall be provided and connected to the perimeter of the main earth grid. These electrodes shall, unless otherwise agreed, consist of copper clad steel cored rods not less than

1.5m long x 15 mm diameter driven into the ground and spaced not less than 3 m apart.

4 CONNECTIONS TO H.V. EQUIPMENT

Each item of h.v. equipment shall be earthed to the main earth grid via a separate branch connection or duplicate connection arranged to form a loop, in which case the conductor size may be reduced. No sub-branches shall be permitted with the exception that a three phase group may be connected to a common branch.

Except when otherwise specified primary equipment bolted to galvanised steel structures may be earthed through the structure. All structures shall be earthed at the base. Each column of gantry type structures shall be separately earthed and trestle type structures shall be earthed at two points. Adequate provisions shall be made to prevent corrosion between copper and galvanised surfaces.

All operating mechanism boxes mounted on structures supporting h.v. equipment shall be separately earthed by a direct, fully rated, continuous connection to the main earth grid. Such connections should run under the point on which a person operating the mechanism would normally stand.

Surge diverters and coupling capacitors shall have, in addition to a fully rated connection to the main grid, a separate h.f. earth connection and electrode. This connection shall be short and as free from changes in direction as possible.

The earth terminal of all fixed earthing switches shall be connected directly to the main earth grid by means of a fully rated continuous connection.

Connections to LVAC equipment, auxiliary supplies, fans, large motors, HVAC equipment, etc., shall be made to the main earth bar with earth conductors of cross-sectional area not less than that of the phase conductor supplying such equipment.

When it is necessary to have an assembly of ferrous fittings, e.g. turnbuckles, links, shackles etc., between a tension insulator and a steel structure or anchor point, the assembly shall be bridged by a flexible copper shunt.

Where a metal fence surrounds the substation this shall be earthed independently from the main earth grid by separate earth rods at all corners and at intermediate positions where necessary.

Where circuits are connected to the substation by direct entry overhead line circuits the Contractor shall be responsible for connecting the terminal tower to the substation main earthing system by a buried copper earthing conductor having a cross-sectional area not less than the equivalent copper section of the transmission line earth wire(s).

5 INSTALLATION

Buried earth conductors shall be surrounded by compacted riddled loam or other approved material.

Joints shall have a resistance not exceeding that of an equivalent length of conductor and the Engineer may require any joint to be tested to prove compliance with this requirement.

No drilling of the earth conductor shall be allowed except in the jointing or terminating unless approved by the Engineer.

Joints and connections to the earthing system shall be so effected as to avoid undue reduction of the current carrying capacity and shall be approved.

Special precautions shall be taken to ensure that the available contact area is fully utilised in all connections to plant and apparatus.

All joints and connections underground shall be made by compression or welding. Exposed connections shall be made by compression, welding or bolting and tinning.

The contact faces of earth terminals shall be cleaned before connections are made to the earthing system.

The earth bars shall be tinned before being clamped to the earth stud.

Earth connection points shall be positioned not less than 300 mm above finished floor or ground level, preferably on a vertical plane.

Foundation bolts shall not be used for connections to the earthing system.

Where it is necessary to extend earth connections on steel structures to earthing switch bases etc., the earthing shall be fixed by approved means and where intermittent contact is made with galvanised steel the earth bar should be tinned to prevent corrosion.

6 GUARDS

Where earthing conductors are exposed to mechanical damage steel guards shall be provided to protect them.

7 MEASUREMENT OF EARTH RESISTANCE

Test shall be made on the effectiveness of the bonding and earthing which will include conductivity tests on selected joints, on the main earthing system, and at the connections to equipment and structures. Checks shall also be made on precautions taken to avoid corrosion attack on the earthing system.

The resistance of the earthing system to the general mass of earth shall be tested and recorded including the method and equipment used to carry out the tests. Test probes at approximately 300 and 600 metres separation will normally be required to effectively test the earthing system at major substations. The use of transmission line conductors may be arranged to simplify these testing procedures.

Step and touch potential tests carried out in accordance with recommendations in IEEE 80 shall be carried out to prove the design values.

SECTION 10

**PROTECTIVE EQUIPMENT,
& SCADA INTERFACE**

SECTION 10
PROTECTIVE EQUIPMENT, & SCADA INTERFACE

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SECTION 10
PROTECTIVE EQUIPMENT & SCADA INTERFACE

1 GENERAL

This section contains the general requirements applicable to all protection relays.

Each element of the main plant, transmission and distribution systems shall be provided with high-speed discriminative protection (main protection), capable of detecting all "credible" faults and issuing tripping commands to the associated circuit breakers within the prescribed time. "Credible" faults shall include all faults whether phase/phase or phase/earth irrespective of whether maximum or minimum plant is connected, account being taken of the fault impedance. "Non-credible" faults are those involving a second order plant failure, for example, a broken conductor lying on high resistance ground and for which extended fault clearance time may be acceptable.

High-speed discriminative protection systems shall be engineered as complete schemes, with due account being taken of current and/or voltage transformer performance. Attention shall be paid to the total performance including the behaviour pattern in the presence of system transients for faults "in zone", faults "out-of-zone", and during the period immediately following a switching operation irrespective of whether that operation is to eliminate a network short-circuit or is to energise or to de-energise any part of the network.

In the event of an uncleared external fault or any other abnormal operating condition which may cause damage to plant, time delayed tripping shall be initiated as a back-up action to prevent plant damage.

With reference to the above the protection systems must therefore be designed, manufactured, applied, set and commissioned to offer the highest level of security against incorrect operation for faults beyond the protected circuit or during disturbances or temporary overload conditions from which the power system should recover.

Protection Technology

All relays performing a measuring function shall be of numerical design with continuous self-monitoring. Auxiliary relays, repeat relays, trip relays and any other simple auxiliary or contact multiplication function may be based on standard attracted armature or other electromechanical techniques.

In order to maximise the cost-benefit of the protection in all groups and to reduce lifetime costs, all protection relays shall be of numerical design wherever practical. The main numerical relays should offer instrumentation, disturbance recording and event logging functions in addition to providing protection. Routine test

requirements shall be limited to basic function testing only, through the provision of comprehensive, continuous self-monitoring with alarm and diagnostic functions.

Numerical relays and schemes provided shall all be suitable for connection to a local communications network (either interfaced directly to the substation LAN or to the local BCU) to allow the complete relay scheme to be interfaced to a central computer work station. The communications bus, necessary modems and interface units and all associated software shall be provided as part of the contract. With the resulting system it shall be possible to interrogate all numerical relays and schemes to monitor and extract recorded data (including settings, measurement parameters, disturbance records). It shall also be possible to enable remote adjustment of relay settings if required.

Numerical relays shall also be provided with a local communications port to allow direct interfacing to a lap-top PC, to facilitate local interrogation, setting-up and recorded data extraction. Individual protection units shall be provided with an integral user interface to facilitate setting changes and observation of indications without the use of remote communications.

- Protection relays shall be from approved suppliers and they shall be type-tested according to relevant sections of the current IEC 60255 standards and copies of type test certificates should be provided. Relays shall be CE-marked in accordance with European Union requirements related to Electromagnetic Compatibility and Low Voltage Equipment safety. Equipment complying with other national standards may be accepted where the vendor provides copies of the relevant standards.
- Protection relays shall have a minimum of two year's satisfactory service history in similar applications with at least 5 utilities. The history is to be supported by reference lists.
- Relays must be offered on the basis of a minimum service life of 15 years. Statements must be obtained from the relay manufacturer(s) to this effect, with confirmation that a spares and repairs service will be available for the stated minimum service life.

Protection Discrimination

On the occurrence of an electrical fault on the, 66kV and 11kV power systems, the high speed discriminating protection systems (main protection) shall rapidly detect the fault and initiate the opening of only those circuit breakers which are necessary to disconnect the faulted plant or circuit from the network. Protection equipment associated with adjacent plant or circuits may detect the fault, but there must be discrimination between this protection and that of the faulted plant or circuit. Time delayed tripping is not permitted except where main protection has failed to clear a fault or where plant damage would otherwise occur.

All back-up protection systems shall be able to discriminate with main protection systems, circuit breaker fail protection and with other back-up protection systems installed elsewhere on the electrical system.

Protection Settings

A protection setting study shall be performed as part of the contract and a list of the settings to be applied to all protection equipment, together with all associated calculations, shall be provided for review and approval not less than 3 months prior to the first programme date for commissioning. Any limitations imposed on the power system operation as a result of the settings proposed shall be explicitly stated. In the absence of system data required for calculation purposes, assumptions may be made, providing these are clearly identified as such in the relevant calculations.

Constructional Requirements

GENERAL

For modular protection systems, means shall be provided to positively lock each withdrawable module or unit in the "service" position. It shall not be possible to remove any module without first short-circuiting all associated current transformer circuits. All other main protection relays shall be accommodated within withdrawable cases. Means shall be provided to ensure that current transformer connections are short circuited prior to being disconnected when the relay is withdrawn from its case.

All relay cases shall be earthed except where insulated cases are provided for special requirements.

EQUIPMENT ACCOMMODATION

Protection and control cubicles should be of front access, swing-rack design, with glazed front door through which necessary equipment indications can be observed.

OPERATOR INTERFACE

All numerical protection systems shall be provided with an integral local user interface, to enable communication with the relay without the use of external equipment. Any facilities provided for connection to an external computer shall be an additional feature to the local user interface. No exceptions to this requirement shall be permitted.

Relay serial communication facilities should allow all information which is available locally at the relay front panel to be accessed remotely. It should also be possible to carry out bulk transfer of settings and fault record information using appropriate PC based software. The necessary software for communication with each relay type shall be provided as part of the contract.

Each protection relay shall also comply with the following requirements.

IDENTIFICATION

Each protection relay shall have a unique identifier that is clearly visible. The software reference and issue level shall be identified. The marking of all relays shall comply with Clause 12 of IEC 60255-6 (1988).

Each protection relay shall be provided with a card holder and card or LCD display facilities on which shall be shown:

- The current transformer ratio (if applicable), including all ratios of multi-ratio transformers and the ratio selected.
- Voltage transformer ratio (if applicable).

SETTINGS

Each protection relay shall provide a means by which the user can easily apply the required settings, which is also secure from inadvertent operation. A display of the selected settings shall be provided on the protection relay.

INDICATIONS

Each relay or protection scheme shall be provided with an adequate number of indications to ensure that the appropriate faulted phase, zone, operated element, etc. can be easily identified after a fault condition. Each indicator shall be visible and capable of being reset without removing the relay cover. It shall not be possible to operate the relay when resetting the indication. Unless otherwise approved, indications shall only be given by the protection(s) causing the relay to trip.

The record of relay indications shall be maintained following any DC auxiliary supply interruption.

For numerical relays, indication shall be provided for failures detected in the protection relay or communications equipment. The indications provided shall be designed to allow the defective item to be quickly identified. The status of the dc power supplies shall be permanently indicated.

OUTPUT CONTACTS.

All protection relays shall be provided with an adequate number of contacts of suitable rating to perform the required tripping functions, alarm indications, fault recorder functions and such supplementary signalling functions as may be necessary for initiation of automatic switching control, intertripping etc. In all cases contacts intended for tripping duty shall be designed such that:

- they cannot inadvertently interrupt trip coil current.

- they initiate the circuit breaker trip coil directly without the interposition of auxiliary relays or reinforcing contacts.

TEST AND ISOLATION FACILITIES

Each functional protection relay shall be so arranged that operational and calibration checks can be carried out with the associated primary circuit(s) in service.

Adequate test facilities shall be provided within the protection scheme to enable the protection and control equipment to be tested from the front of the protection equipment panel with the primary circuit(s) in service. The test points shall be clearly identified and labelled.

Numerical relays shall include continuous self-monitoring and supervision of all parts of the relay hardware, firmware and software. An alarm contact shall close for any detected failure.

Adequate facilities shall be provided, preferably at the front of each protection equipment panel, to isolate all DC and AC incoming and outgoing circuits so that work may be carried out on the equipment with complete safety for personnel and without loss of security in the operation of the switching station. The isolation points shall be clearly identified and labelled. The labels on the isolation points shall either describe the function or be uniquely numbered.

A list of all of the protection and control equipment being offered under the contract shall be provided together with a list of all of the test and ancillary equipment required for commissioning and routine testing of all protection and control equipment.

Service Life and Service Support

The protection systems shall be designed for a service life of 15 years, allowing for only routine testing that is limited to basic functional testing in accordance with manufacturers recommendations.

The service life of the protection system equipment in relation to that of the main HV plant and apparatus shall be stated so that the cost of any replacement during the life of the substation can be assessed.

The period for which lifetime support will be provided for the protection system equipment shall be stated. Recommendations for the provision of spare parts are required.

Circuit diagrams for each protection system and the associated tripping system(s) shall be supplied. The diagrams shall provide sufficient information to enable fault finding and maintenance to be carried out and shall not consist solely of information used for equipment manufacture.

A service to enable any faulty item of protection equipment to be rectified or replaced within a stated period of the fault being reported shall be provided. The repair/ replacement period shall be defined.

Training for the purchaser's personnel in the operation and maintenance of the protection equipment shall be offered.

Protective equipment shall be designed to disconnect faulty circuits with speed and certainty, without interference with healthy circuits. They shall also be so designed that, when properly applied, incorrect operation of the circuit-breakers does not occur as a result of transient phenomena not arising from a faulty condition of the section of line or plant associated with each set of relays but which may occur during fault periods due to disturbances on the system.

The Contractor shall be responsible for ensuring the correct operation of the protective equipment and shall submit for approval recommended relay settings, supported by design calculations for all forms of protective equipment being supplied. The calculation shall demonstrate that all faults on the primary equipment shall be completely and correctly isolated within a maximum of 100m sec from fault inception providing all appropriate circuit-breakers, protective devices and communication channels are in service and where appropriate shall co-ordinate with existing in-service relays. Protection circuits shall be designed to reduce the standing load on the d.c. supply to the minimum.

1.1 Relays

All relays shall be contained in dustproof cases. All metal bases and frames of relays shall be earthed except where the latter must be insulated for special requirements. All principal protective relays shall be mounted on the front only of relay panels. Where auxiliary relays are accommodated internally they shall be so mounted as to be accessible for inspection and wiring. All flag or operation indicators shall be visible from the panel front.

The relays shall be so arranged that replacements can be effected quickly and with the minimum amount of labour. Relay equipments incorporating electronic devices shall be arranged to jack in, and shall have positive means for retaining them in the service position. Equipment incorporating telephone type relays shall have similar facilities.

Current transformer operated relay coils shall have continuous thermal ratings of not less than the maximum continuous secondary current of the current transformer at the full rating of the circuit in which the current transformer is connected.

The contacts of all relays shall be capable of making the maximum current which can occur in the circuit which they have to control. They shall also be capable of breaking such currents unless provision is made for breaking the current on contacts elsewhere in the circuits. Relays shall not be affected by mechanical

shock or vibration, or by external magnetic fields consistent with the place or method of mounting. The contacts shall be capable of repeated operation without deterioration.

All relays which are connected to complete either the tripping circuit of a circuit-breaker or the coil circuit of an auxiliary tripping relay shall be provided with operation indicators which, wherever possible, shall be of the mechanical type and shall be visible from the panel front.

Indicators shall also be provided on such additional relay elements as will enable the type or phase of the fault condition to be identified. Each indicator whether of the electrically operated or mechanically operated type shall be capable of being reset by hand without opening the relay case, and it shall not be possible to operate the relay when resetting the operation indicator. Each indicator shall be so designed that it cannot move before the relay has completed its operation, except for induction disc relays, where the indication may show just before the trip contacts are made. Indicators shall be clearly visible from the front when operated and concealed at all other times.

All relays which are of the hand reset type shall be capable of being reset without the necessity of opening the case. It shall not be possible to operate any relay by hand without opening the case.

All protective relays which initiate tripping (excluding tripping relays) shall not have less than two independent pairs of contacts, one of which shall operate the tripping relay or circuit-breaker directly without the interposition of auxiliary contactors, and preferably without the use of reinforcing contactors.

All relays shall be so arranged that, provided that reasonable care be taken, any dust which may have collected on the case shall not fall on the relay mechanism when opening the case.

Overcurrent relays and earth fault relays shall be of the inverse definite minimum time lag (IDMTL) pattern with separately adjustable time and current settings. The time/current curves shall normally be to BS 60255, but other National Standards may be approved in specific cases.

Balanced earth fault relays shall be instantaneous in action. The arrangement, however, shall be such that the relay is stable under "transient" conditions. In order to facilitate testing, each earth fault relay shall be fitted with a plug bridge.

Thermal overload devices for motor protection shall have a characteristic so related to the characteristics of the motor with which they are associated that effective protection is obtained.

Where relays are required to operate with a time delay the delaying attachment shall not be of the dashpot type.

Directional relay elements which are designed to be energised normally by voltage and current when carrying any current between zero and 15 times rated current, shall take up such a position that the contacts are open when the voltage coil is not energised.

All d.c. relays used shall operate over the voltage range specified in IEC 56 and shall be compatible under all operating conditions of the battery system installed.

All relays shall be suitably marked with the following information:-

- (a) Function of relay.
- (b) Phase identification of the current supply.
- (c) Characteristic curve, where appropriate.
- (d) Rated current and/or voltage of the relay coils.
- (e) Rated making capacity of tripping contacts.

Items (a) and (b) above shall be visible from the front without removing the cover.

Rectifiers used in or in association with protective relays shall be of the selenium type.

In order to minimise the effects of electrolysis, operation indicator coils and d.c. relay operating coils shall be so placed in the circuit that they are not connected to the positive pole of the battery except through contacts which are normally open.

Withdrawable pattern relays shall be designed so that, when in the withdrawn position, associated current transformers shall be automatically short-circuited and tripping circuits disconnected.

1.2 Directional Overcurrent Protection

Where specified in Schedule 'G', circuits shall be provided with directional overcurrent and directional earth fault protection.

The overcurrent and earth fault time-current characteristics and range of settings for current and time shall be as specified for plain overcurrent and earth fault relays.

The external current and voltage connections to the directional overcurrent elements shall be arranged so that the phase current in any one element is associated with a voltage signal which is derived from the line voltage and which lags the current by 90° (i.e. 90° relay quadrature connection).

The internal connections of the directional overcurrent element shall be such that the maximum torque in a direction to close the directional contacts is produced when the current flowing in the current circuit leads the voltage applied to the voltage circuits by 45° (i.e. 45° maximum torque angle).

The current signal for the directional earth fault relay shall be derived from the residual circuit of the directional overcurrent relay. The voltage signal shall be the residual voltage produced by an open delta circuit. The internal connections of the relay shall be such that the maximum torque in a direction to close the directional contacts is produced when the angle between the current and voltage is between 10° and 15° .

For both the directional overcurrent and directional earth fault relays the construction shall be such that the time delay associated with an overcurrent does not commence until the directional contacts have operated to prevent any danger of an instantaneous operation under conditions of a changing fault current direction.

1.3 Transformer Protection

Where a pilot system of balanced transformer protection is employed, means shall be provided to prevent operation of the protective gear due to the magnetising current when switching in a transformer or changing transformer tapplings. Operation of main and h.v. back up protection shall trip both h.v. and l.v. circuit-breakers. Facilities shall be retained for independent tripping by hand of either circuit-breaker.

Restricted earth fault protection shall be so arranged that it does not operate with any type of fault external to the transformer winding. To ensure compliance with this requirement the equipment shall be so designed that the current flowing in the relay operating coil, with any type of fault having a magnitude up to the maximum figure specified, shall preferably be not more than a quarter and in no case more than one-half of the current required to operate the relay when adjusted to the prescribed setting. The setting of the relay shall be such that it will operate reliably with current of the following magnitudes in the primary winding of the neutral current transformer alone: -

- (a) When the protected winding of the transformer is connected to a solidly earthed power system, the fault setting shall be between 10 per cent and 60 per cent of the rated current of the protected winding. When a transformer winding has more than one rating, the percentage setting shall be based on the lowest of the ratings. When more than one transformer winding is connected in parallel, the percentage setting shall be based on the lowest of the rated currents of the individual transformers.
- (b) When the protected winding of the transformer is not connected to a solidly earthed power system, the fault setting shall be between 10 per cent and 25

per cent of the minimum current available for an earth fault at the transformer terminals.

Where the prescribed settings cannot be obtained special approval of the performance shall be obtained.

Where earth fault protection is employed for the winding of a transformer which is earthed either directly or through an earthing device, the Contractor shall provide and fix current transformers in the neutral earthing connection of the winding of the power transformer. One such current transformer in the neutral connection shall be used for the balanced earth fault protection and standby earth fault protection shall be obtained from a second current transformer having a primary current rating of the winding of the power transformer with which the standby earth fault current transformer is associated.

The standby earth fault relay shall be of the inductive pattern so designed that it will operate in 10 secs.

Current transformers which are used for transformer earth fault protection shall not be used for any other purpose.

1.4 66 kV Busbar Protection

The busbar protection shall be based on the circulating current differential principle using high impedance relays to provide phase and earth fault protection in the busbar zone.

The equipment shall be stable, with an adequate margin of safety, when out of zone phase or earth fault current, equal in magnitude to the full short-circuit current rating of the switchgear, is applied gradually or suddenly.

There shall be fully discriminative clearance of busbar faults on any section of the busbar.

When a busbar fault occurs, all circuit-breakers connected to the faulted busbar shall be tripped simultaneously, whether they can feed fault current or not. The rating of the trip connections from the battery and also the fuses shall be suitable for meeting this requirement.

The speed of operation of a busbar protective equipment shall be as short as possible consistent with ensuring that faults which can be cleared by individual circuit protection do not result in operation of the busbar equipment.

The busbar protective equipment shall not be affected by harmonic circulating currents such as may be experienced in a multiple earthed power system.

The equipment for busbar protection shall be independent, electrically and physically, from other equipment as far as practicable. Separate relay panels and multi-core cables shall be employed and if separate terminal boxes are not specified the wiring and terminals shall be carefully segregated from other circuits.

CT shorting links shall be provided to enable individual circuit testing to take place without taking the busbar protection out of service for extended periods.

Where common circuit-breaker trip coils are used for busbar and circuit protection, the busbar protection shall not use a separate trip supply common to all breakers. Instead, the segregation of trip circuits shall be maintained by taking the trip supply for each breaker from its associated control or relay panel. This precaution may be omitted where separate trip coils are provided on the circuit-breakers for sole use by the busbar protection.

Means shall be provided at the front of the busbar protection panel for interrupting in emergency the trip and intertrip functions of the busbar protection while leaving the operation and indication of the equipment otherwise unimpaired. Where each breaker has only a single trip coil, it is necessary when taking the equipment out of commission to interrupt each trip circuit and any intertrip circuits. For this purpose a master two-way multi-contact switch of approved type and provided with padlock, shall be mounted on the front of the busbar protection panel. The contacts of this switch shall be connected on the live (positive) side of each of the busbar trip relay contacts. Where separate trip coils are used solely with the busbar protection, it is sufficient for the master switch to interrupt the common trip supply.

Means shall be provided to permit tripping and intertripping of individual circuit-breakers from test operations of the protection, without tripping all circuit-breakers connected to the protected busbars. Where common breaker trip coils are used, these means shall comprise insulated links, distinctively labelled and located on the front of the panel and connected in the trip and intertrip circuit connections on the side of the busbar trip relay contacts remote from the master switch contacts. Where separate trip coils are used for the busbar protection, similar means shall be used but fuses shall be supplied instead of links in series with the trip circuits, to ensure clearance of faults on the small wiring.

The trip circuits in the busbar protection cubicle shall be fully insulated or shrouded on the positive side of the master switch contacts and on the trip coil and intertrip relay coil sides of the fuses or links.

Full provision for testing each part of the equipment shall be made so that it is not necessary to disconnect wires from terminals.

Where insulated cable glands are supplied in association with current transformers fitted over the cables means shall be provided for testing the insulation. These means shall comprise the provision of two stages of insulation between the cable

sheath and the switchgear framework, the two stages being separated by a metallic island-layer fitted with test terminal and removable earth link.

1.5 11 kV Busbar Protection

A busbar protection system shall be included based on overcurrent relaying.

1.6 66 kV Line Unit Protection

Fibre optic channels will be provided embedded in the overhead line earth wire for amongst other functions, protection purposes. The 66 kV feeder protection shall be of the current or phase comparison type able to detect all types of fault. It is required to trip the circuit-breakers at both ends of the line irrespective of the end feeding the fault. Facilities will be provided to monitor the protection communication channel and signal an alarm in the event of channel failure.

1.7 Trip Relays

Where specified, trip relays shall be electrically resettable and shall be of the "high burden" type.

2 SCADA RTU AND POWER SYSTEM SUPERVISORY INTERFACE

2.1 General

Facilities shall be provided on all 66 kV and 11 kV switchgear and power system plant to enable it to be interfaced to the SCADA system via a Remote Terminal Unit (RTU) located on the same site. The RTU will communicate with the SCADA system master station located at the Cul de Sac System Control Centre via the optical fibre communications system. These facilities shall include wiring out all controls and signals to a "SCADA Interface Cubicle".

2.2 SCADA Interface Cubicle

All plant supervisory facilities shall be wired out to a "SCADA Interface Cubicle". This interface cubicle shall provide space for control interposing relays, transducers and marshalling termination blocks so that supervisory control connections are not made directly between the plant and the RTU.

At least 20% spare space and 10% spare of each type of termination block shall be provided in each interface cubicle to facilitate the marshalling of additional circuits in the future.

Terminal blocks or sections of terminal blocks shall be clearly labelled with the name of the circuit and its alphanumeric identity.

All equipment in the interface cubicles, e.g. terminals, relays and transducers, shall preferably be rail mounted to facilitate the ready replacement of faulty units.

All terminals shall be of the insertion type, incorporating screw operated pressure plates for clamping the conductors or, where applicable, of the stud type for bolted connection of cable lugs.

With the exception of terminals for connections in current transformer (CT) circuits, all terminals shall be provided with an isolating link which may be operated without disturbing the connected wiring to facilitate the isolation of selected circuits and the testing of the plant supervisory signals independently from the RTU signals.

Terminals used in CT circuits shall provide a means of maintaining continuity of the external CT circuit, without disturbing the connected wiring, so that equipment in the interface cubicle (such as transducers) may be safely disconnected from those terminals without disrupting the CT circuit.

Terminals for the connection of transducer fly leads shall be arranged to enable any one transducer to be disconnected and replaced without disrupting the connections or operation of any other transducer, particularly where more than one transducer is connected to the same CT or VT input signals.

2.3 Circuit Conditions on the Plant Side of the SCADA Interface

The power plant at each substation shall be equipped to permit: -

- (a) Remote operation of circuit breakers, bus section and circuit isolators, transformer tap changers and any other specified control function.
- (b) Supervision of the position of all high voltage circuit breakers, isolators, tap changers, earth switches, remote/supervisory selector switches and other equipment status indication, remote indication of fault or other abnormal conditions.
- (c) Telemetry of instantaneous values of watts, VARS, volts, amperes, frequency and transformer tap position.

The characteristics of each of the devices or attachments on the power plant side of the interface required to permit the above desired functions are as follows and shall be compatible in every respect for interfacing to the RTU.

2.3.1 Control Functions

A suitable interposing relay shall be provided in the SCADA interface cubicle for each control function (e.g. "Open", "Close", "Transformer Manual Tap Change Mode Select", "Raise/Lower Tap", "Trip Relay Reset", etc.). The interposing relay coil shall be initiated by the RTU control outputs using power from the RTU's d.c. power supply. The operating current of the interposing relay shall not exceed

80 mA. The interposing relay contacts shall be rated for 100 VA inductive loads at voltages up to 250 V d.c.

The output contacts of the interposing relays may either be used directly in plant control circuits or, where necessary (e.g. to achieve the required number of initiating contacts or to drive a higher burden than the interposing relays can sustain), via auxiliary relays accommodated inside the appropriate plant control/relay panel. In all cases, the power supply for the plant control circuits shall be derived from the plant, i.e. the interposing relays provide volt free initiating contacts to the plant control circuits.

The SCADA RTU will initiate the operation of the interposing relay by applying a pulsed signal of approximately 250 ms duration. The power plant control circuits shall be designed to 'lock-in' during this period.

2.3.2 Indications and Alarms

The following voltage free contacts shall be provided for the equipment indicated: -

66 kV and 11 kV Circuit Breakers	1 NO & 1NC
66 kV Isolators and Busbar Selectors	1 NO & 1NC
66 kV Earth Switches	1 NC
11 kV Switchgear Racked Out/Withdrawn Position	1 NO that closes when the CB is in the 'racked out' position
Alarm functions	1 contact that closes in the alarm condition
Circuit and Transformer Remote/Supervisory Position Switches	1 NO per position
Transformer Auto/Manual Position Switches	1 NO per position
Transformer Master/Follower/Solo Position Switches	1 NO per position
Tap Changers	1 NO that closes to indicate incomplete tap change

2.3.3 Analogue Indication Monitoring

Metering of power, voltage, current and frequency shall be by means of transducers meeting the requirements specified below.

2.4 Transducers

2.4.1 General

All transducers shall comply with IEC 688-1 and the requirements stated below.

Each transducer shall be provided with a nameplate indelibly marked with the following information: -

- name of manufacturer
- manufacturer's type/model reference
- serial number
- rated input voltage and current, as appropriate
- d.c. output current
- overall ratio (e.g. watts or VAr/mA)

The type of transducers selected shall be suitable for use in a digital instrumentation scheme.

Transducers shall be self powered where possible. For SCADA transducers that require an auxiliary power supply, this supply shall be d.c. and taken from the same d.c. power supply as that used to power the SCADA RTU.

The inputs to the transducers will be derived from the secondaries of high voltage power circuit current and voltage transformers. The current transformers (CTs) have nominally rated secondary currents of 1 amp or 5 amps, and the voltage transformers (VTs) have secondaries that are nominally rated at 63.5 volts (line to neutral) or 110 volts (line to line). All transducers supplied under this Contract shall have inputs rated appropriately to the CTs and VTs to which they are to be connected. The type of connection for 3-phase transducers, e.g. 3-wire or 4-wire, shall be suitable to match the CT and VT windings available.

The burden imposed on the power circuit CTs and VTs at full rated input shall not exceed 2 VA and 12 VA respectively. The additional burden imposed on the power circuit CTs at full rated input when the d.c. output is open circuited shall not exceed 2 VA.

Each current input shall be capable of carrying 200% rated current continuously and shall withstand 10 times rated current for 5 seconds without damage. The output shall be accurate up to 120% rated input.

Transducers shall withstand for one hour without damage a short circuit on the output terminals when the input circuits are carrying rated voltage and current.

The steady output voltage of an open circuited transducer shall not exceed 25 volts.

Transducer outputs shall be 4 to 20 mA. The error in the transducer output shall be not more than $\pm 0.5\%$ of full rated output over as great a part of the output range as possible. The error shall not exceed 1.5% due to $\pm 10\%$ voltage variation in the voltage circuit input nor exceed 1.5% due to a $\pm 5\%$ change in the frequency of any input.

The root-mean-square ripple current on a transducer's output shall not exceed 5% of the maximum signal output current and shall preferably be much less.

The response time to reach and remain above 80% of the final steady value for a step change in input from zero to a value equal to full rated output shall not exceed 1 second.

Adjusters shall be provided to allow adjustment of the output current to be made to compensate for errors in CTs and VTs. Adjustment may be continuous or in fixed steps. A range of $\pm 2\%$ adjustment in the output current shall be provided.

2.4.2 Power (Watts/VArS)

For the measurement of three phase balanced power flows, power transducers shall have a d.c. current output linearly proportional to the real or reactive power, depending on the quantity being measured, represented by the a.c. input voltage and current.

Where both active and reactive power are to be monitored on a power circuit, a combined Watt/VAr transducer may be installed.

Only one range is required on each transducer. The effective range of the transducer shall be 0 to 120% of the rated nominal input power, i.e. full scale output shall occur at an input of 120% of the power equivalent to the nominal input voltage rating and nominal input current rating together.

All VAr transducers shall be designed for bi-directional power flow. Watt transducers shall be designed for either unidirectional or bi-directional power flow, as called for in Schedule G. For bi-directional power flow transducers, zero power flow shall produce mid-scale output, i.e. 12 mA. Transducer output shall be greater than 12 mA for positive power flow, i.e. power flowing into a busbar, and less than 12 mA for negative power flow, i.e. power flowing out of a busbar.

2.4.3 Voltage

Voltage transducers shall have a d.c. output current linearly proportional to the a.c. input voltage.

Only one range will be required on each transducer. The effective range of a transducer shall be 60% to 120% of rated input voltage. However, where requested, the range shall be 0% to 120%.

2.4.4 Current

Current transducers shall have a d.c. output current linearly proportional to the a.c. input current.

Only one range is required on each transducer. The effective range of the transducer shall be 0 to 120% of the rated nominal input current.

2.4.5 Frequency

Frequency transducers shall have a d.c. output current linearly proportional to system frequency. The transducer shall record with an accuracy of $\pm 0.25\%$ over the range 48.00 to 52.00 Hz.

2.4.6 Transformer Tap Changer Position

Transformer tap changer position transducers shall have a d.c. output proportional to tap position with discrete output levels representing each tap position (unique transformation ratio). Due account shall be taken of transfer tap positions that do not affect the transformation ratio.

Each transducer shall be suitable for the number of transformer taps and the form in which the tap position is made available by the tap changer equipment.

2.4.7 Summator

Where specified or indicated on drawings, a summator shall be provided to summate the outputs of several transducers. The summator output shall be 4-20 mA. The error of the summator output shall be not more than $\pm 0.5\%$ of full rated output over as great a part of the output range as possible.

2.5 Cubicle Wiring

Wiring shall be installed with due regard for the need to protect against spurious voltages or currents, especially transients as a result of power system switching operations or faults. Particular attention shall be paid to the prevention of wiring insulation breakdown as a result of transient overvoltage and subsequent current flows from connected power sources. Every reasonable effort shall be made by contractors to avoid installing control and signal or metering wiring in close proximity to power wiring, and control, signal and metering wiring shall be protected by properly grounded shielding where it is reasonable to do so or equipped with drainage capacitors and surge arresters where shielding is impractical or inadequate.

3 METERING EQUIPMENT

3.1 Multi-Purpose Meters

When called for in Schedule G, multi-purpose meters shall be supplied. These meters shall display volts, amps, frequency, kW, kVA, kWhr, kVArhr, maximum demand, p.f., etc., when selected by pressing a push button pad mounted on the face of the meter. The size of the display digits shall be such that they are easily readable by an operator standing 1 metre from the meter and under a wide range of ambient light conditions.

Where analogue measurements are required for SCADA on a circuit for which a multi-purpose meter has been requested, those SCADA signals may be derived from the meter instead of from separate transducers if this facility is available on the meter. In this case, the required signals from the meter shall be wired to the SCADA interface cubicle.

SECTION 11

**OPERATING, INDICATING &
RELAY PANELS
& ANCILLARY APPARATUS**

SECTION 11

OPERATING, INDICATING AND RELAY PANELS AND ANCILLARY APPARATUS

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SECTION 11
OPERATING, INDICATING AND RELAY PANELS AND ANCILLARY APPARATUS

1 CONTROL AND RELAY CUBICLES - GENERAL CONSTRUCTION

Control and relay panels shall be of the cubicle type, and shall be constructed of sheet steel not less than 2.5 mm thick unless otherwise approved. Panels shall be reinforced where necessary to prevent distortion or the maloperation of relays or other apparatus by impact, having regard to the number and size of cut-outs and the size of the panel. Cubicles shall be so constructed that the front panel or the equipment mounting panel is removable without disturbing the remainder of the cubicle structure. Principal apparatus shall be flush mounted on the front of the cubicle.

Cubicles shall be drip-proof, dust-proof and vermin-proof. Equipment shall be arranged to give reasonable access to all components mounted on the panel front and inside. To assist in achieving this, cubicle widths shall not be less than 600 mm wide and the depth shall not exceed the width. The width between apparatus mounted on the cubicle side shall not be less than that which will permit full and easy access to all terminals and for apparatus mounted on the panels.

Separate cubicles must be provided for the protection relays associated with each primary circuit. For control purposes one cubicle may accommodate apparatus associated with not more than three circuits in which case vertical barriers must be provided inside the cubicle to segregate the wiring associated with each primary circuit and the front panel shall preferably be removable on a per circuit basis.

Rear access cubicle doors shall be hinged to lie back flat to avoid restricting access. Hinges shall be of the lift-off type. Doors shall be secured by integral handles and provision shall be made for padlocking. Handles and padlocks shall not be more than 2 metres above floor level. Top and bottom doors shall not be interlocked and cross stiffeners shall not impede access to the cubicle. Moulded gaskets of non-ageing material shall be used to provide close sealing.

A lamp shall be fitted inside each cubicle and so arranged that all wiring is illuminated as evenly as possible without dazzle. The lamps shall be controlled from a door switch.

Circuit labels shall be provided on the front and back of the panels and on the outside of cubicle doors. Where cubicles accommodate more than one primary circuit, appropriate interior labelling shall clearly distinguish each circuit.

In general relay and control panels must be of the same dimensions, design and finish as those in service in Union and Vieux Fort substations.

2 CONTROL SWITCHES

Control switches for electrically operated circuit-breakers shall be of the pistol grip or discrepancy type and shall be arranged to operate clockwise when closing the circuits and anti-clockwise when opening them. The control switches shall be so designed as to prevent them from being operated inadvertently and where switches of the discrepancy type are used they shall require two independent movements to effect operation. The control switch shall be so designed that when released by the operator it shall return automatically to the "neutral" position after having been turned to the "closed" position and shall at the same time interrupt the supply of current to the operating mechanism of the circuit-breaker. A label shall be fixed adjacent to the control switch to indicate the name or distinguishing number of the circuit concerned.

Mimic indicators shall be of the magnetic semaphore type.

Switches for other apparatus shall meet the same requirements as for circuit-breakers and shall be operated by switches with spade type handles. The pistol-grip type shall be reserved for circuit-breaker operation only.

Control, reversing, selector and test switches shall be so mounted, constructed and wired as to facilitate the maintenance of contacts without the necessity for disconnecting wiring.

On Local Control Panels the control switches may be of the push-button type provided that they are adequately protected and behind lockable glass panelled cubicle doors.

Front mounted individually padlocked control switches will not be acceptable.

The local/remote and remote/supervisory control switches shall have locks incorporated in their design.

3 INSTRUMENTS

All instruments shall be of the flush mounting type and shall be fitted with non-reflecting glass.

All instruments and apparatus shall be capable of carrying their full load currents without undue heating. They shall not be damaged by the passage of fault currents within the rating of the associated switchgear through the primaries of their corresponding instrument transformers. All instruments and apparatus shall be back connected and the cases thereof shall be earthed. Means shall be provided for zero adjustment of instruments without dismantling.

All voltage circuits to instruments shall be protected by a fuse in each unearthed phase of the circuit placed as close as practicable to the instrument transformer terminals, or, where instruments are direct-connected, as close as practicable to the

main connection. All power factor indicators shall have the star point of their current coils brought out to a separate terminal which shall be connected to the star point of the instrument current transformer secondary windings.

All indicating instrument scales shall be clearly divided and indelibly marked and the pointers shall be of clean outline. The marking on the dials shall be restricted to the scale marking. Instrument transformer ratios, maker's name and accuracy grades shall not appear on the dials. Busbar voltmeters shall be calibrated while hot.

Instrument scales shall be submitted for approval by the Engineer. All instruments mounted on the same panel shall be of similar style and appearance. Instruments shall have 240 degree circular scales.

4 INDICATIONS AND ALARMS

Semaphore indicators shall operate reliably at voltages from 120 to 80 per cent of normal. They shall be arranged so that a supply failure does not at any time create an erroneous indication.

All protection equipment supplies shall be fully supervised and failure conditions alarmed.

Facilities shall also be available to enable the whole alarm and indication equipment to work into a Remote/Supervisory system.

Annunciated alarms and indications shall be by lamps illuminating a legend. The annunciations shall be grouped, each group containing the alarms and indications associated with the particular switchgear concerned. There shall be two push buttons for each group of annunciations, one for "Accept" and the other for "Reset". When an alarm is originated the lamp shall flash and an audible alarm shall sound. On operation of the "Accept" key the lamp shall cease to flash and shall give a steady illumination and the audible alarm shall cease, unless already cancelled by a common "Accept" key which shall cover all alarms. An a.c. operated alarm shall be included to provide an alarm in the event of failure of the d.c. alarm supply.

The duration of the flash shall be such that the legend may be easily read and the speed of flashing shall not exceed three per second.

An alarm whose initiating device does not reset until the abnormality is remedied shall remain illuminated until the initiating device is reset, when it shall be extinguished without the use of the reset key.

Annunciations which arise from signals of short duration (fleeting alarms) shall not restore when the initiating contact restores. It shall be necessary to operate the reset key to clear these. The reset key shall not be effective until after the alarm

has been accepted. If a fleeting alarm is re-operated after acceptance but before resetting, the annunciation shall return to the flashing condition.

The annunciation circuit shall be readily adaptable for use with a fleeting or persistent initiating signal. Alarm initiating contacts have one pole at earth potential.

Facilities shall be provided for lamp test. The lamp test shall include spare windows, which shall be identifiable as such under test conditions and which shall also be fully equipped.

A trip circuit supervision scheme shall be provided for each trip circuit and shall be arranged to monitor the continuity of the circuit-breaker trip coils and as much of the associated tripping wires as possible. The scheme shall be to approval.

The Relay shall be of the three element type providing continuous supervision with the breaker open or closed and shall supervise the alarm supply. External resistors shall be included to limit the current through the trip coil to a safe value below that which will cause tripping in the event of supervision wiring fault or accidental short circuiting of the supervision relay coils.

5 INDICATING LAMPS

All indicating lamps and lamp holder assemblies shall be suitable for continuous operation at the maximum site ambient temperature.

Indicating lamps and lampholders shall be arranged so that replacement of lamps and the cleaning of glasses and reflectors employed can be readily effected.

To reduce heating and fouling of the panels, lamps which are continuously illuminated shall have the minimum consumption consistent with good visibility of indications in a brightly-lit room.

Spare lamps of 100% of each type and size shall be provided.

Indicating lamp glasses on control and relay panels shall conform to the following standard colour code: -

<u>Colour of Glass</u>	<u>Indication</u>
Red	Device closed
Green	Device open
White	Indications normally alight
Amber	Alarm indication (on which action is necessary)
Blue	Circuit earthed

6 SYNCHRONISING APPARATUS

In each circuit equipped with an electrically operated circuit-breaker, when called for in the appropriate section of Schedule G, connections between the control switch and the closing coil of the circuit-breaker shall be made through a synchronising selection arrangement, so that it is impossible to close the circuit-breaker until the appropriate synchronising selection arrangement is made.

A switch shall be provided with each synchroscope to enable it to be disconnected and the voltmeters left in circuit. The connections of regulating voltmeters shall be arranged so that they are connected in circuit by means of the synchronising selection arrangement of any panel equipped with synchronising voltage transformers.

Where busbar voltage transformers are not provided, an automatic voltage selection scheme shall be provided to derive a busbar voltage reference from the circuit voltage transformers. The paralleling of voltage transformer secondaries is not permitted.

The scheme shall employ voltage transformer secondaries with the neutral point earthed and synchronising across yellow phase and neutral.

Synchronising check relays shall not operate when one synchronising voltage or any auxiliary supply is absent or due to transient conditions when being switched in. A voltage check feature shall be incorporated to inhibit synchronising if either voltage is less than a preset value, which shall be adjustable in steps from 80% to 90% of nominal rated voltage. The synchronising relay shall prevent closure when the phase difference exceeds 35°, but alternative settings of 20° and 45° shall be available also. Closure shall be prevented also if the slip exceeds a setting which shall be adjustable over the approximate range 0.25% - 0.1%.

An automatic or manual override relay shall be provided to permit closing under dead line or dead bus condition. This relay shall short-circuit the synchronising check relay contacts when energised by a.c. no-voltage relays having settings not exceeding 30% of nominal rated voltage. A time delay shall be incorporated into this feature so that the override is not effected in less than 3 seconds from time of initiation and energisation of the synchronising check relay.

The no-voltage relays shall form the dead line or dead bus checking arrangements and shall comprise the following: -

- (a) A check relay for no running voltage and a check relay for no incoming voltage to be arranged with normally-opened and normally-closed contacts so that the override relay can be energised if one or the other of these two relays is de-energised, but not both or neither and subject to:

- (b) A fused check relay directly connected to the voltage transformer terminals on the line side of the main voltage transformer fuses for the synchronising phase of every voltage transformer. This relay shall have normally closed contacts which shall be selected by the synchronising selection relay to the appropriate circuit of the running and incoming check relays referred to under (a) so that the override relay can be energised only if the voltage transformer no-volt relay is in agreement with the incoming or running no-volt relay as may be relevant.

Each circuit shall be provided with a synchronising selection switch to enable MANUAL-OFF-CHECK positions to be selected. This switch shall be key operated, the key being released in the OFF position only. In both the MANUAL and CHECK position the synchronising instruments shall be connected to the appropriate voltage transformers and the circuit-breaker closing circuit prepared.

Where necessary, interposing relays shall be provided for the output circuits of check synchronising relays.

The burden imposed on either the running or incoming supply shall not exceed 5 VA.

The check synchronising operation shall be initiated by the local circuit-breaker control switch, this mode of operation shall cause the synchronising selector relay to be sealed in for a period of 5 seconds to ensure completion of the synchronising operation. At the end of this period the equipment shall restore to its de-energised condition.

7 RELAYS, FUSES, LINKS AND ANCILLARY APPARATUS

All relays shall be mounted in such positions that no part requiring inspection or adjustment is less than 450 mm or more than 2 metres above floor level. Where practicable the clearances between relay stems or connecting studs shall not be less than 30 mm and in no case less than 25 mm.

Unless otherwise stated all relays for front of panel mounting shall be flush pattern and withdrawable.

Relays associated with the three phases shall be marked with the appropriate phase identification and the fuses and links shall also be suitably labelled. In addition to the labelling to identify relays on the front of panels, all relays and components shall be identified from the rear of the panels.

Isolating links and fuses (or MCBs) of approved type shall be provided on each panel to facilitate the isolation of all sources of electrical potential to permit testing or other work on the panel without danger to personnel or interference with similar circuits on other panels.

The use of permanently energised relays shall be kept to a minimum and where approved these shall be of a type having a low burden, to prevent drain on the battery.

Fuses (or MCBs) and links in tripping circuits and protective gear test circuits shall be mounted on the front of the panel. Facilities included for secondary injection testing shall permit testing to be carried out without disconnection of any permanent wiring. If these facilities are provided as part of drawout type relays any test plugs appropriate to the design shall be provided. Other links and fuses shall be accommodated within the cubicle or at the rear of the cubicle above the cubicle doors. Fuses (or MCBs) and links shall be grouped and spaced according to their function in order to facilitate identification. Carriers and bases shall be of moulded plastic material coloured white for links and black for fuses. Fuse carriers shall be clearly marked with the correct fuse rating. As an alternative to fuse and links, miniature circuit-breakers will be accepted.

Links in current transformer circuits shall be of the bolted type having size M6 hexagon nuts. M5 size may be used provided the material used is phosphor bronze or stainless steel.

All incoming circuits in which the voltage equals or exceeds 125 volts shall be fed through insulated fuses and/or links, the supplies being connected to the bottom terminal which shall be shrouded. The contacts of the fixed portion of the fuse or link shall be shrouded so that accidental contact with live metal cannot be made when the moving portion is withdrawn.

Resistance boxes shall be so mounted inside the cubicle that their adjustment screws are on a vertical and accessible face. Resistances shall be provided with stud terminals. Set screws shall not be used.

8 EARTHING ARRANGEMENTS

All control and relay panels shall have a continuous earth bar of a sectional area of not less than 85 mm² run along the bottom of the panels with provisions each end to be connected to the main earthing system. All joints shall be tinned. Metal cases of instruments and metal bases of relays on the panels shall be connected to this bar by conductors of a sectional area of not less than 2.5 mm².

Current transformer and voltage transformer secondary circuits shall be complete in themselves and shall be earthed at one point only, through links situated in an accessible position. Each separate circuit shall be earthed through a separate link, suitably labelled. The links shall be of the bolted type, having M6 nuts and provision for attaching test leads.

The earth links for protective and instrument current transformer secondary circuits shall be mounted inside the relay panels. Earth links for metering current transformer secondary circuits shall be mounted at the switchgear.

For voltage transformers consisting of single phase units, separate earth links for each secondary winding shall be provided and shall be situated at the voltage transformer. For other voltage transformers the earth links shall be mounted inside the relay panels.

9 CABLE TERMINATIONS

For the reception of external cables removable gland plates shall be provided.

All cables shall enter vertically from below and at their point of entry to the equipment they shall be sealed by fitted boards. These shall be of an approved, non-flammable, insulating, vermin-proof material. Cable glands and conduits shall project at least 20 mm above the gland plate to prevent any moisture on the plate draining into cable crutches or conduits. Means shall be provided to drain water off the surface of the gland plate.

Separate gland plates shall be provided for each circuit, suitable for PVC/PVC/SWA PVC cable.

10 TESTING FACILITIES

Testing facilities for current transformer secondary injection testing shall be provided for each protection circuit. These facilities shall be such that wires and connections need not be disconnected for the tests to be carried out.

SECTION 12

**JUNCTION BOXES, TERMINAL BOXES AND MARSHALLING
KIOSKS**

SECTION 12

JUNCTION BOXES, TERMINAL BOXES AND MARSHALLING KIOSKS

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SECTION 12

JUNCTION BOXES, TERMINAL BOXES AND MARSHALLING KIOSKS

1 GENERAL

All junction boxes, terminal boxes and marshalling kiosks shall be constructed of steel or cast iron.

All main equipment shall be arranged so that it is accessible from the front of the box or kiosk.

2 OUTDOOR BOXES AND KIOSKS

Outdoor boxes and kiosks shall have domed or sloping roofs and shall be of weatherproof and vermin-proof construction, with adequate ventilation and draining facilities. They shall be so designed that condensation does not affect the insulation of the apparatus, the terminal boards or the cables. Heaters, other than those of the exposed element type, shall be provided and where these exceed 40 watts, they shall be controlled by means of a watertight switch mounted on the outside of the box or kiosk.

Any divisions between compartments inside the boxes or kiosks shall be perforated to assist the natural air circulation.

Earth studs shall be provided on all junction boxes, terminal boxes and marshalling kiosks.

3 ACCESS FACILITIES

Access shall be provided at both the front and back of kiosks and junction boxes, except for small terminal boxes of the type normally employed for wall mounting.

Doors and access covers shall be easily opened and shall not be secured by nuts and bolts. Doors and covers under 14 kg weight may be of the slide-on pattern, above this weight they shall preferably be hinged.

Kiosk doors shall be fastened with integral handles, nuts, bolts, or carriage keys shall not be used. Provision shall be made for padlocking each door.

Hinged doors on outdoor boxes shall be provided with stays to latch the doors in the open position.

4 TRANSFORMER MARSHALLING KIOSKS

Where specified, transformer ancillary equipment shall be housed in a freestanding, outdoor, ventilated, marshalling kiosk. In other cases the ancillary equipment shall be mounted on the transformer tank.

Kiosks shall be divided into four separate compartments for the accommodation of the following equipment: -

- (a) Temperature indicators, cooler control "auto/manual" changeover switch, test links and ammeter for the winding temperature indicator circuits.
- (b) Control and protection equipment for the tap change gear including an isolating switch in the incoming circuit capable of carrying and breaking the full load current of the motor and of being locked in the open position, and interposing relays for supervisory control equipment.
- (c) Control and protection equipment for the cooling plant including an isolating switch in the incoming circuit capable of carrying and breaking the full load current of all cooling plant motors and of being locked in the open position, together with means for isolating each motor circuit or group of motor circuits when a multi-fan arrangement is adopted.
- (d) Terminal boards and gland plates for incoming and outgoing cables, except for the auxiliary supply cables to the tap change and cooler motors which shall terminate at the base of compartment in which the supply is required.

All the above equipments except (d) shall be mounted on panels within the respective compartments and back of panel wiring shall be used for interconnection.

Each compartment shall be provided with access doors at front and rear. All doors shall have "lift off" type hinges.

The temperature indicators shall be so mounted that the dials are not more than 1.5 metres from ground level and the door(s) of the compartment shall be provided with glazed windows of adequate size.

Facilities shall be provided to permit the temperature indicators to be removed from the kiosk without the necessity of passing the capillary tubing and bulbs through the various compartments. Mechanical protection shall be provided and sharp bends avoided where the capillary tubes enter the kiosk.

A metal-clad heater shall be provided controlled by a weatherproof rotary switch mounted on the outside of the kiosk and a fuse and neutral link inside the kiosk.

All three-phase relays, contactors, isolating switches and thermal devices shall be marked with the appropriate phase identification.

Each kiosk shall be fitted with the following switch plug units mounted externally.

- 1 - Water-tight 15 A 3 pin interlocked switch-plug, for an auxiliary single phase 240 V a.c. supply. This switch-plug is to be connected to the kiosk

heater supply circuit through a 15 A fuse in the "live" lead and a link in the neutral lead. (Type Niphan N7012 or similar.)

- 1 - Water-tight 60 A 4 pin interlocked switch socket and plug unit for a 3 phase and neutral 415 V a.c. supply. This switch-socket is to be connected to the auxiliary supply through separate fuses and links, and is to be of the current rating specified. (Walsall V23 A22 or similar.)

5 LOW VOLTAGE CONNECTIONS

If 415 V connections are taken through a box or kiosk, they shall be adequately screened or insulated, and a "415 VOLTS-DANGER" notice shall be fixed on the outside and inside of the box or kiosk.

Voltage in excess of 125 V shall be fully shrouded.

6 CABLE TERMINATIONS

All cables shall enter boxes and kiosks at the base.

Conduits shall not be run at or below ground level, but shall wherever practicable enter boxes or kiosks near the base.

Plates for supporting cable glands shall be at least 450 mm above ground level. Cable glands and conduits shall project at least 20 mm above the gland plate to prevent any moisture on the plate draining into cable crutches or conduits. Means shall be provided to drain water off the surface of the gland plate.

The back, sides and front of the box or kiosk shall project at least 50 mm below the gland plate to prevent moisture draining on to the plate and cable glands.

7 LABELS

Labels shall be provided inside each junction box or kiosk to describe the functions of the various items of equipment. Where the kiosk is divided into compartments each door shall have an external label to identify the compartment.

Each kiosk shall be equipped with an external circuit label (i.e. Transformer 1) which shall be visible from any operating position.

8 PILOT TERMINATION BOXES

Boxes for the termination of pilot cables shall be front entry.

Terminal boards shall be provided sufficient for all pilot cores to be installed whether cores are used or not. The terminals shall be of easy disconnecting type to facilitate testing of the pilot cables.

Barrier equipment shall be provided and installed in the terminal boxes on the basis of one barrier equipment for each pair of pilot cores.

Small wiring between the barrier transformer and the terminal board on the pilot cable side of the barrier transformer shall have an insulation level equal to or in excess of the insulation level of the barrier transformer to which it is connected.

Where a box is used for more than one circuit then barriers between circuits shall be provided.

SECTION 13

**SMALL WIRING AND
TERMINATIONS**

**SECTION 13
SMALL WIRING AND TERMINATIONS**

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SECTION 13
SMALL WIRING AND TERMINATIONS

1 GENERAL

All wiring shall have insulation incapable of supporting combustion.

The size of wiring cores shall be selected with due regard to thermal requirements, voltage drop and mechanical strength. Particular attention is to be paid to fatigue failure of cores due to flexing or vibration including damage at terminations which require disconnection for test purposes. Cores shall be multi- stranded.

The minimum size of wiring other than for light current (telephone type) apparatus shall be 1.5 mm² copper, except for current transformer secondaries which shall be not less than 2.5 mm².

Small wiring shall be black or other approved uniform colour unless otherwise specified or extensions are involved, to existing plant which has already coloured wiring in which case, the existing wire colouring scheme shall be retained as far as existing switchboards are concerned. If coloured wiring is specified for new switchboards then colours shall comply with the following code: -

<u>Colour of Wire</u>	<u>Circuit Particulars</u>
Red) Yellow) Blue)	First, second and third phase connections respectively when directly connected to the primary circuit or connected to the secondary circuits of current and voltage transformers.
Green or Green/Yellow	Connections to earth.
Black	A.C. neutral connections earthed or unearthed either directly connected to the primary circuit or connected to the secondary circuit of current or voltage transformers, a.c. connections other than those above and connections in the a.c./ d.c. circuits.
Grey	Connections in d.c. circuits.

All wiring shall be neatly run and securely fixed in cleats, bunched in neat forms or run in approved wiring troughs or non- corrodible tubes. The numbers of wires in any one bunch or tube shall not exceed 20 and the number in a trough shall not exceed the number and size for which it is designed. The practice of doubling back wires on themselves in a trough to absorb slack is not acceptable and where

bunched or bundled wires are run in troughs the maximum number in each bunch shall be retained at 20.

Cleats shall be of moulded or metal-reinforced insulating material and shall be of the limited compression type. Insulated strapping shall be used for bunched wires. Wiring troughs shall be of insulating material.

Wiring passing out of cubicles and wiring between compartments of metal-clad switchgear shall be run in robust ducting, corrosion resistant flexible tubes or conduit. Wiring shall be protected from sharp edges. Indoor conduit shall be either aluminium, steel or plastic.

All wiring accessories of plastic materials, such as cleats, troughs, conduits and strapping shall be non-ignitable or resistant to flame propagation.

Wherever practicable, wiring shall be accommodated on the sides of the cubicles and the wires for each circuit shall be separately grouped. Back of panel wiring shall be so arranged that access to the connecting stems of relays and other apparatus and to contacts of control and other switches is not impeded. Where provision is made for addition of equipment not required initially, means shall be adopted for supporting and terminating wiring during the interim period.

All wiring shall be taken to terminal boards and wires shall not be jointed or teed between terminal points.

Stranded conductors shall be terminated with a crimped termination.

Numbered ferrules shall be fitted to internal wiring and to all multicore cable tails. Ferrules shall be of white insulating material with glossy finish to minimise adhesion of dirt. They shall not be affected by damp or oil and shall be clearly and permanently marked in black.

The ferrules shall be of sleeve type so fitted that they cannot slip along the cable or be removed from the cable without re-terminating.

All wires forming part of a tripping circuit shall be provided with an additional red ferrule marked "Trip" or "T" in white.

Each wire shall have a letter to denote its function followed by a number to identify the individual wire. A wire shall bear the same identification mark at both ends. Every branch of any particular connection shall bear the same identification mark.

Unused cores in multi-core cables shall be ferruled U1, U2, etc., at both ends and connected to individual spare terminals.

Ferrule numbering shall be in accordance with the following system. The same ferrule number shall not be used on wires in different circuits on the same panels.

2 STANDARD NUMBERING FOR SMALL WIRING FOR SWITCHGEAR AND ASSOCIATED RELAY AND CONTROL PANELS AND KIOSKS

2.1 General

Each wire shall have a letter to denote its function, e.g. control of circuit-breaker, current transformer for primary protection, voltage for instruments, metering and protection. The function letter shall be followed by a number identifying the individual wire. Every branch of any connection shall bear the same identification mark. Where it is necessary to identify branches which are commoned (e.g. current transformer leads), different identification marks for the branches may be employed only if they are commoned through links, or are connected to separate terminals which are then commoned by removable connections. Suffix letters shall be used as indicated in Clause 2.4 of this section.

Numbering shall read from the terminals outwards on all wires.

2.2 Prefix Letters

Where part of a circuit is common to more than one function, the first in alphabetical order of the appropriate function letters in the table, shall be used for the common part. Where the circuits split at a separable contact (e.g. fuse, link, switch or relay contact) the function letter shall change if necessary from the splitting point onwards.

Circuits having functions not included in the function letter table shall not have prefix letters. For example, circuits of devices which provide a continuous indication, such as remote winding temperature indicators or resistance thermometers, shall not have a prefix letter unless the circuit of the particular indication already has a function letter. Where, however, an indication or alarm is initiated by the opening or closing of an auxiliary contact prefix 'L' or 'X' should be used as appropriate.

Where relays are employed, the coil and the contact circuits do not necessarily bear the same function letter; this should be determined by the function of the individual circuit, e.g. the coil circuit of a series flag relay may be 'K' but the contact circuits may bear letters such as 'X', 'L' or 'N' as appropriate.

The following rules shall apply to current and voltage transformer function letters:

Current Transformers for Protection

Prefix 'C' shall be used for all types of overcurrent protection (whether used as primary or back-up protection), standby earth fault, generator negative phase sequence, transformer winding temperature protection, and instruments fed from separate current transformers. Where duplicate primary protection is applied prefix

'A' shall be used for both, the second line being distinguished by adding 300 to the number.

Interposing and Auxiliary Transformers

The function letters shall follow through any interposing and auxiliary current and voltage transformers, including such transformers when used for light current circuits, provided that these are not used as isolating transformers to couple circuits which have differing functions.

Where an a.c. supply, reflecting the primary quantities and derived from a current or voltage transformer, is rectified for the operation of instruments or relays, the d.c. circuit shall carry the same function letter as the a.c. circuit.

Current Transformer Connections for Line Drop Compensation or Compounding

Prefix 'D' shall be used for these circuits, including the current side of the isolating transformer. The connections to the voltage circuit from this transformer shall have prefix 'F'.

Voltage Transformer Connections for Automatic Voltage Control

Prefix 'F' shall be used for these circuits.

Light current equipment may require numbering schemes differing from the above for complete identification. In such cases, where connections from such equipment are associated with power equipment wired in accordance with this Specification, the numbering of such connections shall include the appropriate prefix letter (J, W, X or Y) to distinguish them. The letter 'W' is generally used for the light current side of interposing relays for control purposes.

2.3 Wire Numbers

The wire number may consist of one or more digits as required. For functions A-G, H, J and M, the numbers shall be as given in the column under "Wire Numbers" Clause 2.5 below. D.C. supplies from a positive source shall bear odd numbers and d.c. supplies from a negative source shall bear even numbers. Where coils or resistors are connected in series the change from odd to even shall be made at the coil or resistor lead nearest to the negative supply.

2.4 Suffix Letters

Where similarly numbered leads from separate primary equipments are taken to a common panel (e.g. bus zone protection, summation metering, banked transformers, etc.) suffixes A, B and C, etc. should be used to distinguish them. Where similarly numbered leads from different parts of a unit of primary equipment are taken to a common panel (e.g. generator and unit transformers, h.v. and l.v. sides of a transformer, etc.) the leads of the subsidiary or lower voltage

selective control and for General
Indication equipment

]
]
]

Alternatively, the core number shall be preceded by the cable number.

V - Automatic switching circuits not integral with circuit-breaker control schemes.]	
]	
]	
]	
<u>Table of Circuit Function Letters Cont'd</u>		<u>Wire Numbers</u>
W - Light current control connections]	
]	
X - Alarms and indications to and from General Indication and remote selective control equipments]	Any number from 1 upwards
]	
]	
Y - Telephones]	

* If, for functions A-G and for functions H, J and M, more numbers are required, add multiples of one hundred (e.g. 10-29 may be extended to 110-129, 210-229, etc.).

Note:

'Local' control shall refer to control at the switchboard or item of plant, 'Remote' control at the control/relay panel at the substation and 'supervisory' control at a point away for the substation.

At those points of interconnection between wiring carried out by separate contractors, double ferrules shall be provided on each wire where a change of number cannot be avoided. The change of numbering shall be shown on the appropriate diagrams of the equipment.

Wiring diagrams for control and relay panels shall be drawn as if viewed from the back and it shall be clearly stated on each diagram. They shall show the terminal boards as arranged in service.

Bus wires shall be fully insulated, and shall be run separately along the top or bottom of the cubicle. Fuses and links shall be provided to enable all circuits in a cubicle, except the lighting and heating circuit, to be isolated from the bus wires.

Wherever practicable all circuits in which the voltage exceeds 125 volts shall be kept physically separated from the remaining wiring. The working voltage of each circuit shall be marked on the associated terminal boards. Except for the lighting and heating circuit the working pressure of a.c. circuits brought into relay or control cubicles shall not exceed 125 volts. Lighting and heating circuits in excess of 125 volts shall be fully shrouded throughout.

The d.c. trip and a.c. voltage supplies and the wiring to main protective gear shall be segregated from those for back-up protection and also from protective apparatus for special purposes. Each such group shall be fed through separate fuses direct from the main supply fuses or the bus wires. There shall not be more than one set of supplies to the apparatus comprising each group.

3 EXTERNAL WIRING

Any wiring liable to come in contact with oil shall have suitable oil-resisting insulation. The bared ends of stranded conductors shall be sweated together to prevent creepage of oil along the wire.

There shall be no possibility of oil entering connection boxes for cables or wiring.

Where the use of conduits is agreed the runs shall be laid with suitable falls and the lowest parts of the run shall be external to the kiosks or boxes. All conduit-runs shall be adequately drained and ventilated. Conduits shall not be run at or below ground level.

The external cabling on transformers and between transformers and marshalling kiosks shall be in accordance with Section F with a minimum cross-section of 2.5 mm². The wiring shall enter the bottom compartment of the kiosk through the gland plate in such a manner that the rear is kept clear for access.

4 TERMINAL BOARDS

Terminal boards shall have separate terminals for incoming and outgoing wires and shall be of the Klippon type or to the approval of the Engineer. Not more than two wires shall be connected to any one terminal. Insulating barriers shall be provided between adjacent pairs of terminals. The height of the barriers and the spacing of the terminals shall be such as to give adequate protection while allowing easy access to terminals.

All connections shall be made to the front of the terminal boards. Current shall not be carried through the boards by the studs, except in the case of oil tight terminations, e.g. for oil-immersed current transformers. No live metal shall be exposed at the back of the terminal boards.

Terminations shall be grouped according to function and labels shall be provided to show the group function.

Covers of insulating transparent material shall be provided on terminal boards on which connections for circuits with a voltage greater than 125 volts are terminated.

Rows of terminal boards shall be spaced not less than 100 mm apart. They shall be mounted vertically at the sides of the cubicle and set obliquely towards the rear doors to give easy access to terminations and to enable ferrule numbers to be read without difficulty.

The bottom of terminal boards shall be spaced at least 200 mm above the cable crutch of incoming multicore cables.

The use of terminal boards as junction points for wires which are not required in the associated cubicle shall be avoided.

Sufficient terminals shall be provided in each cubicle or box to terminate all multicore cable cores including spares.

Screw type terminals shall utilise a pressure plate arrangement, single point screw terminations will not be accepted. The size of screws for screw clamps is not restricted provided that the screws are captive, otherwise they shall comply with the requirements for bolt and stud terminals.

SECTION 14

**BATTERIES, CHARGERS AND D C
CONTROL
AND DISTRIBUTION EQUIPMENT**

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**SECTION 14
BATTERIES, CHARGERS AND D.C. CONTROL AND DISTRIBUTION
EQUIPMENT**

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SECTION 14
**BATTERIES, CHARGERS AND D.C. CONTROL AND DISTRIBUTION
EQUIPMENT**

1 SCOPE

D.C. batteries, chargers and distribution equipment for: -

Lead acid batteries rated at 110V, 48V or 24V d.c.

2 STANDARDS

The equipment shall be supplied in accordance with the Specification and IEC Standards.

3 DESIGN RESPONSIBILITIES

The Contractor is responsible for the calculation of battery and charger sizes, and also a complete load diagram for indicating the d.c. power consumption for the complete equipment (present and final stage) under normal and abnormal operating conditions. Each battery charger, voltage control unit and battery shall at least be capable of supplying the entire load of the d.c. main switchboards, in particular the following emergency loads simultaneously.

For the battery design, special reference is made to the tripping features of busbar protection, i.e., all circuit breaker trip coils shall be initiated at once,

- all protection relays,
- tripping of all feeders and subsequent restoration (auto re-closing),
- busbar change over for all feeder isolators,
- all indicators, alarms, etc.,

The d.c. load voltage shall not drop below 90 % of its nominal value after the battery has taken the full emergency load for 10 hours.

When float/trickle or boost charging, the voltage at the d.c. load shall not exceed 110 % of its nominal value.

The batteries shall be protected against over-discharging.

Earth fault detectors for each d.c. busbar shall be provided.

Outgoing a.c. feeders shall be protected by fuses or mcbs and the design shall include calculations to show correct discrimination of this protection.

Curves of battery current plotted against time shall be provided together with design calculations to show charger distribution equipment can withstand these conditions.

4 OPERATING TOLERANCES

The battery/charger/distribution equipment shall be designed such that the voltage at the equipment terminals is always within +10% to -15%.

Due account shall therefore be taken of volt drops in connecting cables between the distribution board and final equipment in order to establish the voltage tolerance allowable at the distribution board terminals.

The ripple content of the d.c. voltage shall not exceed 3.0% peak to peak with the battery disconnected:

5 BATTERY

5.1 Batteries

A battery shall be rated to give 100 % of the entire d.c. load on a ten hour discharge rate basis and under the site environmental conditions, plus a 30 % spare outlet capacity in order to cater for ageing of the battery.

Batteries shall be of the Lead Acid Plante type.

For Nickel Cadmium

End of discharge voltage	=	1.00 volts per cell
Float charge voltage	=	1.45 volts per cell
Boost charge voltage	=	1.60 volts per cell

The batteries shall be rated to give the required capacity under the specified site environmental conditions and of the category suitable for the specified period of discharge.

The cell containers shall be of robust, impact resistant construction in translucent material permitting visual inspection of electrolyte level with appropriate markings denoting minimum and maximum levels. They shall be mounted on appropriate PVC coated steel stands while ensuring that

- a minimum floor area is taken up and a ground clearance of 300 mm from the floor is provided
- each cell is readily accessible and can be removed from its position without having to remove or shift adjacent cells.
- the plated intercell connectors as well as the cell terminals are suitably insulated by LSF shrouds, sleeving or cover plates.

Further, the battery bank terminal cables shall be routed via a double pole wall mounted fuse-switch, and the fuse shall be selected so as to discriminate for a fault on the d.c. bus.

Battery cells shall be clearly identified by numbering.

5.2 Battery Fuses

The rating of the battery fuses shall be at least twice the rating of the largest d.c. fuse or miniature circuit breaker used in the distribution circuits and shall be so sized that they do not fail through fatigue brought on by normal charge/discharge conditions.

The battery shall be protected by fuses inserted in the connections between the chargers and load. The load side of the fuses shall act as the common connection point for the battery chargers and the feed to the d.c. distribution circuits via the output load regulator.

5.3 Battery Earthing

110 volt batteries shall operate with centre point earthed. Means shall be provided to detect low insulation resistance of all the wiring connected to the battery by the following method and to give an earth fault alarm. Separate alarm indications shall be given for both positive and negative poles.

The earth fault detection circuit shall consist in principle of a resistance connected across the battery output on the distribution side of the fuses with a relay connected between the centre point of this resistance and the earth terminal. Any unbalanced leakage current due to the low insulation resistance of the wiring connected to either pole of the battery shall cause a current to flow in the relay, which will operate at a predetermined value.

The earth fault relay shall be equipped with a minimum of three normally open contacts for local indication and remote alarm circuits.

5.4 Battery Accessories

Each battery shall be provided with the following appropriate accessories:-

- One - cell testing voltmeter equipment including voltmeter and thermometer.
- Two - syringe hydrometers, of suitable scale.
- One - plastic filler bottle of distilled water.
- One - cell bridging connector.

One - instruction card and record chart.

Spare electrolyte of normal gravity equal in volume to 10% of the electrolyte in the battery, but not less than 1 litre. This shall be delivered in unbreakable red containers with screwed stoppers and appropriately labelled.

6 BATTERY CHARGERS

The battery chargers shall be of the constant voltage float type each with boost charge facilities and able to boost charge when battery still connected to system. Each charger shall be capable of maintaining the battery fully charged when operating alone.

6.1 Chargers

The charger shall be housed in a separate cubicle. Cubicle sizes and overall views shall be co-ordinated with other cubicles, e.g. d.c. distribution panels being erected in the same room.

Chargers shall be of high efficiency, short control response time with low output ripple when the battery is not connected and rated for continuous output short circuit operation.

Chargers shall be of the thyristor controlled or high frequency switched mode design built-up in a modular fashion. No single module failure shall reduce the rated capacity to less than 100% of the entire station load.

The output voltage shall be closely regulated from low to rated load even with wide variations in input a.c. supply voltage and frequency.

Complete with: -

- (a) Set of a.c. input supply switches and fuses.
- (b) D.C. output voltmeter and ammeter.
- (c) Set of D.C. output switches and fuses.
- (d) Float/boost selector switches.
- (e) Charger fail relay to operate within 30 seconds of the charging current failure with contacts for the local indicating lamp remote and supervisory alarms.
- (f) Charger supply fail relay with contacts for local indicating lamps, remote and supervisory alarms.
- (g) State of charge of battery indicator.

- (h) Battery earth alarm.
- (j) Indication that a module is in service
- (k) Indication that a module is on boost charge
- (m) Indication that a module is faulty
- (n) Indication charger fuse failure/MCB trip
- (p) Indication charger output over-voltage
- (q) Test push button for checking all lamps/LEDs
- (r) Input and output protection and isolation mcb's for the modules and the charger as a whole.
- (s) AC input voltmeter

The charger shall provide the following functions: -

- adjust and set the charger output voltage and current limit values over the full operating range of the charger.
- automatically switch into the boost charging mode when the battery has discharged above a preset value. A battery charge/discharge ampere-hour sensing device shall be provided to control the boost mode on/off switching as well as the boost charging time.
- recharging within twelve hours the battery to a condition enabling the battery for another cycle of emergency discharge. Simultaneously, the charger shall be capable of feeding the rated load of the entire d.c. busbars.
- alarms grouped and connected to the alarm fascia locally and to the SER. Indication of the signal "Charger faulty" shall be suppressed in case of a failure of the a.c. supply to the charger.
- operating characteristic in accordance with DIN 41772/DIN 41773 or equivalent. However, the battery manufacturers recommendations for float/trickle, equalising and boost charging shall be taken into consideration.
- output voltage failure detection insensitive to switching surges or transient loss of voltage due to faults on the power system, or during auto-changeover of the input a.c. supply.
- load sharing and current limiting circuits built-in each module.
- soft start feature.

- a.c. input isolation by the use of a two winding transformer.
- housed in a separate cubicle.
- cubicle protection to be IP42 of IEC 529 as a minimum.
- RFI- Interference protection at least equal to mode "N" according to DIN VDE 0875.

Single or more groups of voltage dropping semiconductor diodes shall be inserted between charger/battery and the d.c. bus to keep the load voltage within operating limits during the different charging modes and for all load conditions. If the load voltage drops below a preset value, supervision relays shall initiate to by-pass the semiconductors and vice-versa. This VCU and its control circuits can be housed in the charger cubicle or separately in another. The diodes shall have a rating of at least twice the board's standing load.

Maintenance and operation instruction manuals and spare parts reference list shall be supplied.

Suitable alarm relays shall be provided to monitor at the distribution board both high and low battery voltages to pre-set values. The relays shall be fitted with variable time delays adjustable between 0-30 seconds. The relays shall indicate the fault condition locally and shall have two sets of voltage free contacts for remote indication.

7 D.C. DISTRIBUTION PANEL

The panels shall house all distribution circuits necessary for the station d.c. circuits; The equipment shall be capable of carrying, making and breaking the maximum possible fault current.

Twenty percent spare, fully equipped feeders shall be provided.

The d.c. distribution board shall be provided with the following instruments which shall be mounted near those provided for the chargers.

- (a) Output Voltage Voltmeter (0-120% max. rated output)
- (b) Battery Charge/Discharge Current Ammeter (0-200% normal standing load).
- (c) Distribution Board Load Ammeter (0-150% normal standing load).

Outgoing distribution cables shall be connected directly to the relevant fuse and link (or mcb).

Cabling and wiring terminations shall be shrouded to avoid accidental short circuit or earthing of the battery. LSF insulation shall be used for fuse wiring connections.

The d.c. system shall be fitted with monitoring devices to check the continuity of the battery circuit. In particular an alarm shall be provided if a battery fuse fails or if the battery circuit impedance rises above a predetermined level due to poor intercell connection or any other reason.

Monitoring devices shall be provided to detect voltage regulator failure, high d.c. voltage and low d.c. voltage conditions. These devices shall incorporate variable time delays adjustable between 0 and 30 seconds.

8 INSTRUMENTS, INDICATIONS AND ALARMS

8.1 General

All the instruments and indicators shall be visible from the front of the cubicle with the door closed and their functions clearly labelled with screw-on labels.

8.2 Annunciators

Alarms and indicators may be provided in the form of an annunciator panel. These shall include facilities for selecting manual/automatic acceptance of alarms and the overall scheme shall include facilities for relays to operate in contact follower mode such that in the event of the initiating relay resetting, the repeat relays in remote equipment shall also reset automatically. The annunciator front fascia shall match those employed on other equipment panels in the same station.

8.3 Alarms and Indications

Each charger shall have facilities to provide or display locally the following alarms and indications.

Alarms	Mains failure	Charger Output failure
Indications	Main ON Rectifier ON	Float Charge Boost Charge

The battery/distribution system shall have facilities to provide and indicate locally the following alarm indications.

Battery fuse failure
Diode assembly failure
Battery circuit faulty
Low D.C. volts
High D.C. volts
Earth fault +ve
Earth fault -ve

Contacts shall be commoned so as to provide 2 separate remote alarm indications of "Battery Faulty".

9 CUBICLES

Cubicles shall be segregated into compartments by sheet steel separators to a protection class of class IP42 to IEC 529.

Individual cubicles shall have a hinged front cover with locking facilities, giving full access to all components and cable connections. Lockable access doors shall be provided for each compartment. All controls and relays shall be placed inside the cubicles. Where ventilation openings are provided these shall be fitted with drip-proof louvres and fine mesh wire or perforated screens to exclude small insects and vermin. Each cubicle/compartment shall be adequately ventilated for continuous operation at site.

All incoming and outgoing cables shall be bottom entry. A gland plate shall be mounted not less than 200 mm from the base of the cubicle.

Where all the battery, charger and distribution equipment is housed in a common cubicle particular attention shall be made with regard to the routing of cables from the base of the cubicle to the respective compartments taking account of ease of installation, segregation from the battery compartment etc.

The complete battery, charger and distribution units shall be designed to enable a complete charger to be removed and replaced with ease and without disturbance to the remainder of the equipment and wiring. Facilities shall be provided for testing batteries and chargers without load disconnection.

All meters and indication lamps shall be flush mounted on the front of the cubicle and their function clearly indicated with screw-on labels.

10 SHIPPING AND SITE ASSEMBLY

The batteries shall be shipped dry and assembled on Site, filled with electrolyte and the initial charge made.

11 BATTERIES AND CHARGERS

Batteries and chargers shall be tested in accordance with the relevant IEC Standard.

11.1 Routine Tests

The normal low-rate (float) charge voltage shall be set in the works at the specified voltage per cell when delivering 50% of rated load. At this setting it shall be demonstrated that the charger can maintain output voltage within the prescribed limits under the specified variations of input voltage and frequency and output load current.

The operation of the boost charge facility shall also be demonstrated. The correct functioning of all control indication and alarm devices shall be verified.

All secondary wiring shall be submitted to a high voltage test of 2 kV a.c. for 1 minute.

Where load voltage limiting regulators/diodes are to be connected it shall be demonstrated and recorded that the load voltage is maintained within -15% to +10% of rated voltage for all stages of battery charging conditions.

11.2 Type Tests

One or more cells, as may be agreed, of each battery type shall be submitted to a suitable discharge test in order to verify the guaranteed capacity. Continuous measurements of battery voltage shall be made together with periodic readings of the electrolytes specific gravity and temperature.

No addition to the electrolyte is permitted during this discharge test.

11.3 Site Tests

Batteries shall be set to work strictly in accordance within the manufacturers recommendation.

SECTION 15

MOTORS

SECTION 15
MOTORS

1 TYPE AND PERFORMANCE..... 1

2 CONSTRUCTION 1

3 PROTECTION 2

SECTION 15 MOTORS

1 TYPE AND PERFORMANCE

A.C. motors shall be of the squirrel cage class F insulated, of drip-proof type construction except in situations exposed to the weather, in which case they shall be of the weatherproof totally- enclosed, or totally-enclosed fan-cooled type. They shall be suitable for direct on-line starting at full voltage. Three-phase motors of IEC rating, 7.5 kW or more shall not, without special approval, have starting currents exceeding 6 times the full load current based on its IEC rating.

The motors shall operate at all loads without undue vibration and with the least practicable amount of noise.

Motors upon which the primary equipment depends for its continued operation at full load shall also be capable of continuous operation at 85% of the nominal voltage at normal frequency without injurious over-heating.

2 CONSTRUCTION

The stator windings shall be adequately braced and suitably impregnated to render them non-hygroscopic and oil resistant. Weatherproof motors shall be provided with suitable means of breathing and of drainage to prevent any accumulation of water.

Motors of the vertical spindle type shall be provided with a canopy of approved design.

Motor terminals shall be of the stud type, totally enclosed and accessible. Rubber insulation shall not be used for connections from the windings to the terminals.

Each motor shall be fitted with a totally enclosed dust proof terminal box either suitable for screwed conduit entry or provided with a cable box as necessary. For motors above 1 kW the terminal box shall be sealed from the internal air circuit of the motor. All joints shall be flanged with gaskets of neoprene or similar material.

If a cable box is provided it shall be provided with all necessary fittings, including a filling plug, an air vent hole, an expansion dome, glands and, for wire armoured cable, a combined armour and earthing clamp. The gland plate shall not be split and a removable front cover shall be provided.

All motors situated outdoors shall be provided with a suitable degree of protection to suit the duty.

Motors shall be provided with a 9 mm diameter earthing stud and lock nuts. The material surrounding the stud shall have a flat surface for an area of 30mm

diameter. For motors below 1 kW a 6 mm diameter earthing stud may be fitted. Holding down bolts shall not be used for earthing purposes.

3 PROTECTION

The following protection shall be provided: -

- (a) Motors up to 1 kW - fuses or magnetic overload.
- (b) Motors 1-30 kW - fuses overcurrent relay and thermal overload operated by thermistor in stator winding.
- (c) Motors 30 kW and above, - fuses or miniature circuit-breakers plus earth fault, thermal overload and single phasing protection.

MOTOR STARTER UNITS

Each motor circuit below 30 kW shall be controlled by a direct-on-line contactor starter and shall be provided with a contactor, isolator, set of HRC fuses and overload device, or a moulded case circuit-breaker, to form a contactor starter unit. The contactor shall be the normal means of stopping and starting the motor. Each unit shall be contained in an individual compartment having a front access door.

Starters shall, in addition to complying with this Specification, comply with IEC 60947 and shall be capable of dealing with normal service and fault conditions. The starter units shall be of the air-insulated, metal-clad type and be designed to ensure safety of operating personnel, formed where appropriate into metal-clad tiered panels.

Multi-tiered starters for use on AC shall preferably be of the horizontal drawout type having automatic shutters. Starters of fixed or semi-drawout pattern having adequate and safe access for maintenance may be offered for consideration.

Interlocks shall be provided to ensure that the unit access door can only be opened when the associated starter is open and that it cannot be closed in the service position until the access door is closed.

The operating characteristics of the protective device and the overload device shall ensure that the protective device always operates before the overload relay at all values of current in excess of the contactor's maximum breaking capacity. Curves showing evidence of this shall be provided by the Contractor for each type of starter. Test evidence proving the maximum breaking capacity assigned to each size of contactor shall also be provided.

Where starters are specified for operation with an ac. closing supply the scheme for deriving such supply shall be approved.

The contactor starter shall be provided, unless otherwise specified or approved, with the following components: -

- Air-break contactor
- Overload protection
- Single-phasing protection
- Time delay relays
- Start, stop, reset push buttons
- Remote/Local changeover switch (where applicable)
- Ammeter

Colour indicating lights, pushbuttons, annunciators and digital readouts shall comply with IEC 60073.

The contactor shall comply with the requirements of Section 20 of this Specification.

SECTION 16

**AUXILLARY SWITCHGEAR
AND CONTROL GEAR**

SECTION 16

AUXILLARY SWITCHGEAR AND CONTROL GEAR

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SECTION 16
AUXILIARY SWITCHGEAR AND CONTROL GEAR

1 MAIN A.C. SUPPLIES

The substation may be provided with either one or two auxiliary supplies as required by the Specification and indicated on the drawings forming part of this document.

2 TYPE OF SWITCH AND CONTROL GEAR

The equipment shall be of air insulated, metal-enclosed type formed into complete switchboards which may be multi-tier design subject to the approval of the Engineer.

3 GENERAL CONSTRUCTION

The switchboards shall be built up of circuit-breaker units, isolating fuse-switches, isolators, contactors, moulded case and miniature circuit-breakers. All units, when built up into a complete switchboard, shall be such that the completed switchboard is of flush-fronted design having a neat and clean appearance and be readily extensible.

All components shall be accessibly mounted in the switchboard and shall not impede access to wiring or terminals. All faults occurring within any individual unit shall be contained within that unit and except for busbar faults shall not cause shut-down of any section of board other than the unit itself. All equipment shall be constructed of non-hygroscopic and non-flammable material. Insulating barriers and bus supports shall be of an approved material. The design shall cater for the interconnection of busbars, both primary and secondary, between adjacent units. The apertures for secondary bus wires between adjacent units and for secondary wiring in individual units shall be 'bushed' to prevent damage to wires on sharp edges of metal.

The construction shall be robust and be designed to prevent the spreading of damage due to fire, short-circuits or other causes.

The switchboards shall be designed to prevent accidental contact with live parts.

4 PRIMARY BUSBARS AND CONNECTIONS

Primary busbars shall be contained in a separate compartment within the switchboard and access shall be possible only by means of bolted-on sheet steel covers which shall clearly be marked "Busbars". Busbars and busbar connections shall not be exposed when covers and doors are opened for access to the remainder of the switchgear.

Primary busbars and connections between the several pieces of apparatus forming the equipment of a cubicle shall be of electrolytic copper.

Each phase conductor, and both positive and negative conductors of d.c. boards, shall in addition to being spaced to give the necessary air clearance for the rated voltage include secondary insulation in the form of PVC sleeving or other approved continuous coating to the maximum extent practicable.

The complete equipment shall be capable of carrying its rated short time current of value and duration as specified in this document under the heading 'Design Criteria' and as may be limited by the cut-off characteristic of the largest fuse-link that may be associated with that part of the equipment.

The busbars and connections in individual circuits shall also be capable of carrying continuously the rated current assigned without damage or overheating of any part. On determining the load current performance of tiered switchboards it shall be assumed that all circuits are carrying their rated current at site ambient temperature.

At all points where connections or joints occur, the busbars and connecting pieces shall be tinned or silver-plated. The resistance of any length of conductor containing a joint shall not be greater than that of an equal length without a joint.

Primary busbars and connections shall be clearly marked and shall be displaced for standard phase sequence Red (R), Yellow (Y), and Blue (B), from front to rear, top to bottom or left to right as viewed from the switching device operating mechanism side. The neutral bar shall be consistently disposed throughout the system. Busbars shall be readily accessible for extension.

5 AIR CIRCUIT-BREAKERS

Primary circuit-breaker units shall be of the metal-enclosed, horizontal draw out air-break type and shall comply with IEC 60947 except where modified by this Specification.

The moving portion of each a.c. circuit-breaker unit shall consist of a four-pole circuit-breaker with operating mechanism, primary and secondary disconnecting devices, auxiliary switches, position indicators and the necessary control wiring all mounted on a substantial steel framework. This framework and all metal parts of the moving portion, apart from current carrying parts, shall be solidly earthed via the fixed portion at the instant of inserting the moving portion into the fixed portion. The earthing of the moving portion shall be approved.

If in the Manufacturer's standard arrangement a special truck is necessary for insertion and removal of a circuit-breaker from the fixed housing portion then three trucks of each type shall be provided. Means of registration shall be provided so that circuit-breakers may be readily placed and secured in the correct position in the fixed portion.

Circuit-breakers of the same current and voltage rating shall be fully interchangeable one with another. Suitable means shall be provided to prevent circuit-breakers from being placed into fixed housings of different ratings. This device shall also prevent damage to isolating and other contacts.

Provision shall be made for temporarily completing the auxiliary circuits when the circuit-breaker is isolated, to enable the function of the circuit-breaker to be tested. The use of an integral device for this latter facility is preferred to an arrangement employing detachable connections.

The fixed and moving contact systems shall comprise both main and arcing contacts, all parts of which shall be easily dismantled and replaced.

Air-break circuit-breakers shall be provided with an arc control device for each one pole set of fixed and moving contacts with an arc shield between poles. The devices shall be convenient for handling and manufactured from suitable material. The material shall be such that arc erosion during operation of the circuit-breaker shall be negligible. If necessary, approved auxiliary devices may be used to reduce arcing times at low values of breaking current. Arc control devices shall be so situated that any emission shall not cause breakdown or damage to insulation.

5.1 Operating Mechanisms

The circuit-breaker mechanism shall be either motor wound spring, solenoid operated or spring assisted manual closing. The circuit-breaker shall be capable of closing fully and latching against its rated making current.

Spring operated mechanisms shall have the following additional measures: -

- (a) If the circuit-breaker is open and the springs charged the circuit-breaker can be closed and then tripped.
- (b) If the circuit-breaker is closed and the springs charged the circuit-breaker can be opened, closed and then tripped.
- (c) Mechanical indication and an auxiliary switch for remote electrical indication shall be provided to indicate the state of the spring.
- (d) Motor charged mechanisms shall be provided with means for charging the springs by hand and also a shrouded pushbutton for releasing the springs. An electrical release coil shall also be provided.
- (e) Under normal operation, motor recharging of the operating spring shall commence immediately and automatically upon the completion of each circuit-breaker closing operation. The time required for spring recharging shall not exceed 30 seconds.

- (f) It shall not be possible to close a circuit-breaker, fitted with a motor charged closing mechanism, whilst the spring is being fully charged. It shall be necessary for the spring to be fully charged and the associated charging mechanism fully prepared for closing before it can be released to close the circuit-breaker.

All circuit-breaker operating mechanisms shall be fitted with an electrical shunt trip release coil and in addition a mechanical hand tripping device.

The electrical tripping and closing devices shall be suitable for operation from a power supply as stated in this Specification and shall operate satisfactorily, over the ambient temperature range when the voltage at their terminals is any value within the voltage range of 85% to 110% of nominal voltage, except the shunt trip release coil shall operate between 70% to 110% of nominal voltage and in addition over the range of all operating conditions of the batteries and chargers supplied under this contract.

All operating coils for use on the d.c. supply shall be connected so that failure of insulation to earth does not cause the coil to become energised.

Tripping and closing circuits shall be provided with a fuse in each pole on each unit and shall be independent of each other and all other circuits.

Approved, positively driven mechanically operated indicating devices shall be provided to indicate whether a circuit-breaker is in the open, closed, service, isolated or earthed position.

Facilities shall be provided for manually charging the springs in case of closing supply failure. Manual operation of circuit-breakers for maintenance purposes shall be provided.

The locking facilities with padlocks shall be provided so that the circuit-breaker can be prevented from being closed when it is open and from being manually tripped when it is closed. These facilities shall not require the fitting of any loose components prior to the insertion of the single padlock required. It shall not be possible, without the aid of tools, to gain access to the tripping toggle or any part of the mechanism which would permit defeat of the locking of the manual trip. It shall not be possible to lock mechanically the trip mechanism so as to render inoperative the electrical tripping.

5.2 Isolating Devices and Shutters

All circuit-breakers shall be connected to their associated busbars and cables through isolating devices of the off-load type but suitable for operation whilst the busbar or feeder circuits are live.

The design shall be such that it is impossible for the isolating devices to be opened by forces due to current in the primary circuit and shall be interlocked with the circuit-breaker so that it is impossible to make or break current with the isolating device. Attempted isolation shall not trip the circuit-breaker.

When isolation is effected by withdrawal of the circuit-breaker provision will be made for positively locating the circuit-breaker in the service, isolated and earthing positions. Stops shall be provided to prevent over-travel and each position shall be clearly indicated.

A mechanical selector mechanism shall be utilised such that when a particular position is selected it is impossible to locate the circuit-breaker in any other position.

Isolating devices shall incorporate self-aligning contacts, the fixed contacts of which shall be such that access can readily be obtained for maintenance purposes.

Metal shutters shall be provided to completely shroud fixed isolating contacts of the circuit-breaker busbar and feeder circuits. These shutters shall be opened and closed automatically by the movement of the circuit-breaker carriage and shall prevent access to fixed isolating contacts when the circuit-breaker is withdrawn.

The shutters for fixed isolating contacts connected to busbars and cables shall have independent operating mechanisms. All shutters shall have permanent labels indicating whether they are busbar or feeder shutters. Facilities shall be provided for padlocking shutters in the closed position.

Self-aligning plug and socket isolating devices of an approved design shall be provided for all auxiliary circuits. The position of these devices shall be such that individual circuits on different units are in the same relative physical positions.

5.3 Interlocking Gear

Interlocking shall be of the mechanical or key operated type and shall be provided to prevent the following operations: -

- (a) A moving portion from being withdrawn from or inserted into the isolating contacts when the circuit-breaker is closed. Attempted isolation shall not trip a closed circuit-breaker.
- (b) The closing of the circuit-breaker unless the movable portion is correctly plugged in or isolated from the equipment.
- (c) The circuit-breaker being closed in the "service" or "earth" location without completing the appropriate auxiliary circuits.

- (d) To apply an earth to busbars until circuit-breakers which can feed the busbars are locked open.

When key interlocking is employed, any attempt to remove the trapped key shall not cause closing or opening of the associated equipment.

Where a circuit-breaker or other switchgear is fitted with means for mechanical and electrical operation, interlocks shall be provided so that it is impossible for the electrical and mechanical devices to operate simultaneously.

The earthing devices shall be provided with interlocks to ensure correct operation in conjunction with the associated circuit-breaker.

In the case of circuit-breaker earthing the electrical tripping of the circuit-breaker shall be rendered inoperative during earthing operations both when closing and when closed in the earth position. It shall not be possible to return to the service position and close the circuit-breaker until the electrical tripping is again operative.

6 MOTOR STARTER UNITS

Each motor circuit below 30 kW shall be controlled by a direct-on-line contactor starter and shall be provided with a contactor, isolator, set of HBC fuses and overload device, or a moulded case circuit-breaker (MCCB), to form a contactor starter unit. The contactor shall be the normal means of stopping and starting the motor. Each unit shall be contained in an individual compartment having a front access door.

The starters, in addition to complying with this Specification shall comply with IEC 60947 as appropriate and shall be capable of dealing with normal and fault conditions.

The starter units shall be of the air-insulated, metal-clad type and be designed to ensure safety of operating personnel.

The contactor starter units shall be formed where appropriate into metal-clad tiered panels. Starters and their component devices shall comply with IEC 292 except as modified or extended by this Specification.

Multi-tiered starters for use on a.c. shall preferably be of the horizontal drawout type having automatic shutters. Starters of fixed or semi-drawout pattern having adequate and safe access for maintenance may be offered for consideration.

Interlocks shall be provided to ensure that the unit access door can only be opened when the associated starter is open and that it cannot be closed in the service position until the access door is closed.

The operating characteristics of the protective device and the overload device shall ensure that the protective device always operates before the overload relay at all values of current in excess of the contactor's maximum breaking capacity. Curves showing evidence of this shall be provided by the Contractor for each type of starter. Test evidence proving the maximum breaking capacity assigned to each size of contactor shall also be provided.

Colour of indicating lights, pushbuttons, annunciators and digital readouts shall comply with ICE 73: 1984 or BS 4099: Part 1: 1986.

Where starters are specified for operation with an a.c. closing supply the scheme for deriving such supply shall be approved.

7 CONTACTORS

Contactors shall be of the air-break form and unless otherwise specified shall be of the mechanical latch-in type for essential supplies and electrical hold-in type for general purpose auxiliaries.

Contactors shall comply with their rated duty, utilisation category and mechanical endurance class. In addition, contactors shall be capable of making and carrying current equivalent to the specified fault capacity as limited in magnitude and duration by the cut-off characteristic of the associated fuse-links without damage.

The contactors shall be capable of the following duties: -

- (a) Making and breaking to Category AC3 for a.c. contactors and DC3 for d.c. contactors as specified in IEC 60947.
- (b) All contactors shall be capable of intermittent duty Class 1. In addition rocker type contactors shall be capable of a mechanical life duty of 500,000 load operations and block type contactors 1,000,000 load operations.
- (c) Carrying the stalled rotor current of the associated motor for a period of 60 seconds with the associated fuses or MCCB replaced by copper links of negligible impedance. At the conclusion of this duty, the performance of contactor shall not have been impaired.

Auxiliary contacts for remote interlocking and indication shall be fitted to each individual contactor. The switchboard indication of operation of the contactor may be of the electrically indicating type but mechanical indicators shall be provided on the contactor.

8 ISOLATING SWITCHES

Each contactor shall be fitted with an isolating switch for two duties, namely: -

- (a) to isolate the contactor or starter from the busbar to permit maintenance. It shall not be possible to gain access to fuses unless the isolating switch is open.
- (b) on motor isolation duty in the case of stalled rotor current switching for motor starters. For this duty isolating switches shall have a breaking capacity not less than that of the contactor with which it is associated.

The switch shall be capable of making the system prospective symmetrical fault power fault when limited in magnitude and duration by the cut off characteristic of the largest HBC fuse that may be fitted to that unit. Starter isolating switches shall be capable, with the fuse replaced with a copper link of negligible impedance, of carrying for a period of 60 seconds and breaking the stalled motor current of the associated motor. If the starter is withdrawable it shall be interlocked to ensure that the additional off-load isolating contacts do not make or break current.

Where applicable, the rating of the fuse or MCCB shall be such that its operating characteristic is co-ordinated with the characteristic of the contactor and overload device as specified for Contactor Starter Units.

Interlocks shall be provided to prevent the following operations: -

- (a) The contactor being withdrawn from or inserted into the primary isolating contacts when the contactor is closed. Attempted removal shall not trip a closed contactor.
- (b) The closing of the contactor unless it is correctly located in the service, isolated or test positions.
- (c) The contactor being closed in the service position without completing the auxiliary circuits.

Main circuit fuses shall also be connected to the busbars through isolating devices of an approved design. This requirement shall preferably be met by employing integral fuse-switch units. Access to live terminals shall be prevented when fuses are removed.

When specified in Schedule 'G', the connections to feeders or other apparatus shall also be made through approved isolating devices. Such isolating switches or devices shall be of the load breaking type unless interlocked to ensure against their making or breaking current.

9 FUSES AND FUSE-SWITCH UNITS

Units shall be of the air break, air insulated, metal-clad type and be designed to ensure safety to operating personnel. The fixed contacts shall be shrouded so that maintenance of the units can be carried out in safety with the busbars live. Switch

mechanisms shall be spring assisted to ensure a definite and high speed opening and closing action which cannot be interrupted once it has been initiated.

The units shall preferably comprise fuse-switches having integral fuses, but manufacturers may offer the alternative of switch fuses in which the air-break switch and connections from it to the associated fuse shall be designed to minimise the possibility of a phase-to-phase short-circuit. In either case the switch shall be capable of breaking 3 times the normal rated current at 0.3 power factor and 110% rated voltage and making and carrying the system prospective symmetrical fault current as limited in magnitude and duration by the cut-off characteristic of the largest HBC fuse which may be fitted to that unit.

The isolating feature of the fuse-switch unit shall be arranged to ensure that the unit access door can only be opened when the associated switch is open and the switch cannot be closed until the access door is closed.

Fuses of the HBC type shall be provided and be such that the fuse carrier is easily withdrawable for replacement of the fuse. All fuses shall be fitted with a device to indicate operation of the fuse.

All fuse links supplied shall be in accordance with IEC Publication 269 for industrial application and shall comply in every respect with this standard. Type Test Certificates giving time/current characteristics of all fuse links shall be provided.

The current rating of fuses shall be of sufficient capacity to afford close short-circuit protection for the specified loads whilst remaining inoperative for such transient currents that may occur in the circuit. The rating shall be such that the characteristic of the fuse matches the characteristic of the contactor thermal device as specified above.

Motor circuit fuses shall accommodate the starting i^2t and duty of the motors to which they are connected.

10 ISOLATORS

Isolator units shall be capable of dealing with normal operating and through fault conditions.

The isolator units shall be of the air-insulated air-break, metal-enclosed type and be designed to ensure safety of operating personnel. The isolators shall be of the double-break, off-load type with the fixed contacts shrouded so that maintenance of the unit can be carried out in safety with either the busbars or the incoming circuit live. They shall be of the three or four-pole type as appropriate. When four-pole isolators are specified in Schedule 'G', all four poles shall be coupled to, and operated by one operating mechanism, bolted type links will not be acceptable for this duty.

The isolators are generally for busbar isolation purposes on the secondary side of transformers or as one end of a tie-feeder. In either case the remote end, primary side of transformer or remote end of tie-feeder, is controlled by a circuit-breaker or fuse-switch and a key interlock shall be provided on the isolator interlocked with remote end switching device so as to prevent operation of isolator unless the remote end switching device is open.

When the isolator is fed from a circuit-breaker it shall be capable of carrying the system prospective symmetrical fault power for a period of 1 second. If fed from a fuse-switch it shall be capable of carrying the system prospective symmetrical fault power but limited in magnitude and duration by the cut-off characteristic of the largest HBC fuse that may be fitted to the fuse-switch unit.

Interlocks shall be provided to ensure that the unit access door can only be opened when the associated isolator is open and the switch cannot be closed until the access door is closed.

11 DISTRIBUTION PANELS

Distribution panels shall be provided as required and shall be of the metal-enclosed, wall-mounting type. They shall be provided with top and bottom removable gland plates which shall be drilled to suit the cables and cable glands.

All distribution panels shall be fitted with miniature circuit-breakers having thermal-magnetic overload short-circuit protection. The characteristics of the protective devices and associated HBC fuse feeding the distribution panel shall be such that for all currents in excess of the maximum capability of the miniature circuit-breaker, a time of not less than 0.01 seconds shall exist between the maximum fusing time of the HBC fuses and the minimum time of operation of the miniature circuit-breakers on that particular value of current.

Characteristics illustrating this shall be provided.

When in the Specification a panel is called for as being three-pole it shall be understood that the miniature circuit-breakers mounted in that panel shall be of the three-pole type. The operation of the protective device in any one phase shall cause opening of all three-phases.

Distribution panels shall be fitted with an integral incoming isolator.

When three-phase and neutral panels are called for the panel shall be fitted with a neutral busbar having facilities for terminating as many neutral cables as single phase ways in the panel.

Each distribution panel shall be fitted with an earth stud located in an accessible position on the outside of the board. All metal parts of the panel except current carrying parts shall be bonded together electrically and to the earth busbar.

Where PVC conduit or any other system involving individual circuit earths is adopted the distribution panel shall be fitted with an earth busbar having facilities for terminating all circuit earth wires separately.

Each distribution panel shall be fitted with phase barriers of an oil and fire resistant insulating material, fitted in such a manner that it is not readily possible for personnel to touch the phase busbars. Insulating barriers shall be fitted around the circuit-breakers such that only the surface and mechanism toggle of the circuit-breakers are available on the front.

Each distribution panel shall be fitted with a card index of circuits on the inside of the front cover.

12 MOULDED CASE AND MINIATURE CIRCUIT-BREAKERS

Circuit-breakers shall be manually operated with trip-free operating mechanism of the quick-make quick-break type with de-ionizing type arc shutes and fitted with adjustable thermal releases and instantaneous magnetic release.

Multipole circuit-breakers shall be contained within a common moulded case of high mechanical strength and dust-proof. All poles of such circuit-breakers shall be operated simultaneously by a common operating lever. Clear indication shall be given on each circuit-breaker to show whether it is in the closed, open or tripped condition and also each circuit-breaker shall be provided with one set of alarm contacts for remote signalling. These contacts shall close in the event of an automatic trip.

Circuit-breakers shall be suitable for use on a.c. or d.c. systems up to the maximum fault current levels available on the system.

Attention is drawn to the relationship between the overcurrent characteristics of the circuit-breaker and any preceding high breaking capacity fuse which is providing short-circuit back-up protection. The characteristic of the circuit-breaker and that of the fuse shall be so related that the maximum fusing time of the fuse shall be at least 0.01 seconds less than the minimum operating time of the circuit-breaker for currents in excess of the maximum breaking capacity of the circuit-breaker.

13 LOCKING FACILITIES

In addition to any requirements already specified the following padlocking facilities shall also be included:-

- (a) Selector mechanisms on circuit-breaker - isolated and service positions

- (b) Safety shutters on primary contact isolating orifices in closed position.

All cubicle access doors, other than those which are interlocked with a switching device shall be provided with an integral type locking facility.

14 EQUIPMENT EARTHING

All metal parts other than those forming part of an electrical circuit shall be connected in an approved manner to a hard drawn, high conductivity copper earth busbar which shall run the full length, and be bolted to the main frame, of the switchboard. At the position where joints occur, the earth busbar shall be tinned. The earth busbar shall be rated to carry currents equal to magnitude and duration to that associated with the short-circuit rating of the equipment.

The design and construction of the equipment shall be such that all metal parts, other than current carrying parts, of withdrawal equipment are earthed before the primary connections are made.

Metal case supports and bases of all instruments, relays or other associated components mounted on the switchgear shall be connected to the earthed busbar by conductors of not less than 2.5 mm^2 cross-sectional area.

When components are provided for mounting separately, each shall be provided with an earthing terminal not less than 30 mm^2 cross-sectional area.

15 CIRCUIT AND BUSBAR EARTHING FACILITIES

Facilities shall be provided on all circuit-breaker units for earthing the circuit. The facilities shall be by means of an incorporated switch, which must have a proven fault making capability equivalent to the rating of the switchgear.

Busbar earthing facilities are also to be provided on selected circuits of each section of the switchboard. The circuits used for busbar earthing are to be agreed.

Where earthing is effected through the circuit-breaker it is required that the facilities shall be integral in the design and construction of the switchgear and that the devices for circuit earthing be provided for each circuit. No form of earthing will be accepted which employs the use of separate attachments or requires manual adjustment.

Labelling shall be provided to show whether the equipment is prepared for "SERVICE". Such indication shall be visible from the front of the equipment at all times.

In addition to the main provision for earthing, the design of the unit shall be such that a temporary earth can be applied to each equipment for the purpose of permitting work on the unit (e.g. for cleaning of insulators, or to release a circuit-breaker for maintenance) after earthing the circuit with the prescribed fault making

earthing device. Such temporary earths shall be capable of being applied to each of the phases separately.

16 TESTING FACILITIES

All circuit-breaker units shall be provided with facilities to enable applied high voltage tests to be carried out.

Provision shall also be made for temporarily completing the auxiliary circuits when a circuit-breaker or contactor is isolated and withdrawn, to enable the functioning of the unit to be tested.

When current transformers and protective relays are fitted facilities shall be provided for primary and secondary injection tests to be carried out. These facilities shall be such that wires and connections need not be disconnected for the tests to be carried out.

17 ANTI-CONDENSATION HEATERS

Anti-condensation heaters of an approved type shall be provided inside each cubicle. They shall be shrouded and located so as not to cause injury to personnel or damage to equipment. The heaters shall be thermostatically controlled and shall be arranged to cut off when the local ambient room temperature exceeds between 30-35°C. A master heater circuit switch shall be provided on the switchboard or panel with an indicating lamp to show whether the supply is on or off. The location of the heater circuit switch and indicating lamp shall be either on a common panel or in such a location that it does not require moving when extensions are provided. The heaters shall operate from a single phase a.c. supply.

18 HEAVY DUTY SOCKETS

Where specified heavy duty sockets shall be provided and shall be four-pole interlocked, fuse-switched socket outlets. They shall be metal-enclosed and watertight to IP55 level and shall be suitable for welding, oil filtration and portable pumping equipment. Outlets shall be located adjacent to storage tanks, transformer bays and wherever portable equipment may be required.

The sockets shall be wall or kiosk mounted with bolted on front cover and removable gland plates.

The complete switched socket outlet shall be interlocked to prevent: -

- (a) Operation of the switch if the plug is not plugged in and screwed home.
- (b) Removal of the front cover when the plug is plugged in and screwed home.
- (c) Withdrawal of the plug when the switch is in the 'on' position.

Each socket outlet shall be provided complete with three HBC fuses and plug which shall be glanded to receive a flexible cable.

The terminations, both incoming and outgoing, shall be of the crimped or compressive type. Pinching screws or soldered lugs will not be acceptable.

Each socket shall be fitted with an earth stud located in an accessible position on the outside of the body. All metal parts of the socket, except current carrying parts, shall be bonded together electrically and to the earth stud.

SECTION 17

**LIGHTING AND LOW
VOLTAGE POWER SERVICES**

SECTION 17
LIGHTING AND LOW VOLTAGE POWER SERVICES

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SECTION 17
LIGHTING & LOW VOLTAGE POWER SERVICES

1 SYSTEM OF INSTALLATION

All fuse switchgear, distribution panels, circuit-breakers, fuses, contactors, cables and earthing systems, provided for these services shall be consistent with the design and manufacture of similar equipment detailed under relevant clauses in this Specification.

The supply of these services shall be distributed through distribution boards fitted with HBC fuses or miniature circuit-breakers. All distribution boards shall have spare circuit and in addition shall have spare ways and due allowance made for extension facilities indicated.

System wiring shall generally be PVC insulated with copper conductors in continuous conduit.

Security and roadway lighting cables shall be copper conductors PVC insulated, PVC sheathed, steel wire armoured and PVC sheathed overall.

2 CONDUIT

The whole of the various installations described shall be carried out in screwed heavy gauge welded steel conduit or heavy gauge PVC conduit. No conduit less than 20 mm diameter will be permitted.

Conduit runs shall, wherever possible, be concealed in ceilings, voids and walls, chases etc., and in rooms of secondary importance (with back outlet entries to switch boxes etc. especially on fair faced brickwork) otherwise the conduits shall be securely fixed to the surface of walls using heavy cast distance saddles. Where plastered finishes are called for, buried conduit systems shall be provided.

Where the system of wiring is concealed, the 'looping-in' system of conduit shall be used and the 'looping-in' boxes shall conform to BSS31, Class B3.

All steel conduit and accessories shall be heavily galvanised.

A separate insulated earth conductor, coloured green, shall be run in PVC conduits and earth facilities shall be provided at all terminal points.

Wherever the installation is specified as being flame-proof, conduit runs entering these areas shall have a barrier box inserted in the run immediately before the conduit passes into the flame-proof area. All conduit work inside the flame-proof area shall be carried out with solid drawn galvanised conduit and all conduit fittings, sockets and accessories shall be galvanised and certified suitable for Group 1 hazard. At the completion of the wiring all machine faces on accessories shall be

thoroughly cleaned and greased, prior to the screwing or bolting of all accessory cover plates into their final flame-proof secured position.

The ends of all steel conduits shall be reamed to remove all burrs or sharp edges after the screw threads have been cut. All dirt, paint or oil on the screw threads, the conduit, sockets and accessories must be removed prior to erection. All conduits shall be swabbed through prior to installation of cables.

The ends of the conduit shall butt solidly in all couplings. Where they terminate in fuse-switches distribution boards, adaptable boxes, non-spouted switch boxes, they shall be connected thereto by means of smooth bore male brass bushes, compression washers and sockets. All exposed threads and all bends shall be painted with an aluminium spirit paint after erection.

All conduit and accessories, after being installed, shall be examined and all parts where the surface has been chipped or scratched shall be painted.

All conduits shall be kept 80 mm clear of water, gas and other services. Should this prove impracticable, then they shall be properly bonded by means of pipe clamps or other device ensuring mechanically sound, electrically continuous connection.

The method of installing PVC conduit and fittings shall conform strictly to the Manufacturer's recommendations. These recommendations shall be submitted when seeking approval to the system proposed. In general the clauses dealing with steel conduit shall apply.

PVC tube not exceeding 25 mm in diameter shall be bent cold by means of the appropriate spring and the tube shall be saddled as quickly as possible after bending. When bending larger sizes of tube, the tube must be heated in an approved manner until it is pliable. A 90° bend shall have a radius of not less than five times the outside diameter of the tube.

Joints between conduits and conduit fittings shall be watertight and shall be made by means of a solvent adhesive as recommended by the Manufacturer. Care should be taken to ensure that the tube is clean and free from damp and grease and in particular dust, mould and oil.

The Contractor shall provide PVC tube ends and flexible covers to prevent ingress of concrete grout into the tubing and boxes.

All bends are to be made on Site to suit conditions and not more than two right angle bends will be permitted without the interposition of a draw box. No tees, elbows, sleeves, either of inspection or solid type will be permitted. Generally long straight conduit runs from point to point shall have draw boxes installed at maximum intervals of 10 metres.

Deep boxes or extension rings on standard circular conduit boxes shall be used where necessary in order to bring the front of each box flush with the surface of the ceiling or wall. Where conduits are laid direct on the shuttering of the reinforced slab construction conduit extension rings or deep boxes shall be used to raise the run of conduit to between the top and bottom reinforcing. Galvanised draw wires or other approved types shall be provided where conduits are not be wired on completion or are to be wired by others.

All draw boxes and junction boxes shall be of ample size to permit the cables being drawn in and out. They shall be made of malleable iron and the jointing surface machined to ensure a dust tight joint. All circular boxes shall be provided with long spouts internally threaded incorporating a shoulder for the proper butting of the conduit and a solid brass earth terminal tapped and screwed into the base of the box.

All conduit boxes shall be screwed on or in walls, ceilings etc. by countersunk wood screws of appropriate size. Holes in boxes shall be adequately countersunk to ensure the complete recession of the fixing screws. All inspection and draw-in boxes shall be provided with covers fixed by round head brass screws.

Where surface conduit is specified, it shall be fixed by means of distance saddles and shall terminate in raised back pattern conduit boxes. Surface conduits shall not be bent or set to enter accessories, and where they turn through walls back outlet boxes shall be provided. Conduits shall be fixed at 1200 mm centres on vertical runs and 900 mm apart on horizontal runs.

Vertical conduit runs shall have saddles at 300 mm maximum from their points of emergence from floors or ceilings and the remaining saddles shall be fixed consistent with the requirements of spacing and appearance. Saddles shall be fixed on each side of every bend at 300 mm maximum from the point of intersection of the centre line conduit.

Conduits in ceiling cavities shall be supported independent of the suspended ceiling.

Where conduits cross expansion joints, the Contractor shall allow for the installation of expansion couplers at the positions of the expansion joint and at right angles to it. The Contractor shall provide a bonding earth wire between each terminal fitted in the nearest conduit box each side of the coupler.

All flexible metallic tubing shall be galvanised watertight pattern fitted with sweated brass adaptors. External earth conductors, wrapped around the tubing, shall be provided.

Where conduits are laid in slab floors etc., the Contractor shall arrange for a competent person to be in attendance whilst the concrete pouring or screeding operation is being carried out, in order to avoid damage being caused to the

conduits and also to ensure that the conduit work is in sound condition, properly and efficiently maintained during this installation period.

Particular care should be taken when setting out conduit runs to outlet points where they are to be fitted to furniture, kitchen fittings etc. The Contractor shall ascertain exact details of the furniture and fittings construction in order that all conduit work shall wherever possible be concealed.

Conduits installed in chases of walls and floors shall be firmly secured by wrought iron pipe hooks or crampets and these fixings shall in themselves be sufficient to hold the conduits in place. Conduits installed in chases shall be painted with one coat of bitumastic paint before erection and a further coat shall be applied to all accessible surfaces including the hooks and the crampets after erection.

Recessed conduits buried in plaster shall permit a full 6 mm depth of cover over its entire length.

Provision shall be made for the tapping of condensed moisture.

Care shall be taken to prevent water, dirt or rubbish entering the conduit system during erection. Screwed metal caps or plugs shall be used for protecting open ends.

All conduit systems shall be erected completely with all conduit accessories connected, it shall then be offered for inspection and approval by the Engineer before any cables are installed. Conduit boxes shall be fixed to the structure of the building independently of the conduit.

Where a conduit is exposed to different temperatures (either by surrounding air conditions or by virtue of the surrounding medium with which it is in contact) at any particular time, the section of the conduit at the higher temperature shall be isolated from the section at the lower temperature by means of a conduit box filled with an approved permanently plastic compound, after completion and testing of all wiring. Such a condition would arise if a conduit running in a warmed building is run to exterior points.

Where galvanised conduit is specified all conduit, accessories, switch boxes and all associated apparatus used in the installation must also be galvanised. Galvanised conduit shall be used when mounted outside a building installed in floor chases subject to dampness or accidental flooding, or buried in the ground. Conduit system shall be weatherproof when erected outside a building. Exposed conduit threads shall be given a coat of zinc rich paint.

All adaptable boxes shall be grey iron pattern unless otherwise specified. Where adaptable boxes are fitted flush, the cover plates shall be heavy gauge metal with 12 mm overlap on all sides. The internal depth of a box shall be not less than 40 mm.

Covers shall be secured by a screw at each corner and by additional screws as necessary to provide a maximum spacing of 300 mm between adjacent screws. Fixing screws shall be brass (round or cheese head).

Covers for boxes shall be of the same material as the box. For boxes mounted in weatherproof situations, the cover shall have a machined surface around the perimeter mating with a similar machined surface on the box and shall be complete with a gasket.

Every flush outlet box to which a luminaire pull cord switch or similar is to be fitted shall be fitted with an approved type of break joint ring.

3 CABLE TRUNKING

Where trunking is specified it shall be constructed of 1.65 mm minimum thickness zinc coated mild steel and shall have a removable cover throughout its length with centre screw latch fixings. Trunking shall be rigidly fixed and supplied complete with purpose manufactured fittings, connectors, dividers, flanges, cable retaining clips, racks and copper earth continuity links. As an alternative if approved, a proprietary brand of heavy duty plastic trunking may be acceptable. When submitting details for approval, full installation instructions as recommended by the manufacturer shall be included in the details.

All cables installed in trunking shall be laced and identified in an approved manner. Clips shall be at 600 mm centres. Vertical cable trunking shall be fitted with cable pin racks arranged to avoid any strain on the cables.

All steel trunking shall be rust proofed, primed and painted and fixed at intervals not greater than 1,000 mm.

4 LIGHTING

4.1 General

The lighting system shall be fed from the Essential Service Board and provide adequate illumination of all parts of the Contract area.

Road/Site lighting shall be installed on lighting poles along and the access road and at appropriate locations within the substation to meet operational requirements.

Lighting shall be designed to produce adequate visual performance, safety and amenity, and shall be free from excessive glare, stroboscopic effects and flicker from discharge lamps. The system shall include provision for ease of erection, maintenance, cleaning, lamp replacement and future extension. Lamp replacement and maintenance should unless otherwise approved be possible without taking outages on main plant items.

Lighting apparatus shall be of top quality designed to ensure satisfactory operation and service life under all variations of load, frequency and temperature. Sodium discharge lighting shall not be used except for road and security lighting.

4.2 Levels of Illumination

Levels of illumination for particular areas shall be designed to the following values:-

	<u>Illumination</u>	<u>Glare Index</u>
Control rooms (vertical face of control panels)	300 lux	16
Control room (rear of control panels)	50 lux	-
66 kV Switchrooms	200 lux	-
Relay and Telecommunications	200 lux	25
Battery Rooms	100 lux	-
Outdoor Locations	40 lux	-
Site Roadways	20 lux	-

Site measurements shall take into account ageing characteristics at the time of measurements and shall be taken after all fittings have been cleaned.

4.3 Lighting Fittings

Lighting fittings shall generally be fluorescent and in accordance with IEC 60400. They shall be complete with instant start control gear, bi-pin lampholders and totally enclosed spines of minimum width 6 cms and suitable for mounting on conduit boxes and trunking.

The built-in ballast units shall comply with IEC 60928 and shall include radio interference suppressors and capacitors to correct the fitting power factor to a minimum of 0.85 lagging. Control gear noise levels shall be minimal.

Fluorescent lamps shall be in accordance with IEC 60081, and shall have colour rendering values of $x = 0.335$ and $y = 0.342$ (i.e. colour 2) on the CIE chromaticity scale.

Fittings shall be supplied complete with closed end vitreous enamelled metal reflectors or totally enclosed opal plastic diffusers which shall be fully interchangeable.

Bulkhead fittings shall have cast bases tapped for conduit entry, hinged bezels, heat resisting prismatic glasses fitted with neoprene gaskets and porcelain lampholders. Circuit cables shall not be connected direct to bulkhead fittings but shall terminate in a fixed base connector mounted in a conduit box adjacent to the fitting. Final connections to each fitting shall be carried out with silicone rubber covered cable. All bulkhead fittings shall be water-tight pattern.

Lampholders for tungsten lamps up to 150 watts shall be brass or porcelain B.C. type and for higher ratings shall be E.S. or G.E.S. according to size.

Security and roadway lighting fittings shall comprise a tapered hot dipped galvanised steel column complete with 470 cms x 150 cms base compartment totally enclosed aluminium alloy lantern with prismatic diffuser, auxiliary control gear and a 16 amp S.P. and N cut-out equipped with two glands for incoming and outgoing 2 core 16 sq.mm PVC SWA PVC cable. A 2 core and earth 4 sq.mm butyl rubber flexible cable shall connect the lantern to the cut-out.

All fittings shall be adequately earthed and all earth terminations and fitting fixing brackets and supports shall be included.

4.4 Lighting Switches

Lighting switches shall generally be metal-clad 240 volt, 16 Amp., "a.c. only" type capable of operating at their full rated capacity.

Switches shall be one way, two way or intermediate as required and where mounted together they shall be fitted in a common box. For surface installations they shall be fitted with fixed grids and in flush installations the grids shall be adjustable.

Switch-boxes shall be galvanised and fitted with screwed stainless steel front plates having a 6 mm overlap minimum for flush installations. They shall be suitably barriered and labelled where two phases are connected in the same box.

Switches mounted externally shall be of weatherproof pattern to IP55 level fitted with machined box and cover joint, brass operating handles, neoprene weathertight seals and external fixing feet.

Switches shall be mounted 1.4 m above finished floor level.

4.5 Photo-electric Cells

All road and area lighting will be automatically switched by a photo-electric cell. There shall also be a photo-electric cell by-pass switch. The photo-electric cell shall have extended operational life.

4.6 Emergency Lighting

Emergency supplies shall be provided to maintain essential lighting in the event of complete loss of a.c. supply and shall provide sufficient exit lighting in all areas to ensure the safe evacuation of personnel.

In addition lighting shall be provided in control and switchgear rooms to enable essential operation to be carried out at all times. 50% of fittings in these areas shall be fitted with an integral battery pack to operate in the event of loss of supply.

In addition to the above emergency portable rechargeable hand lamps shall be installed in specified locations.

5 SOCKET OUTLETS

Socket outlets up to 30 Amp rating shall generally be of 220 volt, 3-pin shuttered galvanised industrial pattern fitted with stainless steel front plates and shall not be interchangeable for different voltages. All socket outlets shall be provided with approved type plugs and shall be adequately earthed.

Socket outlets mounted externally shall be weathertight pattern fitted with machined joint, brass plug and screwed cover plate.

Heavy duty socket outlets shall be .60 Amp four pole with earth connection and interlocked switch-fuse as detailed separately.

SECTION 18

FIRE PROTECTION

SECTION 18
FIRE PROTECTION

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**SECTION 18
FIRE PROTECTION**

1 GENERAL

The minimum quantity of fire extinguishers to be provided are given in the Schedules attached to this Specification. The actual quantities and types shall be agreed by the Contractor with the Engineer, and shall be dependent upon the final size of building and equipment being provided.

2 PORTABLE FIRE EXTINGUISHERS

2.1 75 kg - Dry Powder Trolley Extinguishers

The extinguisher shall comprise a powder container and a pressurising CO₂ Cylinder. The powder shall be discharged through a braided synthetic hose and nozzle.

2.2 1.1 kg CO₂ Hand Held Extinguisher

CO₂ cylinders shall have steel bodies and incorporate a gunmetal valve. Extinguishers shall have trigger type valves, swivel elbow and discharge horn. Each appliance shall be equipped with chained safety pin and wall mounting bracket.

2.3 2 Gallon Water/CO₂ Extinguisher

Water/CO₂ extinguishers shall comprise a steel canister with polythene lining. CO₂ propellant shall be in a replaceable cartridge. Water shall be discharged through a short hose and nozzle. Wall mounting brackets shall be included.

2.4 3 kg Dry Powder Extinguisher

3 kg Dry Powder Extinguisher shall have a steel body filled with dry powder which shall be expelled through a short non-perishable reinforced hose by a carbon dioxide cartridge.

SECTION 19

**STRUCTURES FOR OUTDOOR
EQUIPMENT**

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SECTION 19
STRUCTURES FOR OUTDOOR EQUIPMENT

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SECTION 19
STRUCTURES FOR OUTDOOR EQUIPMENT

1 GENERAL

Structures shall be provided to carry all conductors, insulators, isolating switches, circuit-breakers and other items of plant included in the contract. Facilities shall also be provided for the termination of the incoming overhead transmission lines.

The structures shall be designed to ensure that the specified minimum phase, earth and section clearances are maintained under all conditions.

The strength and rigidity of the structures shall be such that the alignment of the apparatus which they carry shall not be affected by the static and dynamic loads to which the structures are subjected.

Designs shall be such as to keep the number of different parts as few as possible to facilitate transport, erection and inspection.

The Contractor shall submit for approval loading diagrams for each type of structure before proceeding with detail design. Subsequently the Contractor shall submit for acceptance, outline drawings, conductor clearance diagrams, stress calculations and a summary setting out for each structure member the design load, member size, L/R ratio, permissible load, material and end connection details. After acceptance of the structure design, the Contractor shall prepare and submit general arrangement and erection drawings, calculations of design foundation loads, foundation designs and drawings.

2 ASSUMED WORKING LOADS

The structures shall be designed to meet the maximum of the total forces calculated vectorially from the following.

- (a) Wind loading
- (b) Conductor tension
- (c) Short-circuit forces including 'snatch' in the case of bundle conductors
- (d) Seismic forces
- (e) Dead weight, loads of conductors, insulators and electrical apparatus
- (f) A point load of 100 kg anywhere on the structure

Wind loading and seismic forces shall not be assumed to act simultaneously. Care shall be taken in the design to allow for any additional loads to which the structure may be subjected during the erection of conductors and substation equipment.

3

FACTORS OF SAFETY AND STRUCTURE MEMBERS

The ratio between ultimate loads and working loads shall be 2.0 for all members whether under tensile, compressive, bending or combined stresses, except in the case of wind loads and other short duration forces where the factor may be taken as 1.5. The factor of safety against overturning shall not be less than 2.5 under any conditions.

Maximum ratios of effective unsupported length of steel members to the relevant radius of gyration (L/R) shall not exceed: -

For leg members and gantry chords	120
For other load bearing compression members	200
For redundant members without calculated stress	250
Tension members	500

In no cases shall a bar width (b) to flange thickness (t) ratio of 16 be exceeded.

The minimum thickness and diameter of material used in members and bolts shall be as follows: -

(a) For leg members and compressive chords in gantries	6 mm
(b) For other members carrying calculated stress	5 mm
(c) For redundant members without calculated stress	4 mm
(d) Gusset plates	6 mm
(e) Minimum bolt diameter for members carrying calculated stress	16 mm
(f) Minimum bolt diameter for redundant members without calculated stress	12 mm

Each member whose longitudinal axis makes an angle less than 45 degrees with the horizontal shall be of sufficient section to withstand, in addition to all other loadings, a concentrated load of 100 kgf applied normal to the longitudinal axis at any point along its length.

The minimum angle between any two intersecting members shall be 15 degrees with 20 degrees preferred.

Members shall be of such size, shape and length as to preclude damage or failure from vibration or stress reversal.

4 MAXIMUM ALLOWABLE MEMBER STRESSES

The determination of maximum allowable stresses shall be based on the equations and factors given below unless otherwise approved.

The ultimate compressive stress on the gross section of axially loaded compressive member is

$$F_c = \frac{1}{2} \frac{F_y}{C} \left[\frac{KL}{R} \right]^2 \quad \text{where } \frac{KL}{R} \leq C$$

or

$$F_c = \frac{\pi^2 E}{(KL/R)^2} \quad \text{where } \frac{KL}{R} \geq C$$

and

$$C = \pi \sqrt{\frac{2E}{F_y}}$$

where F_c = Ultimate compressive stress in member kg/mm^2

F_y = Yield stress of the steel kg/mm^2

E = Elastic modulus of the steel kg/mm^2

For leg sections or members with concentric loadings at both ends of the unsupported panel $KL/R = L/R$ for values of L/R up to and including 120. (i.e. $K = 1.0$).

For all other compression members carrying calculated stress, the following adjusted slenderness ratios, KL/R shall be used:-

- (1) For members with concentric loading at one end and normal framing eccentricities at the other end of the unsupported panel.

$$\frac{KL}{R} = 30 + 0.75 \frac{L}{R} \quad \text{for values of } L/R \text{ up to and including } 120$$

- (2) For members with normal framing eccentricities at both ends of the unsupported panel

$$\frac{KL}{R} = 60 + 0.50 \frac{L}{R} \quad \text{for values of } L/R \text{ up to and including } 120$$

- (3) For members unrestrained against rotation at both ends of the unsupported panel

$$\frac{KL}{R} = L/R \text{ for values of } L/R \text{ from } 120 \text{ to } 200$$

- (4) For members partially restrained against rotation at one end of the unsupported panel

$$\frac{KL}{R} = 28.6 + 0.762 \frac{L}{R} \text{ for values of } L/R \text{ from } 120 \text{ to } 200$$

- (5) For members partially restrained against rotation at both ends of the unsupported panel

$$\frac{KL}{R} = 46.2 + 0.615 \frac{L}{R} \text{ for values of } L/R \text{ from } 120 \text{ to } 200$$

A single bolt connection shall not be considered as offering restraint against rotation. A multiple bolt connection properly detailed to minimise eccentricities shall be considered to offer partial restraint if connection is to a member having adequate flexural strength to resist rotation of the joint. Points of intermediate support shall not be considered as offering restraint to rotation unless they meet the above outlined criteria.

In the design of members the length, L, shall be the length between the intersection points of the member centre lines at the joints.

The ultimate tensile stress (Ft) on the minimum Net Section shall be taken as the applicable Yield Point (Fy). The Net Section shall be computed from the following equations:-

- (1) Single Angle connected through one leg:

To the net sectional area of the connected leg, add the sectional area of the unconnected leg multiplied by:-

$$3a_1 / (3a_1 + a_2)$$

where a_1 = the net sectional area of the connected leg.

a_2 = the sectional area of the un-connected leg.

Where lug angles are used, the net sectional area of the whole of the angle member shall be taken.

- (2) A pair of angles connected together along their length and attached to the same side of a gusset or the equivalent by only one leg of each angle:

To the net sectional area of the connected part, add the sectional area of the unconnected part, multiplied by:-

$$5a_1 / (5a_1 + a_2)$$

where a_1 = the net sectional area of the connected part.

a_2 = the sectional area of the unconnected part.

Where angles are spaced greater than 25 mm apart this equation does not apply, and the member shall be treated as individual members.

- (3) Double angles or tees placed back to back and connected to each side of a gusset or to each side of part of a rolled section. For computing the mean tensile stress the net sectional area of the pair shall be taken, provided the members are suitably connected together along their length.

Ultimate bending stress (Fb) on the extreme fibres shall be taken as the applicable Yield Point (Fy).

Ultimate shear stress, (Fs) shall be taken as 0.94 of the applicable Yield Point (Fy).

Allowable ultimate bearing stress, for all steel materials specified herein shall be taken as 1.85 times the applicable Yield Point, (Fy).

5 WIND LOADING

The basic wind pressures to be adopted for the substation structure design shall be those specified under Design Criteria. The basic wind pressure, P_{10} kgf/m² at a height of 10 metres shall be subject to variation for the height and shape at the design case under consideration to give the total wind load.

In the cases of structures, to allow for variation of wind pressure with height and to allow for the pressure on the leeward face of the structure, the total wind load on the panel, T_w kgf, shall be calculated from the expression

$$T_w = 4.3 (1 - 1.16 S_r) P_{10} (H/10)^{0.087} . W_a$$

where H = height above ground level in metres to the top of the panel being considered

S_r = solidity ratio of the panel (i.e. the net area of the members of panel in the windward face divided by total area enclosed by panel)

W_a = projected area of exposed members on the windward face in square metres

In the cases of tubes, rods and wires to allow for variation of wind pressure with height and to allow for varying shape the total wind load, T_w kgf, shall be calculated from the expression

$$T_w = 4.3 (1 - 1.6 S_r) P_{10} (H/10)^{0.087} W_a$$

where H = height above ground level in metres of tube, rod or wire

C_f = force co-efficient

W_a = projected area of windward face of tube, rod or wire in square metres

The force co-efficient of C_f shall be selected depending on the item length/diameter ratio (l/d) and diameter as follows:-

d(mm)	l/d	C_f
150 to 199	≥ 100	0.5
	50	0.4
	10	0.35
100 to 149	≥ 100	0.7
	50	0.6
	10	0.45
50 to 99	≥ 100	1.0
	50	0.8
		100.65
Less than 50	≥ 100	1.2
	50	1.0
	10	0.8

In the case of porcelain shedded insulators the same expression shall be used except that C_f shall be assumed equal to 0.6 and also H shall be the height to the top of the insulator. W_a shall refer to a cylinder having a height equal to the insulator total height and diameter equal to the insulator mean diameter.

6 MATERIALS AND WORKMANSHIP

Compression members shall consist of rolled steel section and tension members of rolled steel sections or flats.

Rollled steel sections, flats, plates and bolt and nut bars shall consist of mild steel to the requirements of ISO Recommendation R630 Grade Fe44A or other approved grade. High tensile steel, where required, shall be to ISO Grade Fe52B or other

approved grade. Steel sections shall preferably be standard sections chosen with a view to avoiding delays in obtaining material.

Where high tensile steel is used all bends shall be formed hot, in accordance with an approved Standard. The steel shall be free from blisters, scale, laminations and other defects.

The use of welding to form major structural items is subject to approval by the Engineer prior to fabrication commencing. The Contractor must take due cognisance of the minimum ambient temperature and prior to approval being given details of the quality of steel, Charpy Impact value and stress relieving he proposes to undertake must be given.

Cast iron shall be close grained, tough and uniform in character and shall be cast from the best grey pig and scrap iron. It shall have a tensile strength of not less than 140 MN/m².

All members shall be cut to jig and all holes shall be punched and drilled to jig. All parts shall be carefully cut and holes accurately located so that when the members are in position the holes will be truly opposite each other before being bolted up. Drifting or 'reaming' of holes will not be allowed. All burrs shall be removed before galvanising.

The drilling, punching, cutting, bending and welding of all fabricated steelwork shall be carried out before galvanising and shall be such as to prevent any possibility of irregularity occurring which might cause difficulty in the erection of the supports on the Site.

Punching of holes will only be permitted for Mild Steel members up to 8 mm thick and in no case shall a hole be punched where the thickness of the materials exceed the diameter of the punched hole.

No bolt hole shall be more than 1.5 mm larger than the diameter of the bolt, but after galvanising sufficient clearance shall be left for the insertion of the bolts. For large diameter bolts such as foundation bolts the clearances shall be to approval.

Approved steel gauges of the stud type shall be provided to enable the Engineer to carry out such checking of members as he may consider necessary.

Built members shall, when finished, be true and free from all kinks, twists and open joints, and the material shall not be defective or strained in any way.

Minimum bolt spacings and distances from edges of members shall be as listed below.

Bolt diameter	mm	12	16	20	24
---------------	----	----	----	----	----

Bolt spacing	mm	35	45	60	70
Edge distance sheared edge	mm	18	24	30	36
Edge distance rolled edge	mm	18	22	25	35

Edge distances specified above shall not be reduced by under-run caused by rolling tolerances.

Where the calculated deflections under all permanent loads of any part of a structure exceeds the lesser of 6 mm or 1/200 of the span then a reverse camber equal to 1.5 times the calculated deflection shall be built in to the unloaded structure.

7 NUTS AND BOLTS

All metal parts shall be secured by means of bolts and nuts whose minimum diameter shall be M16 unless specially approved. Bolts and nuts shall be of steel with hexagonal heads.

All bolts shall be galvanised including the threaded portions. The threads of all bolts shall be cleared of smelter by spinning or brushing. A die shall not be used for cleaning the threads unless specially approved by the Engineer. All nuts shall be galvanised with the exception of the threads which shall be oiled.

When in position all bolts shall project through the corresponding nuts, but such projection shall not exceed 10 mm. Where cutting of bolt ends on Site is required by this provision, the threads and cut ends of these shall be then painted with bitumastic or other approved paint. The nuts of all bolts attaching insulator sets and earth conductor clamps to the structure shall be locked in an approved manner.

The length of the screwed portions of bolts shall be such that no screw thread may form part of a shearing or bearing plane.

At least one, and not more than two, washers of approved thickness shall be placed under each nut. Taper washers shall be provided where necessary.

If bolts and nuts are placed so that they are inaccessible by means of an ordinary spanner a suitable spanner shall be provided.

The bolts of any one diameter on a structure shall be one grade of steel.

Foundation bolts and tubes shall be provided and fitted with washer plates or anchor angles and flats, nuts etc., and shall be manufactured from mild or special steel in accordance with the design requirements of the bolts.

Foundation bolts, nuts, washers and assemblies shall be protected with lanolin grease only. Where foundation bolts or assemblies are to be cast into concrete bases they shall be despatched in time to arrive on Site at least one month before the programmed concrete casting date.

After the erection of the steel structures the projecting bolt threads, nuts, washers etc., shall be wire brushed and cleaned with white spirit to remove grease. Three substantial coats of an approved zinc rich paint system shall then be applied to the approval of the Engineer.

8 GALVANISING

Steel structures shall be hot dipped galvanised in accordance with the general specification for galvanising.

9 GENERAL CONSTRUCTION

Proper precautions shall be taken to ensure that structures will not be strained or damaged in any way during erection of the structures themselves, or of the conductors and other apparatus.

Special care shall be taken not to injure galvanised or specially treated surfaces during erection. Care shall be taken to prevent or remove any rust streaks or foreign matter deposited on galvanised surfaces during storing or transport or after erection.

All members shall be permanently marked for erection purposes. The numbers or letters shall be at least 20 mm in size and shall be clearly legible after galvanising.

As far as conveniently possible, bolt heads rather than nuts shall be on the outer faces of the structure members.

Pockets and depressions likely to hold water shall be avoided or if not avoidable shall be properly drained.

All structures shall be provided with such holes, bolts and fittings as may be necessary to accommodate the insulators, switchgear and other apparatus provided under the Contract and to secure the structures to their foundations.

Where overhead transmission lines are terminated at the station structures, eyebolts of approved size and position shall be provided for reception of the transmission lines insulator fittings and earth conductors clamps, which will be supplied and fixed under other contracts.

Structures required for the accommodation of cable sealing ends shall be provided with arrangements for supporting the cables.

Means shall be provided for fixing and bonding earthing conductor to the steelwork at sufficient points to ensure efficient earthing. Earth connections shall be made to a vertical face clear of the ground. Foundation bolts shall not be used for the attachment of earth connections.

To facilitate safe inspection and maintenance the structures shall be provided with ladders or step bolts, screens, guards and other facilities in suitable positions to be agreed with the Engineers. Ladders shall terminate 2.0 m above ground level.

10 GROUTING OF FOUNDATIONS

Grout shall consist of cement and sand mixed in the proportion of one part of cement to two parts of sand with sufficient water added to make it fluid.

All cement used for grouting and filling shall be of Portland or other approved composition obtained from an approved maker.

SECTION 20

SCADA SYSTEM

SECTION 20
SCADA SYSTEM

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1 SCADA SYSTEM

1.1 General

An existing SCADA system provided by Neles Automation is in service. All inputs as listed below shall be added/modified on the SCADA system.

A From/To Union 66 kV Substation

A.1	66/11kV Transformer 1	1 set
A.2	66/11kV Transformer 2 (as required)	1 set

B From/To Vieux Fort 66kV Substation

B.1	66/11kV Transformer 1	1 set
B.2	66/11kV Transformer 2	1 set

Facilities on a 66kV Transformer Circuit

Signal Type	Signal Name	Number of Signals per Circuit Type
A	Current	1
A	Tap Position	1
B	Buchholz Alarm	1
B	Buchholz Alarm	1
B	Tap Changer Alarm	1
B	Tap Changer Trip	1
B	Winding Oil Temp. Trip	1
B	Winding Oil Temp. Alarm	1
B	Tap Changes Out of Step	1
B	Buchholz Trip	1
B	Buchholz Trip	1
B	Transformer Cooler Failure	1
B	Oil Temperature Alarm	1
BB	66kV CB Status	1
BB	66kV D/S Status	1
B	66kV CB Control Circuit Faulty	1
B	66kV CB Trip Circuit Faulty	1
B	66kV CB Lockout	1
B	66kV Transformer Main Protection Operated	1
B	66kV CB and T/C Supervisory Control Select	1
B	Low Oil Level Alarm	1
B	Pressure Relief Vent Trip	1

B	Circuit Breaker Control (Open/Close)	1
B		1
CC		1

NOTES

The signal types are as follows:-

- Signal Type A : Analogue Input (0-10mA)
Signal Type B : Single Status Signal
Signal Type BB : Double Status Signal
Signal Type C: : A Single Command Signal
Signal Type CC : A Double Command Signal

2 SCOPE OF SUPPLY

An existing Supervisory Control and Data Acquisition (SCADA) System is in service controlling LUCELEC's 66 kV and 11 kV network. The System consists of a master station located in the System Control Centre at the Cul de Sac Power Station and a set of Remote Terminal Units (RTU)s located at each of the existing six power station/substation sites.

Additional facilities will be required from existing RTUs into the SCADA system from existing substations at Union and Vieux Fort

At both Union and Vieux Fort substations an existing RTU is provided in a self-contained floor standing cubicle complete with its battery/charger power supply.

RTUs may require the addition of further input/output cards as necessary to add the new input/output requirements and to retain some future capacity.

The master station software is unchanged apart from reconfiguration and display diagram amendment to achieve this future capacity.

The Contractor will be required to cable up all control, indication, alarm and metering points from equipment or devices in the switchyard or in the substation to existing Supervisory-interface/metering panels except where otherwise specified. Wiring is then required from these panels to the existing RTUs.

Testing

The Contractor will be responsible for testing from each new point in either an existing substation or a new substation through to the master Station in the System Control Centre and then to the display screens and event/alarm recorders .

2.1 Remote Terminal Units (RTU)

(a) General

Where specified, RTU's shall be provided, sized and fully equipped for all the signals requested in Schedule 'M'. These signals shall be cabled and terminated between the substation signal marshalling cubicle and the RTU. In addition, fully wired rack space and input/output terminations shall be provided for the 'future' signal capacity stated Schedule 'M' for each RTU, such that only the insertion of printed circuit boards shall be necessary to bring the RTU up to that expanded capacity.

The equipment shall be solid state throughout, except that relays may be used within analogue multiplexing circuitry and for digital outputs.

(b) Field Signal Interface

All RTU inputs and outputs, analogue and digital, shall meet the requirements of Test Voltage Class II of IEC 60255-4, Appendix E. Additionally, they shall provide 2 kV isolation between field circuits and the RTU internal circuitry.

Analogue inputs and outputs shall withstand 100 V rms 50 Hz common mode for 1 minute.

(c) Analogue Inputs

Analogue signals will be derived from transducers mounted in the Plant signal marshalling cubicles. All such transducers required at each site shall be installed under this Contract.

The resolution of the analogue-to-digital converter (excluding the sign bit) shall be at least one part in 1,000 of maximum span. Accuracy, both short-term and long-term, shall be compatible with this resolution.

All components used in measuring circuits which affect accuracy shall be of high stability, adequate rating and low temperature coefficient.

The common mode rejection shall be better than 80 dB under normal operation. The integrating interval of analogue measurement sampling shall be 20 ms or, alternatively, filters shall be provided to achieve better than 50 dB series mode noise rejection at 50 Hz. The dynamic response of any

input filtering shall be such that 99% of any step change in input is reflected in a digitised value taken one second after the change.

The outputs of all transducers will have a linear relationship with the value to be displayed at the master station.

Analogue inputs shall be rated for 0 to ± 10 mA and have 100% over range withstand capability.

(d) Digital Outputs

Digital outputs are required to operate items of power system plant equipment, either directly or via auxiliary relays mounted in the plant control cubicles. The electrical supply requirements of the control circuits which operate the Plant will be sourced from the power system Plant.

RTU outputs shall be provided in the form of output relays with normally open voltage free contacts which will form the initiating elements in the above control circuits.

The RTU shall give a pulsed output whereby the output relay contacts close for a period that can be configured for each output, typically 500 ms. The contacts shall be rated for 100 VA inductive loads at voltages up to 250 V DC.

(e) Digital Inputs

Status and alarm input information will be supplied from normally open voltage free contacts located within the power system Plant. They will close to register the specified status or alarm.

The RTU shall provide the interrogation voltage to monitor these contacts. This voltage shall nominally be in the range 24 to 60 V DC and the interrogation circuit current shall typically be in the range 5 to 20 mA.

(f) Power Supply

The RTU shall be provided with a battery/charger power supply system, mounted within the RTU cubicle. This system shall derive its primary power supply from the mains via a single phase way on the substation's LVAC distribution board and shall be cabled and connected to that way.

The battery cells shall be of sealed type construction and require minimal maintenance over their lifetime which shall be at least 10 years. The battery cells shall be mounted in a ventilated compartment within the RTU cubicle if this is necessary to prevent damage to other equipment contained in that cubicle from any gases released by the cells.

The battery shall be sized such that it can maintain full operation of the fully expanded RTU for a minimum period of 6 hours in the absence of mains power supply.

(g) RTU Alarms

The RTU shall be equipped to generate the following alarms which shall be annunciated at the master station:

- (i) RTU Battery Charger Faulty Alarm
- (ii) RTU Battery Nearing Full Discharge Alarm
- (iii) RTU Circuit(s) Faulty Alarm
- (iv) RTU Cubicle High Temperature Alarm.

2.2 Diagnostics And Fault Handling Facilities

(a) Introduction

A complete package of diagnostic programs shall be provided that will allow testing of all System devices, including communications with RTUs, to determine whether or not a problem exists and to identify any detected problems. Both online and offline diagnostics shall be included.

(b) Error Detection and Reporting

Malfunctions reported shall include excessive program execution time, communications errors and the identification of faults in each hardware device provided.

Any malfunction shall cause an alarm to be generated so that remedial action can be initiated.

Facilities shall be provided to display the status of all devices on demand.

(c) Telemetry Communications Statistics

The System shall continuously calculate and update statistics on telemetry scans and errors and provided facilities for this information to be displayed on request.

3. INTERFACES

3.1 Communications Interface

The Contractor shall be responsible for connecting the RTU to the new communications system node at the substation, including the provision of any interface cards, modem or other equipment required to establish that connection, providing and installing suitable interface cards for the new multiplexer equipment, and for the new optical fibre communications equipment being provided in association with the protection schemes for the new overhead 66 kV lines. The master station and RTUs shall be cabled and connected to those communication system interface cards.

3.2 SCADA Remote Station Interface

(a) General

Facilities are to be provided on the 66 kV and 11 kV Plant to enable it to be interfaced to a SCADA system. These facilities include the wiring out of controls and signals to a Supervisory-interface/metering cubicle. The interface cubicle includes all Plant signal terminations and space for transducers so that no signal connections are required directly between the RTU and the Plant.

(b) Power Apparatus Side of the Interface

The power apparatus at each substation is equipped to permit:

- (i) Remote operation of circuit breakers, bus section and circuit isolators, transformer tap changers and any other specified equipment.
- (ii) Remote indication of the status of high voltage circuit breakers, bus sections and circuit isolators, tap changers, earth switches, remote/supervisory selector switches and any other specified equipment.
- (iii) Remote indication of alarm, fault or other abnormal conditions.
- (iv) Telemetry of instantaneous values of watts, VARs, volts, amperes and transformer tap position.

SECTION 21

**WORKS TESTS, SITE TESTS AND COMMISSIONING
TESTS**

SECTION 21

WORKS TESTS, SITE TESTS AND COMMISSIONING TESTS

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SECTION 21

WORKS TESTS, SITE TESTS AND COMMISSIONING TESTS

1 WORKS TESTS

1.1 General Test Requirements

Tests shall be carried out in order to determine whether the materials and apparatus comply with the Specification and to provide the necessary operation data. All tests shall be arranged to represent the working conditions as closely as possible.

Unless an alternative place of testing is agreed or specified the tests shall be carried out at the Manufacturer's Works.

Not less than ten days' notice of all tests shall be given to the Engineer in order that he may be present if he so desires. As many tests as possible shall be arranged together, in accordance with a programme to be agreed with the Engineer. Six copies of the Contractor's records of all tests shall be submitted to the Engineer immediately after the conclusion of each test. These records shall be clearly marked so that the Contract equipment items or components to which they refer can be readily identified.

Type tests will not be required in those cases where the Contractor can produce certified evidence to the satisfaction of the Engineer that the required type tests have been performed successfully on identical equipment, or equipment which is for practical test purposes similar and produced in the factory where effect shall be submitted at the time of tendering, or as soon as practicable thereafter.

High voltage tests shall be conducted generally in accordance with IEC 60.

Insulating oil or gas used in any equipment undergoing tests shall comply with the requirements of IEC 296 and 376 respectively.

Except where otherwise indicated all electrical tests shall be carried out at rated frequency and with the supply voltage waveform approximately sinusoidal.

The Manufacturer's test equipment shall be of satisfactory quality and condition and where necessary shall be calibrated at the expense of the Contractor by such other body as may be agreed.

After the Contract has been awarded and the main features of the project design are known then an Engineer's Inspection and Testing Programme will be established with the Contractor.

Where no tests are detailed for items of equipment a full programme of tests shall be agreed with the Engineer.

The Engineer reserves the right to call for such additional tests as may be necessary to prove compliance with the Specification.

Manufacturer's Inspection and Testing Programme

The Contractor shall carry out a comprehensive Inspection and Testing Programme during manufacture of plant. The Contractor shall allow in his Tender for the cost of carrying out the following stages of inspection and/or test. These are not intended to form a comprehensive programme, as it is the Contractor's responsibility to draw up and carry out and furnish evidence of "type tests" on certain items of equipment.

1.2 Circuit-Breakers

1.2.1 Routine Tests

In accordance with the requirements of IEC 56 together with any tests carried out as a normal routine procedure by the manufacturer. In addition, leakage tests shall be carried out on gas-filled circuit-breakers.

1.2.2 Type Tests

In accordance with the requirements of IEC 56. Details of the transient recovery voltage to which the circuit-breaker will be subjected during short-circuit testing shall be submitted to the Engineer for approval.

The Engineer may require in addition any of the following tests to be carried out, the details of which will be agreed between the Engineer and the Contractor:

- Earth Fault Interruption tests
- Out of Phase Switching tests to IEC 267
- Capacitance Switching tests
- Small Inductive Breaking Current Switching tests
- Tests under environmental conditions
- Voltage withstand test after breaking capacity tests

1.3 Metal-Enclosed Switchgear

The requirements of this section are intended to cover complete switchgear assemblies. Component parts such as circuit-breakers, isolators, current and voltage transformers, instruments shall have already been submitted to separate tests as specified in the relevant IEC Recommendation. Additional pressure tests are specified however for the compartment chambers of gas-insulated switchgear.

1.3.1 Routine Tests

In accordance with the requirements of IEC 298 or 517 as applicable. The interchangeability feature of identical units, together with the interlocking provided

for preventing units of different ratings being interchanged shall be demonstrated. Supply voltage variations for auxiliary devices shall be in accordance with the requirements of this Specification. Fluid leakage tests and partial discharge tests shall be included for gas-filled switchgear.

Each pressurised chamber of gas-insulated switchgear shall be subject to a hydraulic test after completion of all welding and machinery operations for a period of 15 minutes. There shall be no sign of leakage or undue strain during the test and no permanent distortion after pressure has been released. The test pressure shall be not less than 1.5 times the design pressure of the compartment or as may be varied to the requirement of regulations of the country of installation and to the satisfaction of the Engineer.

1.3.2 Type Tests

In accordance with the requirements of IEC 298 or 517 as applicable.

A weatherproofing test, will not be required for completely indoor mounted equipment.

Hydraulic tests shall be conducted on chambers of gas-insulated switchgear to confirm the design withstand pressure. Where cast aluminium is employed the test may be extended to confirm the design bursting pressure. Tests shall be performed on samples selected by the Engineer to represent the various compartments employed. Test pressure shall be subject to agreement and shall be based upon design data submitted to the Engineer.

1.4 Oil-Filled Vessels other than Cable Boxes

1.4.1 Routine Tests

All oil-filled vessels other than circuit-breaker tanks or cable boxes shall be filled with insulating oil and subjected to service operating pressure, or, if vented to atmosphere, to a pressure of 1 bar. They shall be left standing for a period of 24 hours. During this period no leakage shall occur.

1.5 Insulated Pressure Containers

1.5.1 Routine Tests

Containers made of insulating material which have in service to withstand gas pressures in excess of atmospheric pressure shall each be tested hydraulically after all necessary grinding or machining work on them has been completed. For containers having fittings permanently attached thereto, the tests shall be made after the fittings have been added.

The tests shall be carried out at the pressure given below for a period of 15 minutes and components shall thereafter be marked in an agreed manner.

- (a) For containers subject to static gas pressure loads only, and not subject to material mechanical shock in service, the test shall be made twice maximum working pressure.
- (b) For containers subject to rapid changes of gas pressure, or to gas pressure plus mechanical shock, the test shall be made three times maximum working pressure.

1.6 Isolators and Earthing Switches and Switch Isolators

1.6.1 Routine Tests

In accordance with the requirements of IEC 129.

1.6.2 Type Tests

In accordance with the requirements of IEC 129.

If required by the Engineer, a completely assembled unit of each type shall be mounted as in service and operational tests carried out.

1.7 Bushings

The requirements of this section are applicable to ceramic, treated paper, condenser and other bushings for use indoors or outdoors and may be with or without oil or other filling as appropriate.

1.7.1 Routine Tests

In accordance with the requirements of IEC 137/1984.

1.7.2 Sample Tests

In accordance with the requirements of IEC 137/1984.

1.7.3 Type Tests

In accordance with the requirements of IEC 137/1984.

1.8 Porcelain Hollow Insulators

The requirements of this section are applicable to porcelain insulators which are complete in themselves or form part of complete bushing assemblies.

1.8.1 Routine Tests

In accordance with the requirements of IEC 233.

1.8.2 Sample Tests

In accordance with the requirements of IEC 233.

1.9 Post Insulators

1.9.1 Routine Tests

In accordance with the requirements of IEC 168. The mechanical routine test shall consist of a tension test. The insulators shall withstand a load not less than 30% of the tension failing load, for 3 seconds, without failure or loosening of fittings.

Where solid-core insulators are used an ultrasonic test shall be applied as a routine test on the insulating part of each insulator before assembly. The frequency of the ultrasonic wave shall be between 0.8 MHz and 50 MHz. The test shall be made along the axis of the insulator and radially.

1.9.2 Sample Tests

In accordance with the requirements of IEC 168. The tests shall be carried out on a sample of 0.5% with a minimum of three insulators. All insulators shall be submitted to tests (1) to (4) of Clause 34. Porosity tests - test (5) - shall be carried out on fragments of porcelain from insulators broken during other tests.

Galvanising tests - test (6) may be carried out on new unmounted fittings, selected from the Manufacturers' stocks of identical material.

1.9.3 Type Tests

In accordance with the requirements of IEC 168. Mechanical tests shall consist of bending, torsion and tensile tests. The bending test shall be carried out in four directions spaced 90° apart.

1.10 Protective Equipment

1.10.1 Routine Tests

All relays, instruments and other equipment shall be subjected to routine tests as specified in relevant IEC publications or other standard before incorporation in the complete equipment.

All apparatus directly connected to pilots which pass outside the switching station shall withstand a high voltage test of 4 kV to earth for one minute. During the test all other windings, connections or contacts shall be earthed.

Composite relay systems, e.g. distance relays, auto reclose relays, shall be subject to such testing to IEC or other standards by approved manufacturer's works

inspection and testing procedure as shall satisfactorily prove the correctness of the assembly and its settings and ranges of operation.

1.10.2 Type Tests

Type tests shall be in accordance with the relevant IEC Recommendation or other applicable standard. Tests shall also be carried out to prove composite relay systems, e.g. distance relays, auto-reclose relays in respect of stability sensitivity, operating time, settings and setting ranges under all fault conditions.

These shall be performed in a manner to simulate working conditions as closely as possible utilising equipment assembled as in service and including resistance not less in value of any external leads associated with the equipment as connected at Site.

1.11 Current Transformers

1.11.1 Routine Tests

In accordance with the requirements of IEC 185. These shall also include a check of the magnetisation characteristic.

1.11.2 Type Tests

In accordance with the requirements of IEC 185.

1.12 Voltage Transformers

1.12.1 Routine Tests

In accordance with the requirements of IEC 186.

1.12.2 Type Tests

In accordance with the requirements of IEC 186.

Additionally, for magnetic voltage transformers, it shall be demonstrated to the satisfaction of the Engineer that capacitance discharge capability of the transformer is not less than the rating assigned or stated in the Schedules. Where deemed necessary by the Engineer discharge tests shall be made on representative units to confirm the mechanical and thermal stability of the windings.

1.13 Control and Indicating Panels, Marshalling Kiosks, Terminal Boxes, Meters, Instruments and Secondary Wiring

1.13.1 Type Tests

Performance tests to the approval of the Engineer under extremes of environmental and operating conditions on a sample of each item of equipment. This test may be waived if acceptable records of such tests are available for inspection.

1.13.2 Routine Tests

All components shall have been tested in accordance with relevant IEC recommendations or other standards prior to assembly in the complete equipment.

Tests shall be carried out to prove the correct functioning and wiring of the complete equipment to the requirements of the Specification.

All secondary wiring including panel wiring and control circuits and all apparatus connected directly thereto shall withstand a high voltage test of 2 kV to earth unless subject to other requirements such as detailed under Protective Equipment.

1.14 Motors

1.14.1 Type Tests - A.C. Motors

One motor of each type shall be submitted to the following tests which shall be carried out in accordance with IEC 34.

- (a) Inspection at 50% assembly stage on h.v. motors 1.0 kV and above.
- (b) Loss tangent measurement on each phase of h.v. motors 5.0 kV and above.
- (c) Measurement of winding resistance also resistance measurement detectors and heaters where applicable.
- (d) Verification of direction of rotation relative to the phase sequence of the supply.
- (e) No load loss measurement at nominal voltage with check for balance with the machine unbolted from the bedplate. All h.v. motors shall be run for 15 minutes at 120% nominal voltage.
- (f) Temperature rise test.
- (g) Locked rotor test.
- (h) Verification of load characteristics and momentary excess torque capability.

- (j) Verification of capability to produce rated output at minimum transient voltage, with measurement of slip.
- (k) Measurement of breakaway, pull-up and pull-out torques.
- (m) Measurement of breakaway starting current. When this test is carried out at a reduced voltage due to limitation of test plant, allowance shall be made for the effects of saturation when deducing the value at nominal voltage.
- (n) Overspeed test at 120% nominal speed for 5 minutes on h.v. motors and prototype designs. (Visual examination on high speed or highly stressed rotors and welded rotor assemblies).
- (p) Dielectric tests including measurement of insulation resistance.
- (q) Noise measurement where applicable.
- (r) Vibration measurements when required.
- (s) High voltage test.

1.14.2 Routine Tests - A.C. Motors

All other motors shall be submitted to test (a), (b), (c), (d), (e), (g), (j), (n), (r), and (s) of the above.

1.14.3 Type Tests - D.C. Motors

One motor or each type shall be submitted to the following tests which shall be carried out in accordance with IEC 34 where appropriate.

- (a) Insulation resistances.
- (b) Resistance measurements of windings and heaters where applicable.
- (c) Winding polarity checks.
- (d) Light run figures and balance.
- (e) Load characteristics.
- (f) Temperature rise tests.
- (g) Commutation tests.
- (h) Overspeed tests.
- (j) High voltage test.

- (k) Noise tests where applicable.
- (m) The above tests shall be conducted on the first motor of each basic design although test certification for tests (f) and (k) may be submitted for approval.
- (n) Where special series or ballast resistors are used, these shall be tested with the motor.

1.14.4 Routine tests - D.C. Motors

Tests as for 16.3 above (a), (b), (c), (d), (g), (h), (j) and (n).

1.15 Oil Filtering and Storage Equipment

1.15.1 Routine Tests

All storage tanks shall be tested for oil tightness by being completely filled with insulating oil for a period of 24 hours during which time no leakage shall occur.

Alternatively, with the agreement of the Engineer, an air pressure test shall be made. Prior to the air test, the structural soundness of the tank shall be proved by a hydraulic test at a pressure not less than that to be employed for the air pressure test. Air pressure tests shall be made before painting or varnishing, under cover, and in the presence of the Engineer. The pressure shall be equal to the pressure of the normal maximum head of oil plus 35 kN/m^2 and when all joints are painted with an approved detector, there shall be no evidence of leakage.

1.15.2 Type Tests

- (a) Two tanks shall be fitted with oil subjected for 30 minutes to a test pressure equal to twice the normal pressure due to the head of oil when the tank is filled up to the normal level plus 35 kN/m^2 . There shall be no sign of leakage or undue strain during the test and no permanent distortion after the pressure has been released.
- (b) The oil pump of each size and type shall be tested in operation for six hours at the rating stated in the Schedules.

1.16 Material

1.16.1 Sample Tests

Samples selected by the Engineer from metals used in the Contract Works shall be tested to prove compliance with the Specification, including the guarantees stated in the Schedules.

1.17 Galvanising

1.17.1 Sample Tests

Representative samples, selected by the Engineer of all galvanised material shall be submitted to galvanising tests. Galvanised fittings associated with insulators, and steel cores for aluminium conductor steel reinforced cables shall be tested in line with the relevant IEC Recommendation. All other fittings, fabrications, hardware and fixings shall be inspected and tested in accordance with ISO Recommendations RI460 and RI461.

1.18 Structures

1.18.1 Type Tests

If required, one type of each structure shall be erected in the Works in order to check the fabrication of the steelwork.

If required, loads corresponding to the assumed conditions of loading shall be applied to the structures.

1.19 Insulating Oil and Gas

1.19.1 Sample Tests

Samples of oil and gas from each consignment shall be tested before despatch and shall comply with the requirements of IEC 296 and 376 respectively.

1.20 Compound

1.20.1 Sample Tests

Samples of compound selected by the Engineer from the bulk shall be tested to prove compliance with the requirements of the standards for the appropriate grade of compound.

1.21 Handling Devices and Lifting Tackle

1.21.1 Routine Tests

All handling devices and lifting tackle supplied for maintenance purposes under the Contract shall, unless they are built into and form part of the equipment, be tested, marked and certificates of test provided.

Lifting tackle built into and forming part of the equipment shall be operated with the maximum working load to the satisfaction of the Engineer.

1.22 Surge Arresters

1.22.1 Routine Tests

In accordance with the requirements of the IEC 99.1.

1.22.2 Type Tests

In accordance with the requirements of the IEC 99.1.

1.22.3 Sample Tests

In accordance with the requirements of IEC 99.1 Clause 68. A residual voltage test shall be carried out.

1.23 Batteries and Chargers

1.23.1 Routine Tests

The normal low-rate (float) charge voltage shall be set in the works at the specified voltage per cell when delivering 50% of rated load. At this setting it shall be demonstrated that the charger can maintain output voltage within the prescribed limits under the specified variations of input voltage and frequency and output load current.

The operation of the boost charge facility shall also be demonstrated. The correct functioning of all control indication and alarm devices shall be verified.

All secondary wiring shall be submitted to a high voltage test of 2 kV a.c. for 1 minute.

Where load voltage limiting regulators/diodes are to be connected it shall be demonstrated and recorded that the load voltage is maintained within -15% to +10% of rated voltage for all stages of battery charging conditions.

1.23.2 Type Tests

One or more cells, as may be agreed, of each battery type shall be submitted to a suitable discharge test in order to verify the guaranteed capacity. Continuous measurements of battery voltage shall be made together with periodic readings of the electrolytes specific gravity and temperature.

No addition to the electrolyte is permitted during this discharge test.

1.24 Low Voltage Switchgear

1.24.1 Routine Tests

Routine tests shall be carried out in accordance with the appropriate IEC Recommendation.

1.24.2 Type Tests

Type tests shall be carried out in accordance with the appropriate IEC Recommendation.

1.25 Transformers

1.25.1 Routine Tests

(a) Dielectric Tests - The windings and all connections of each transformer with its voltage control apparatus when completely assembled including bushing insulators or cable boxes, shall be subjected to dielectric tests in accordance with the provisions of IEC 76 except where these are varied by the following requirements:-

- (i) Where single phase induced voltage tests are used, the tests shall be applied to each phase in succession.
- (ii) The applied voltage test for 132 kV and above star connected windings shall be 38 kV.
- (iii) Insulation resistance tests on the windings shall be carried out by an approved method both before and after the high voltage tests.

Where the normal specified voltage ratio is adjusted to take account of anticipated voltage regulation the value of test voltage selected shall be based on that appropriate to the highest system voltage.

(b) Full-Wave Impulse - Voltage Withstand Tests. Each transformer of each outdoor design, rating and voltage ratio shall be in accordance with IEC 76.

(c) Other Tests - Each transformer shall be tested in accordance with IEC 76 to prove compliance with the guarantees in respect of the following:-

Fixed and load losses

Impedance Voltage

Regulation

Magnetising Current

Voltage ratio

Vector group reference

Winding resistance

Radio Interference Voltage - (in accordance with an agreed Standard)

1.25.2 Type Tests

- (a) Impulse-Voltage Withstand Test - One transformer of each outdoor design, rating and voltage ratio shall be subjected to the impulse tests specified below and such tests shall precede the power frequency tests on three-phase transformers. Impulse tests shall be made in accordance with IEC 76.

Neutral terminals shall be connected as in service, i.e. the neutrals of windings with graded insulation shall be earthed and neutrals of fully insulated windings shall be left isolated.

Approved means shall be provided to prevent voltages in excess of 75% of the design impulse voltage of the associated winding from appearing at the line terminals not under test.

Except where modified below at least one terminal of the winding or windings not under test on the same limb as the winding under test shall be solidly earthed.

The transformer tank shall be efficiently connected by low impedance copper strip to the impulse generator earth point and the whole well earthed. Arcing horns, if fitted to the transformer bushings, shall be adjusted to the maximum setting permitted by the bushing design or shall be removed.

The impulse voltage test shall comprise:-

- (i) One full wave voltage application followed by
 - (ii) Two chopped wave voltage applications followed by
 - (iii) Two full wave voltage applications
- (b) Temperature Rise Test - One transformer of each rating and voltage ratio with its own tank voltage control apparatus and cooling apparatus shall be tested in accordance with the provisions of IEC 76. Transformers with combined natural and forced cooling shall be tested at each specified rating and during these tests the accuracy of the oil and winding temperature

indicators shall be determined. Unless otherwise agreed with the Engineer the temperature rise test shall be carried out with the transformer on normal ratio.

- (c) Capacitance Test - If required by the Engineer the capacitance between windings and to earth shall be measured by an approved method.
- (d) Noise Level Test - Noise levels shall be measured with the transformer on no load at normal voltage and frequency. Where a transformer has more than one rating, measurements shall be repeated with the cooling system corresponding to each rating in operation.

All readings shall be made at "A" weighting using a precision sound level meter conforming with IEC 179. The calibration of this instrument shall be verified before and after the tests.

The background noise level shall be 10 dB below that of the transformer under test. Wherever possible the transformer shall be positioned at least 3 m from any reflecting surface. Where this is not possible any readings influenced by reflections may, at the discretion of the Engineer be disregarded when computing the average noise level.

Measurements shall be made at intervals not exceeding 1 m in a horizontal plane 1.2 m or half the tank height, whichever is the lesser, above the tank base. The microphone shall be located at points situated 0.3 m from an imaginary string passed round the transformer to include all major projections from the tank but excluding valves and similar fittings.

The average surface noise level shall be calculated from the average of the readings obtained.

1.25.3 Special Tests

Measurement of zero-phase sequence impedance - One transformer of each rating and voltage ratio with its own tank, voltage control apparatus, and cooling apparatus shall be tested in accordance with the provisions of IEC 76.

1.26 Voltage Control Equipment

1.26.1 Routine Tests

- (a) Duty Cycle - All switching apparatus, when completely assembled, shall be operated ten times in the normal manner through the complete cycle with the transformer unexcited. This shall be followed by one operation in the normal manner through the complete cycle when the transformer is energised at normal Volts on open circuit.

- (b) Dielectric Tests - Auxiliary circuits shall withstand the dielectric tests specified in IEC 214.
- (c) Operational Tests - The correct functioning of all control devices including limit switches and mechanical end stops shall be demonstrated.

1.26.2 Type Tests

In accordance with the requirements of IEC 214, the power frequency withstand voltage test to be applied between electrically adjacent contacts and connections shall be as follows:-

- (a) For normal service voltage above 120 kV or where the regulating equipment is connected to tappings at the neutral end; one quarter of normal service voltage shall be applied.
- (b) For all other cases the test shall be carried out at half the normal service voltage.

1.27 Magnetic Circuits

1.27.1 Routine Tests

- (a) After assembly each core shall be pressure tested for one minute at 2,000 Volts a.c. between all bolts, side-plates, structural steelwork and the core.
- (b) Immediately prior to the despatch of the equipment from the Contractor's Works the magnetic circuit shall be pressure tested for one minute at 2 000 Volts a.c. between the core and earth. Alternatively the test may be made with a 2,500 Volt megger and the transformer considered to be satisfactory providing a reading in excess of 5 megohms is obtained.

1.28 Cable Boxes and Disconnecting Chambers

1.28.1 Routine Tests

- (a) Oil Leakage - All cable boxes and disconnecting chambers shall be tested with oil with a viscosity not greater than that of the appropriate grade of insulating oil when at a temperature of 15°C at a pressure of 70 kN/m² for 12 hours during which time no leakage shall occur nor shall there be any permanent set when the pressure is released.
- (b) High Voltage - Cable boxes and disconnecting or sealing end chambers shall withstand the following voltages for 15 minutes:-

$$\text{or } \begin{array}{l} 2E \text{ kV d.c.} \\ \frac{4E}{3} \text{ kV a.c.} \end{array}$$

Where E is the rated nominal rated system voltage between phases.

1.29 Tanks

1.29.1 Routine Tests

- (a) Oil Leakage Test - All tanks and oil-filled compartments shall be tested for oil tightness by being completely filled with oil of a viscosity not greater than that of the appropriate grade of insulating oil at a temperature of 15°C and subjected to a pressure equal to the normal pressure plus 35 kN/m². This pressure shall be maintained for a period of not less than 24 hours, during which time no leakage shall occur.

1.29.2 Type Tests

- (a) Vacuum Test - One transformer tank of each size shall be subjected when empty of oil to a vacuum of 70 kN/m² below atmospheric pressure. The permanent deflection of flat plates after the vacuum has been released shall not exceed the value specified below.

<u>Horizontal Length of Flat Plate</u> <u>mm</u>	<u>Permanent Deflection</u> <u>mm</u>
Up to 750	5
Over 750 to 1,250	6.5
Over 1,250 to 1,800	8
Over 1,800 to 2,000	9.5
Over 2,000 to 2,300	11
Over 2,300 to 2,500	12.5
Over 2,500 to 3,000	16
Over 3,000	19

- (b) Pressure Test - One tank of each size together with its radiators, conservator vessel and other fittings shall be subjected to a pressure corresponding to twice the normal head of oil or to the normal pressure plus 35 kN/m² whichever is the lower. The permanent deflection of flat plates after the excess pressure has been released shall not exceed the figure specified in the Vacuum Test.
- (c) Pressure Relief Device Test - Where required by the Engineer one pressure relief device of each size shall be subjected to increasing oil pressure and shall operate

before reaching the test pressure specified. The operating pressure shall be recorded on the test certificate.

1.30 Cooling Plant

1.30.1 Routine Tests

- (a) Coolers - All coolers shall be filled with transformer oil and shall withstand for a period of 30 minutes a pressure equal to twice the maximum working pressure at the inlet to the cooler under service conditions. During this time no leakage shall occur.

The oil spaces and water spaces of all water-cooled oil coolers shall be tested separately to withstand an hydraulic pressure of 350 kN/m^2 for 15 minutes. All spaces which will be subsequently filled with oil shall be tested with oil of a viscosity not greater than that of insulating oil to the appropriate grade. While the tests are in progress the apparatus shall be hammered all over with a one kilogram hammer.

- (b) Pumps, Pipework and Valves - The bodies of all oil pumps and the oil pipework and valves shall withstand an hydraulic pressure of 140 kN/m^2 for 15 minutes. The testing medium shall be oil viscosity not greater than that of insulating oil to the appropriate grade.

Water pumps, water pipework and valves shall withstand an hydraulic pressure of 700 kN/m^2 for 15 minutes.

1.30.2 Type Tests

- (a) Cooling Plant - The cooling plant of such equipment as are subjected to temperature tests shall during these tests be subjected to such tests as the Engineer may require to prove compliance with this Specification.

1.31 Gas and Oil-Actuated Relays

1.31.1 Routine Tests

The following tests shall be made on relays when completely assembled and ready for mounting as in service. Where oil is referred to it shall have a viscosity not greater than that of the appropriate grade of insulating oil at 15°C .

- (a) Oil Leakage - The relay when filled with oil shall be subjected to an internal pressure of 140 kN/m^2 for 15 minutes. No leakage shall occur either from the casing or into normally oil-free spaces, such as floats, within the casing.

(b) Gas Collection

- (i) The relay shall be mounted in a straight run of pipework such that the provisions of the Specification are satisfied with regard to length and size on both the tank and conservator sides. With the relay mounted, as in service and at a rising angle of 5 degrees (tank to conservator) and full of oil, gas shall be introduced into the relay until the gas collection contacts close. The oil level reading at the time of contact closing shall be stated in the test certificate. The low oil level/surge contacts shall not close when gas is escaping freely from the relay on the conservator side. These contacts shall, however, close when the pipework is free of oil.
 - (ii) The empty relay shall be tilted, as if mounted in pipework rising from tank to conservator, at an increasing angle until the gas collection contacts open. The angle of tilt shall then be reduced and the gas collection contacts shall close before the angle is reduced to less than 13 degrees to the horizontal.
 - (iii) With the relay mounted at a falling angle of 16 degrees to the horizontal and full of oil, the gas collection contacts shall be open.
- (c) Oil Surge - With the same mounting condition as in test (b) (i) and with the relay full of oil at approximately 15°C, the surge contacts shall close within the steady oil flow limits specified in the Specification. This operation shall not be adversely affected when the gas collection contacts have already closed and gas is escaping freely.
- (d) Dielectric Test - With the relay empty of oil a voltage of 2 kV shall be applied in turn between each of the electrical circuits and the casing for one minute, the remaining circuits being connected to the casing.

1.31.2 Sample Tests

At the discretion of the Engineer any part or the whole of the following tests shall be made:-

With the mounting conditions prescribed in test (b) (i) the mounting angle shall be varied within the rising angle limits of 1° and 9° and tests made in accordance with those prescribed in tests (b) (i) and (c). It is permissible for this test to be combined with tests (b) (i) and (c).

1.32 XLPE Power Cables and Accessories

1.32.1 Routine Tests - Cables

Routine tests shall be carried out on each completed cable length of XLPE insulated power cable in accordance with IEC 60502 or IEC 60840 as appropriate to the type of cable under test and shall include the following:-

- (a) Conductor resistance test.
- (b) High voltage a.c. test.
- (c) Partial discharge test.
- (d) Electrical test on cables having graphite coated oversheaths:-

The oversheath shall withstand a d.c. voltage test equal to 8 kV per mm of sheath thickness applied between the metallic layer beneath the oversheath and the outer conducting coating for one minute subject to a maximum of 25 kV.

1.32.2 Special Tests - Cables

The Contractor shall carry out the special tests detailed in IEC 60502 or IEC 60840 as appropriate to the type of cable under test, and shall include the following:-

- (a) Conductor examination and dimensional check.
- (b) Bending Test/Partial discharge test.
- (c) Check of dimensions and thickness of insulation, screens, metallic sheath and oversheath on a sample from each drum of cable.
- (d) Volume Resistivity of Semi-Conducting Screens.
- (e) Insulation shrinkage tests.
- (f) Hot set tests.
- (g) Insulation/Screen moisture content test.
- (h) Tests at low temperature for PVC.

1.32.3 Type Tests - Cables/Accessories

The Contractor shall carry out the type tests detailed in IEC 60502 or IEC 60840 as appropriate to the type of cable under test.

These type test requirements may be waived on production of documentary proof that samples of similar cable manufactured in the same works with equivalent or larger conductor sections have passed identical or more onerous tests which have been witnessed by an approved electricity authority or their duly appointed representatives. Failure by the Contractor to provide such documentary proof in advance of cable manufacture commencing will render the Contractor liable to carry out the full type test programme.

1.32.4 Accessories

Accessories shall be tested in accordance with IEC60502 or IEC 60840 and in accordance with the relevant clauses of this Specification. Routine tests shall include material and dimensional checks on samples of accessories and type test assemblies shall include sealing ends and joints appropriate to the Contract which will be subject to lightning impulse voltage and dielectric security tests.

1.33 Auxiliary and Multi-Pair Cables

1.33.1 Routine Tests

- (a) PVC Insulated Auxiliary Cables
 - (i) Voltage test - Every drum of completed cable shall be tested without immersion in water for 5 minutes at 3 kV rms a.c. between conductors and between each conductor and the armour which shall be earthed. The voltage shall be increased gradually and maintained at the full value for 5 minutes.
 - (ii) Insulation resistance - After completion of the voltage test the insulation resistance between each conductor and the remaining conductors in the cable which shall be connected to the armour shall be measured and shall be not less than 18 megohms per 1,000m at 20°C for 2.5 mm² cross sectional area conductors.
 - (iii) Conductor resistance - The d.c. resistance of each conductor shall be measured and shall be not greater than the figure stated in Schedule 'D' when corrected to 20°C.
 - (iv) Armour resistance - The d.c. resistance of the armour shall be measured and shall be not greater than the figure stated in Schedule 'D' when corrected to 20°C.
 - (v) Insulation thickness - Measurements shall be made on representative samples of core taken not less than 0.30 m from the end of every factory length of cable, and the method of measurement shall be approved by the Engineer.

- (vi) Extruded bedding and sheath thickness - Measurements shall be made on representative samples taken not less than 0.150 m from the end of every factory length of cable, and the method of measurement shall be approved by the Engineer.
- (vii) Spark test on oversheath - The extruded oversheath shall be spark tested in an approved manner.

(b) Polyethelene Multi-pair Cables

- (i) Voltage test - Every drum of completed cable shall be tested between conductors and between all conductors and the armour which shall be earthed. No breakdown of the insulation shall occur. The voltage shall be increased gradually to 5 kV a.c. or 10 kV d.c. and maintained at the full value for 1 minute.
- (ii) Insulation resistance - The insulation resistance shall be measured between each conductor and the other conductors connected to the armour after completion of the voltage test. The measured value shall not be less than that indicated in Schedule 'D'.
- (iii) Conductor resistance - The d.c. resistance of the conductors shall be measured and the results when corrected to 20°C shall not be greater than the figures stated in Schedule 'D'.
- (iv) Mutual capacitance of telephone pairs - The mutual capacitance shall be measured between the two conductors of each telephone pair with other conductors of the cable and the armour earthed. The mean value using alternating current and a suitable bridge shall be recorded.
- (v) Capacitance unbalance - Measurement of pair-to-pair capacitance unbalance shall be made at a suitable audio frequency with all other conductors and any screen connected to the armour and earthed. The measured value shall be divided by:-

$$* \left(\frac{L}{500} + \frac{L}{500} \right)$$

Where L is the length in metres.

- (vi) Mutual inductance - Measurements shall be made at 5 kHz on carrier pairs. The measured value shall be divided by:-

$$* \left(\frac{L}{500} + \frac{L}{500} \right)$$

Where L is the length in metres.

- (vii) Spark test - The PVC oversheath shall be subject during manufacture to a spark test in an approved manner. The voltage applied between electrode and armour shall be 6 kV a.c. per mm of thickness or 9 kV d.c. per mm of thickness.

1.33.2 Sample Tests

- (a) PVC Auxiliary Cables
- (b) Polyethelene Multi-pair Cables

Sample tests shall be carried out on the first length and on not less than 10 per cent of drum lengths of cable supplied to the contract.

The method of testing insulation and sheath shall be in accordance with IEC Recommendation No. 540. The physical examination of cable shall include measurement of insulation and sheath thickness, diameter and number of armouring wires, cable diameter and make up of cable to comply with the Schedule 'D' particulars.

1.34 Fibre Optic Cable

1.34.1 General

As provided in the Conditions of Contract, the whole of the materials used in the Works shall be subject to inspection and tests at the works as the Engineer may direct from time to time as the work proceeds. The whole cost of such inspection and tests, including the provision and use of equipment, shall be included in the Contract.

1.34.2 Factory Systems Acceptance Tests

Prior to shipment to Site, a test of the fibre optic system shall take place at the Supplier's factory. This factory test shall be witnessed and approved by the Engineer.

The test is intended to check the following:-

- (a) That the units operate correctly within specified tolerances when connected as a system in its operational configuration.
- (b) That the fault rate is acceptably low during an extended period of operation and that the availability of the complete system is high.
- (c) The length of time and technique necessary to carry out a satisfactory repair on each of a number of agreed faults shall be demonstrated to the satisfaction of the Engineer.

The duration of the factory system test shall be not less than 200 hours and shall be in periods of not less than 100 hours.

The Engineer reserves the right to re-initiate the 200 hours system test if he considers the equipment performance to be unsatisfactory.

The Engineer reserves the right to specify additional tests on any equipment where necessary.

The Contractor shall draw up and agree with the Engineer schedules of measurements to be taken over the 200 hour period to verify that the system meets the Specification.

For the purposes of the Factory Acceptance Tests the optical fibres may be simulated by the use of optical attenuators. The attenuators shall be set to a value representative of the attenuation expected on the optical fibres, plus the 6 dB system margin.

2 SITE AND COMMISSIONING TESTS

2.1 General Test Requirements

2.1.1 Procedure

Not less than 2 months before the commencement of site testing the Contractor shall submit to the Engineer a test programme for all sites to meet the erection and commissioning programme agreed.

Together with this programme the Contractor shall provide in adequate time for approval by the Engineer before site testing is due to commence a set of pro forma test forms for each item or type of equipment showing details of the proposed tests, checks and method of recording results. A list of all general checks shall also be included. The forms shall record type of equipment, serial numbers and any other identifying marks, substation name and circuit identification and shall include space for the test Engineer's and witnessing Engineer's signature.

No testing shall commence until the format and test procedures are agreed and all results shall be submitted on the approved form.

Where testing of common equipment such as bus zone protection and voltage selection schemes are involved as extensions to existing and operational sites the submission shall clearly state the outage requirements or 'risk of trip' conditions which would apply to operational plant and where wiring modifications are involved on existing plant marked diagrams shall be submitted showing any wiring additions and deletions if these have not been previously submitted.

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

The Contractor shall advise the Engineer in writing at the time of commencement of site erection of the site supplies which will be required for the operation of the test equipment.

The Contractor shall provide the requisite experienced test personnel and all relevant test equipment, unless otherwise agreed by the Engineer or stated in the Schedules.

On completion of any group of tests the Contractor shall submit two clean copies of the test results recorded on the approved form. The Engineer shall countersign the test sheets if found to be satisfactory and retain one copy.

The Contractor shall subsequently provide to the Engineer six bound copies of all site test sheets as final records. The test sheets shall be grouped by substation subdivided by plant type and further on a circuit-by-circuit basis.

So that the records may be used for maintenance tests the final records shall be provided as soon as possible after completion of testing.

No tests as agreed under the programme of tests shall be waived except upon the instruction of the Engineer in writing.

All tests shall be carried out in the presence of the Engineer unless otherwise agreed.

2.1.2 Standards and Methods

The method of testing, unless specified in the Schedules, shall be agreed with the Engineer.

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

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

The testing requirements detailed under this Specification may be subject to some variation upon the instruction or agreement of the Engineer where necessitated by changed conditions at Site or by differing design, manufacture or constructional techniques.

2.2 Protection, Control, Alarm, Measurement and Indication Equipment

2.2.1 Wiring

Insulation Resistance Test at not less than 500 Volts d.c. are to be carried out on all a.c. and d.c. protection, control, alarm and indication circuits to ensure that wiring is in a satisfactory condition. The insulation of all circuits shall be checked before proceeding with other tests and it is also essential that all a.c. wiring is proved, relay contacts, auxiliary contacts, etc., being operated to verify this. Wiring checks for completeness shall be made before testing commences on cable glands, cable jointing, fuse or circuit-breaker ratings and small panel items such as indicating lamps.

Static equipment which may be damaged by the application of test voltage shall have the appropriate terminals short-circuited.

Inter-relay, inter-unit and cubicle wiring carried out at Site is to be checked to the appropriate circuit wiring diagram. Where it is found necessary during pre commissioning work to effect Site modifications to the secondary wiring, Site copies of the appropriate schematic and wiring diagrams shall be suitably marked as agreed with the Engineer before the circuit is commissioned.

Loop resistance measurements are to be made on all current transformer circuits. Separate values are required for current transformer and lead resistance and all measurements are to be recorded on lead resistance diagrams.

Pilot cable lead resistance and intercore capacitance measurements shall be made when pilot cables are to be used with unit type protection. The Contractor responsible for the protection equipment commissioning shall measure these values.

2.2.2 Mechanical Inspection

All relays are to be examined to ensure that they are in proper working condition and correctly adjusted, correctly labelled and that the relay case, cover, glass and gaskets are in good order and properly fitting.

2.2.3 Secondary Injection

Secondary injection shall be carried out on all a.c. relays, using voltage and current of sinusoidal wave form and rated power frequency.

When testing distance relays a switched voltage and current input should be used to simulate fault conditions.

For circulation current protection employing voltage operated relays, the points of injection for relay voltage setting tests shall be across the relay and stabilizing

resistance. The fault setting for this type of protection is to be established by secondary injection, where it is impracticable to ascertain this value by primary injection. Injection is to be made across the appropriate relay bus wires with all associated relays, setting resistors and CTs connected.

2.3 Current Transformer Magnetising Tests

The magnetisation characteristic of all current transformers shall be checked at a sufficient number of points to identify the current transformers with reference to the Manufacturer's estimated design curve and to determine the suitability of the current transformer for its intended duty. It may be noted that it is not normally necessary to check the characteristic up to the knee-point for this purpose. Special measures may have to be taken to ensure that the core is fully demagnetised before commencing the test.

2.3.1 Primary Injection

Primary current injection tests are to be carried out by the Contractor. The primary injection methods employed for a particular installation are to be agreed with the Engineer.

Tests are to be carried out as follows:-

- (a) Local primary injection to establish the ratio and polarity of current transformers as a group, care being taken to prove the identity of current transformers of similar ratio.
- (b) Overall primary injection to prove correct inter-connections between current transformer groups and associated relays.
- (c) Fault setting tests to establish the value of current necessary to produce operation of the relays.

2.3.2 D.C. Operations

Tests are to be carried out to prove the correctness of all d.c. polarities, the operating levels of d.c. relays and the correct functioning of d.c. relay schemes, selection and control switching, indicating and alarms.

2.3.3 On-load Tests

In view of the hazards inherent in these tests, they shall be carried out under the direct supervision of the Engineer and/or the Employer.

An operation and stability test shall be carried out for on load commissioning of unit type protection.

Test for restraint shall be carried out to prove the characteristics of protective systems with directional characteristics.

On-load checks shall be made after the protection gear has been placed in service to ensure that all connections and test links have been replaced and test leads removed as well as to confirm the integrity of the current transformer circuits. Where necessary voltage readings shall be taken at the terminals on each relay to ensure that loop connections between the relays are complete. Special attention shall be paid to broken delta voltages and residual current circuits where zero voltage or current respectively may not be proof of the completeness of the circuit.

2.4 Transformers and Reactors

- (a) General mechanical checks.
- (b) Core and winding insulation tests.
- (c) Ratio and h.v. magnetisation current tests.
- (d) Vector group check.
- (e) Motors - overload protection tests.
- (f) Buchholz device tests.
- (g) Temperature instrument calibration and tests.
- (h) Operational tests on tap change equipment.
- (j) Electric strength tests on insulation oil.
- (k) Oil/SF6 bushing tests.

2.5 Switchgear

2.5.1 General

A general check of all the main switchgear, labelling and ancillary equipment shall be made and shall include a check of the completeness, correctness and condition of earth connections, arcing ring and horn gaps, painted surfaces, cables, wiring, pipework, valves, blanking plates and all other auxiliary and ancillary items. Checks shall be made for oil and gas leaks and that insulators are clean and free from external damage. A check shall be made that loose items which are to be handed over to the Employer, e.g. blanking plates, tools, spares, are in order and are correctly stored or handed over.

2.6 Main Circuit-Breaker Tests

Following completion of erection of metal-clad and metal-enclosed switchgear all high voltage circuits and apparatus shall withstand a high voltage withstand test with a.c. voltage at a level to be agreed. If an acceptable alternative site test is proposed, e.g. impulse test, the a.c. test shall have been carried out on all the equipment at the Manufacturer's Works.

Local air components associated with pneumatic operation, including air compressors, shall be tested and air loss measurements and pressure and alarm settings checked. Tests shall be made also on mechanical and hydraulic operating systems.

Contact resistance tests shall be carried out with not less than 15 amperes passing through the contacts. In the case of multi- interrupter circuit-breakers resistance tests will be required at each interrupter or pair of interrupters as well as through the series of interrupters on each pole.

Operational tests will include local and remote trip/close. Circuit-breaker timing tests shall be carried out on all circuit- breakers. Circuit-breakers rated below 60 kV and which are both not assembled at Site and have mechanically ganged pole operation are excepted.

In the case of gas type circuit-breakers testing will be required on the gas system to prove the gas quantity, its dryness and its dielectric strength. The gas leakage shall also be measured.

2.7 Low Voltage Switchboards and Switchboards up to 12 kV

General testing and inspection shall be carried out as referred to above so far as is applicable. Attention is drawn to the requirement for functional testing and timing testing on circuit- breakers and a.c. and d.c. circuits associated with standby auxiliary supplies and standby generating sets, particularly where automatic operation is specified.

Insulation tests shall be carried out with a 500 Volt insulation test set.

Shutters, interlocking, earthing procedures and the inter- changeability of components shall be checked.

2.8 Isolators, Earthing Switches and Switch Isolators

Manually operated equipment shall be subject to operational tests to confirm contact pressures, contact resistance, synchronism of operation of all phases and the ease of operation.

Checks shall be made of the local and remote indications and operation of auxiliary contacts.

Motorised equipment shall be tested to prove the motor operation, including local and remote operation. Timing tests shall also be carried out. Motors shall be subjected to overload and single phasing tests.

Earth switches and maintenance earthing devices shall be tested to confirm the opening and closing sequences and checks shall be made on the earth mat, indications and manual locking devices.

2.9 Voltage Transformers

The following tests shall be carried out on electromagnetic type voltage transformers:-

- (a) Insulation tests at 500 Volts to earth and between windings.
- (b) Checks on gas/oil relays.
- (c) On oil-filled units of 60 kV system voltage and above, a check on no-load current and gas accumulation by exciting the transformer for 30 minutes from the secondary windings with the primary disconnected.

All voltage transformers shall be checked for polarity phasing and for secondary output.

In the case of capacitor voltage transformers used as carrier coupling units tests will be required on the coupling equipment and on the high frequency earth rods and their connections.

Where voltage transformers form part of h.v. metal-enclosed switchgear they shall be subject to the high voltage tests after erection as specified in IEC 517.

2.10 Busbars and Connections

Flexible busbars and connections shall be tested to ensure that the correct tensions, sags and clearances will be maintained over the range of environmental conditions and loads without stress to other equipment. If dynamometers are used to check the sags and tensions, they shall be checked both before and after use.

Rigid busbars and connections shall be tested to ensure that the busbars will not cause overloading of the supporting insulators under load conditions and under the range of climatic variations applicable to the Site, that expansion and contraction of the equipment is fully accommodated by flexible connections.

Conductivity tests are required on all connections and joints which are made on Site without exception.

2.11 Earthing System

Tests shall be made on the effectiveness of the bonding and earthing which will include conductivity tests on selected joints, on the main earthing system, and at the connections to equipment and structures. Checks shall also be made on precautions taken to avoid corrosion attack on the earthing system.

The resistance of the earthing system to the general mass of earth shall be tested and recorded including the method and equipment used to carry out the tests. Test probes at approximately 300 and 600 metres separation will normally be required to effectively test the earthing system at major substations. The use of transmission line conductors may be arranged to simplify these testing procedures.

2.12 Batteries and Battery Charging Equipment

The insulation to earth of the complete d.c. installation shall be tested.

Tests shall be carried out on the batteries and chargers to confirm the charger ratings and adjustment and on the battery and charger alarm systems and to confirm battery capacity.

The specific gravity and cell voltages of the batteries when fully charged shall be recorded.

2.13 Instruments and Meters

Instruments and instrument transformer circuits shall be checked for polarity or direction and for calibration including any interposing transformers or transducers. These checks shall be made on all current transformer ratios.

Meters shall be checked for correct operation and rotation. The meters will subsequently be taken to the Employer's test laboratory and if they are found to be inaccurate and out of limits will be dealt with as a defect during the guarantee period rather than a commissioning defect.

2.14 High Voltage Surge Arresters

Tests shall be carried out in accordance with IEC 99-1, 1A or 2 as applicable.

General inspection shall be carried out to verify the condition and satisfactory mounting of the arrester and its earth connections and electrodes.

Secondary injection tests shall be carried out on surge counters to prove their operational characteristics.

2.15 Interlocking

All interlocking arrangements both electrical and mechanical shall be fully checked and tested.

2.16 Cables

2.16.1 XLPE Cables

(a) Conductor Resistance Test

The d.c. resistance of each conductor of every completed cable shall be measured and recorded and shall not exceed the figure stated in Schedule 'D' after correction for temperature to 20°C.

(b) High Voltage Test

For a system voltage of 11 kV a test voltage of 25 kV d.c. shall be applied between conductor and screen for 15 minutes.

For a system voltage of 66 kV a test voltage of 72 kV a.c. shall be applied between conductor and screen for 1 hour.

(c) Voltage Test on Extruded Anti-Corrosion Sheath

The completed installation shall withstand an applied voltage of 4 kV d.c. per mm of covering thickness with a maximum of 10 kV d.c. between screen, sheath or armour and the external conducting (graphite) surface of the covering for one minute.

(d) Measurement of Positive Phase and Zero Phase Sequence

Impedance

Positive phase and zero phase impedance shall be calculated from recorded values of current, voltage and either power or phase angle measured by means of 3-phase and single phase current injection tests carried out on all single core cable circuits.

All sheaths shall be earthed as for normal operation and where a circuit contains two cables per phase the test shall be carried out on the total circuit in addition.

Resistances shall be adjusted to working temperature from recorded ambient cable temperatures. Contact resistances shall be checked to ensure they are small compared with conductor resistance.

2.16.2 PVC Insulated Auxiliary Cables

- (a) Voltage Test - Each 600/1,000 Volt PVC insulated cable shall after installation and glanding but before connecting tails to equipment terminals be tested at 3.5 kV d.c. During the test the voltage shall be increased gradually to the full value and maintained continuously for 1 minute between conductors and between each conductor and armour without breakdown.
- (b) Insulation resistance - The insulation resistance of each completed cable circuit shall be measured and recorded.
- (c) Capacitance - The capacitance of each core of each completed cable circuit shall be measured and recorded.

2.16.3 Polyethylene Insulated Multi-pair Cables

- (a) Voltage test - After installation, jointing and glanding but before connecting to equipment terminals the cable shall be tested at 8.5 kV d.c. between conductors and between conductors and armour for 1 minute at the full value.
- (b) Conductor resistance - The conductor resistance shall be measured and recorded.
- (c) Insulation resistance - The insulation resistance shall be measured between each conductor and the other conductors and armour after the application of 500 V d.c. for one minute. The measured values shall not be less than 500 millions when corrected to 20°C.
- (d) Capacitance - The capacitance of each core of each completed cable circuit shall be measured and recorded.
- (e) Attenuation - The attenuation of audio and any carrier pairs shall be measured and the corrected values shall not exceed those stated in Schedule 'D'. The measured attenuation shall be corrected by multiplying the value recorded by $1 + 0.0016 (T-20)$ where T is the temperature of the cable in degrees celsius.
- (f) Cross-talk - The cross-talk between all pairs shall be measured and shall not be less than the values stated in Schedule 'D'.
- (g) Impedance - Measurement of the impedance of all pairs shall be made over a range of frequencies to be agreed, to record the spread of values.

2.16.4 Fibre Optic Cable

The Contractor shall draw up and agree with the Engineer a schedule of tests to prove that the installed system meets the requirements of the Specification. These tests shall include but not be limited to the following:-

- (a) Attenuation of each fibre between each transmitter and receiver in the direction of transmission.
- (b) Backscatter tests from each end of each fibre.
- (c) Bandwidth of each fibre between each transmitter and receiver in the direction of transmission.
- (d) Bit error rate measurement.
- (e) Correct operation of all alarms.
- (f) VF performance.

3 TESTS ON COMPLETION

3.1 General

Tests on completion shall be carried out after all erection and site tests have been satisfactorily completed and shall include:-

- 1 Energisation of each busbar level at 10% above normal system voltage period of 15 minutes. The tests shall be conducted in such a manner that all equipment is satisfactorily proven.
- 2 Energisation of all equipment under no-load condition, normal system voltage, for 48 hours.
- 3 Verification of correct indication of all instruments and meters under varying loads and voltages.
- 4 End-to-end tests of F.O. operated protection, intertripping and communications circuits under live line conditions, including F.O. attenuation measurements. Operational tests on C.B. switching and synchronising equipment.
- 5 Directional tests on distance, and directional overcurrent and earth fault protection where appropriate.
- 6 On-load stability tests of unit protection systems.
- 7 Phasing checks on LVAC systems, VT supplies and main systems.

- 8 On-load and voltage operational checks on transformer tap changers, coolers etc.
- 9 Energise and 'soak' transformers for a period of 24 hours.
- 10 Check buchholz for gas collection after 24 hours operation.

The exact nature of the tests and presentation of the results shall be to the approval of the Engineer.

SECTION 22

SUBSTATION CIVIL WORKS

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SUBSTATION CIVIL WORKS

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SECTION 22
SUBSTATION CIVIL WORKS

1. GENERAL

1.1 Scope of Works

The civil engineering and building works include the design, detailing, construction and maintenance for the defects liability period of the whole of the works.

These works shall include, but not be limited to, the following:-

1.1.1 Union and Vieux Fort Substations

- (a) Site preparation
- (b) Ground improvement, (if found necessary)
- (c) A new Transformer foundation and enclosure at Union and the modification of existing foundations and enclosures at Union and Vieux Fort to cater for the replacement transformers, including sufficient oil interceptor and drainage to handle the increased volume of transformer oil.
- (e) Equipment foundations for switchgear.
- (f) All necessary site services, cable racks and trenches.
- (g) Modification to surface water drainage system to suit.
- (h) Installation or modification of surfacing as required.
- (i) Installation of and modification to fencing at Union

The works shall also include all such other miscellaneous civil engineering and building works as may be necessary for the satisfactory and safe construction, operation and maintenance of the works.

1.2 General Requirements

The work shall be carried out by the Contractor who shall be wholly responsible for ensuring that all materials used in the work and temporary works comply with the approved standards, and that all processes of construction are carried out with a high degree of efficiency, in accordance with an approved programme, and in compliance with the requirements of this specification.

While the civil works are in progress the Contractor shall employ a suitably qualified competent English speaking civil engineer full-time at site to verify the

work and monitor progress. He shall be responsible for liaison with the Engineer's Representative.

The Contractor shall inspect, check and test each item of the works and assure himself that it is wholly satisfactory before submitting any item to the Engineer for his approval.

The Engineer's Representative will be responsible for ensuring, through inspections, meetings and discussions, that the Contractor exercises competent supervision over his work-force and will have the power to instruct the Contractor to remove any work which, in his opinion, is unsatisfactory, and to reconstruct such work to his satisfaction.

All work shall be carried out in accordance with recognised standards of safety, and the Engineer's Representative will have the power to instruct the Contractor to comply with any requirements in this respect which he may deem desirable. This will not relieve the Contractor of any of his obligations under the Contract. All personnel working on the site shall wear appropriate protective clothing including safety helmets. At all entrances to working areas there shall be notices stating that the site is a "hard hat" area.

All work shall be constructed to the lines and levels shown on the drawings prepared either by the Contractor and approved by the Engineer, unless varied by written instruction of the Engineer, or prepared by the Engineer.

The civil engineering works shall be carried out to a standard of workmanship compatible with best practice, and an indication of the minimum acceptable standard of workmanship is given in this specification. All elements shall be designed to require minimum maintenance and be of durable construction.

All designs shall be prepared in accordance with the best current engineering practice and with the requirements of the appropriate National Codes of Practice and Standards approved by the Engineer in so far as they are applicable and current.

Any departure from the approved Codes and Standards shall be fully submitted in writing to the Engineer for his approval.

1.3 Site Conditions

Tenderers are required to make their own assessment of the existing conditions.

All foundations shall be treated with anti termite material before commencing any construction.

1.4 Architecture

The architecture of the substation sites, shall conform to an overall concept which shall be suited to the site and its topography

Buildings shall be aesthetically pleasing both externally and internally and be suitable for all operating and climatic conditions prevailing.

A high standard of finish shall be provided throughout.

The colour scheme for the buildings shall be to the approval of Lucelec.

1.5 Description of Works

- 1.5.1 Ducts for cables shall be surrounded with concrete, and jointed and sealed to ensure that cables are completely dry at all times. Bell mouths and bends of adequate radius shall be employed. All ducts into substation buildings will be sealed to prevent ingress of water into those buildings.

All trench covers shall be manually removable.

Site rainwater shall pass directly into a surface water drainage system leading via an oil/water separator to a suitable and approved discharge point beyond the site.

1.5.2 Transformer Compounds

Transformers shall sit on a reinforced concrete base within a reinforced concrete pit provided to retain any oil that may be accidentally spilt from the transformer.

The transformer pit may be filled with 40mm single sized stone or be surfaced with gravel supported on a galvanised steel grid. In either case, the net volume of the pit shall be sufficient to retain the spillage of the total volume of the oil in the transformer plus 24 hours rainwater. A minimum of 0.3 metre freeboard shall be allowed for added water volume.

The transformer pit shall be provided with a manually controlled oil separator and drainage sump.

The dimensions of each compound shall be adequate for installation, operation and removal, and to allow for sufficient cooling of the transformers.

The ground in front of the enclosures shall be suitably treated to facilitate installation, maintenance and replacement of the transformers.

Surfaces shall be sloped away so that the storm water run-off into the pits are eliminated.

1.5.3 Fencing

Union

The existing fence along side the main road at Union substation shall be provided with a one metre high reinforced concrete upstand that is to act as a crash barrier and shall protect the substation equipment from damage by any vehicle crash from the main road. The fence shall then have a galvanised chain link security fence topped with 6 strands of barbed wire to give an overall height from the ground of 3.9 metres. The fence shall be supported by galvanised steel angles with cranked tops set in concrete foundations. The fence shall be complete with all necessary struts, braces and straining wires.

2 MATERIALS

2.1 General

All materials incorporated in the Works shall conform to the requirements of an approved standard or code of practice. The Contractor will be required to supply sufficient information in English to enable the Engineer to determine the suitability of any material.

The location layout and quality of all architectural finishes shall be subject to the approval of the Engineers site representative.

All architectural and services finishes and fittings such as wall floor and ceiling tiling, doors, door furniture, sanitary plumbing and light fittings etc. shall be submitted to the Engineer on site at the earliest opportunity for the purpose of obtaining written approval of their acceptability. Such items shall be in accordance with this Specification and of the highest quality. Where possible, they shall be from local sources.

The Contractor shall, wherever possible, provide samples and/or illustrated brochures with his submission.

No additional costs or delay shall be allowed due to the Contractors failure to obtain Engineers approval to these items in time to meet his construction programme.

The Engineer may at his discretion and the Contractors cost, order such tests as he may deem necessary to prove the acceptability of any material.

The Contractor shall provide, erect and maintain adequate temporary facilities for the storage of materials brought onto site. Such facilities will be subject to the approval of the Engineer. Any facilities deemed to be inadequate to maintain the materials stored therein, shall be immediately replaced and any material stored in an inadequate facility will be subject to rejection by the Engineer.

Any approved material of proprietary manufacture shall be stored and used strictly in accordance with the manufacturers instructions/recommendations.

2.2 Inspection

As soon as practicable after the Contract has been awarded, the Contractor shall submit to the Engineer, a list of suppliers from whom he intends to purchase the materials necessary for the execution of the Works.

Each supplier must be willing to admit the Engineer to his premises during ordinary working hours for the purpose of obtaining samples of the materials in question. Alternatively, if required by the Engineer, the Contractor shall deliver samples of the materials to the Engineer's office.

2.3 Testing

The Contractor will be required to provide facilities for carrying out all testing deemed necessary by the Engineer to verify compliance of any materials with the Specification

The Contractor shall grant the Engineer or his representative full access at all times to the testing facilities provided and shall produce on demand, full records of testing carried out on materials for the Works.

The entire costs involved in testing and all remedial works shall be borne by the Contractor whether testing proves the work under investigation. to be to specification or not.

3 EARTHWORKS

3.1 Site Clearance

The Contractor shall clear all areas of the site over which the Works are to be constructed. He shall remove all debris to sites approved by the Engineer and no debris shall be deposited except on such sites.

3.2 Surface Levels

Before any work on any section of the Works is commenced levels of the ground surface shall be taken, and a drawing for record purposes provided to the Engineer. All levels shall relate to the existing Datum.

3.3 Unsuitable Material

Where in the opinion of the Engineer existing material to be retained by or to support new works is unsuitable the Contractor shall remove such unsuitable material and replace it with filling approved by the Engineer.

3.4 Excavations

Where excavation is in un-supported open cut the Contractor shall be entirely responsible for ensuring that the side slopes are suitable for stability. The sides of excavation in trench shall be made secure by means of adequate supports.

The excavation shall be carried out by the Contractor in such a way as to avoid disturbance to the surrounding ground. The Contractor shall comply with all instructions of the Engineer regarding the supporting of the sides of excavation but such compliance shall not relieve him of any of his responsibilities under the Contract for the safety of the Works and to personnel.

The excavated surfaces shall be kept dry and clean by pumping or otherwise and no concrete, masonry, brickwork or other materials shall be placed or built until the surfaces are properly drained.

The Contractor shall submit, for the Engineer's approval, his proposals for disposing of water arising from dewatering excavations.

3.5 Approval of Excavation

When excavations, whether in open or in trench, have been accurately taken out to the profiles or dimensions required for the work, due intimation shall be given by the Contractor to the Engineer and the same be inspected by or on behalf of the Engineer.

3.6 Excavation Beyond True Line and Level

If from any cause whatsoever excavations other than for concrete work are carried out beyond their true line and level other than at the direction of the Engineer, the Contractor shall at his own cost make good to the required line and level with concrete or other approved material and in such a manner as the Engineer may direct

3.7 Disposal of Spoil

The Contractor shall remove spoil from excavations and shall place it at a dumping point designated (or approved) by the Engineer.

3.8 Filling

Filling of trenches and other excavations shall unless otherwise specified be formed with selected materials as approved by the Engineer. The materials shall be placed in layers not exceeding 200 mm thick and compacted to 95% of its optimum dry density.

The Contractor shall take particular care in placing and compacting filling around pipes, cables, structures and the like.

The Contractor shall make good any damage or defects to the Works caused by settlements, slips or falls to any excavations or embankments.

3.9 Subsoil Improvement

Should the Contractor consider any form of subsoil improvement, he shall, prior to the mobilisation of any sub-contractor, provide for the Engineer's approval a detailed method statement. Such a statement, shall indicate the nature and extent of the ground improvement and proposals for ensuring that the site is kept clean and free from excessive water/mud throughout the ground improvement operation.

3.10 Stabilisation

Prior to the mobilisation of any subcontractor the Contractor shall provide a detailed method statement to the Engineer for approval.

4 CONCRETE AND REINFORCED CONCRETE

4.1 General

The Contractor may obtain concrete from a suitable ready mix supplier or suppliers subject to the approval of the Engineer

Approval of any supply will depend upon the Engineer being satisfied that concrete can be consistently supplied to specification in the required quantities. The Contractor shall demonstrate, with certification where required, that all materials comply with the Specification and that they are correctly stored and batched by suitable equipment.

4.2 Materials

4.2.1 Cement

Cement shall comply with the following types:

(a) Ordinary Portland Cement (OPC)

Cement complying with BS12 but containing not less than 4% and not more than 13% by mass of tri-calcium aluminate.

(b) Moderate Sulphate Resisting Portland Cement (MRSPC)

Cement complying with BS12 but containing not less than 4% and not more than 8% by mass of tri-calcium aluminate, or cement complying with ASTM C150 Type II. In either case, the cement shall not contain more than 2.7% by mass of sulphur trioxide.

(c) Sulphate Resisting Portland Cement (SRPC)

Cement shall comply with either BS 4027 or ASTM C150 Type V.

Cement shall comply with the following requirements:-

- (d) The acid-soluble alkali level measured as $(Na_2O + 0.658 K_2O)$ shall not exceed 0.6% by mass.
- (e) The heat of hydration shall not exceed 75 calories per gramme at 7 days when tested in accordance with ASTM C186.
- (f) The specific surface shall not be greater than 325 m²/Kg and not less than 225 m²/Kg when tested as described in BS 4550 Part 3 Section 3.3
- (g) The temperature of the cement shall not exceed 75°C at the time of incorporation into a concrete mix.

High alumina cement shall not be used in any part of the Works.

4.2.2 Aggregate - General

Aggregate shall be free from earth, clay, loam and soft clayey shaley or decomposed stone, organic matter and other impurities and shall be hard and dense.

The percentage of hollow shells shall not exceed 3% by mass retained on a BS 2.26 mm sieve.

Aggregate to be used in the construction of structures for retaining aqueous liquids shall comply with Clause 21.2.3 of BS 5337. Aggregate shall conform in all respects with BS 882 and 1201.

The combined grading of aggregates shall be constant for each approved design mix. New trial mixes shall be prepared whenever the combined grading of the concrete for the works varies by more than 4% from the grading in the approved design mix.

4.2.3 Fine Aggregate

Fine aggregate shall be capable of passing through a 5 mm BS test sieve and shall be graded so that when mixed with the coarse aggregate and cement, a concrete of maximum density is produced. It shall not contain appreciable amounts of flaky or elongated particles.

Crushed sand may be added to natural sand in approved proportions in order to achieve the required grading. Crushed sand alone may not be used without approval. The amount of material passing a 75 micron BS 410 fine test sieve when

tested in accordance with the BS 812 (wet sieving method) shall not exceed 3% by mass.

The use of beach sand dug from above high water level at authorised locations is permissible subject to compliance with specified grading and salt limits.

4.2.4 Coarse Aggregate

Coarse aggregate shall be totally retained on a 5.00 mm BS test sieve; the grading shall be within the limits prescribed in BS 882 Table 1 so that when mixed with the approved fine aggregate and cement a workable concrete of maximum density is produced. The densities of the classes of concrete shall be as approved after tests have been carried out on the site.

The amount of material passing a 75 micron BS 410 fine test sieve when tested in accordance with BS 812 (wet-sieving method) shall not exceed 1% by mass.

Coarse aggregate shall be tested for drying shrinkage characteristics in accordance with BRS Digest No. 35.

When subjected to 5 cycles of the soundness test specified in ASTM C88, coarse aggregate shall not show a loss exceeding 10% when magnesium sulphate solution is used.

The flakiness and elongation indices of the predominant size fractions in each single-sized coarse aggregate, determined in accordance with BS 812, shall not exceed 20% and 25% by mass respectively.

Material for use in concrete which is subject to abrasion and impact shall comply with the test requirements of BS 812 and the specifications of BS 1984 and BS 882.

4.2.5 Potential Alkali Reactivity

Aggregate shall not contain any materials that are reactive with alkalis in the aggregate itself or in the cement, the mixing water or in water in contact with the finished concrete or mortar in amounts sufficient to cause excessive localised or general expansion of the concrete or mortar.

The Contractor may initially assess an aggregate source by testing in accordance with ASTM C289. If potential reactivity is indicated, then mortar bar tests in accordance with ASTM C227 shall be carried out and the results shall comply with the limits given in ASTM C33 for overall effect on the permanent works mixes, before use of the aggregate is approved.

4.2.6 Sulphate and Chloride Content

The acid-soluble sulphate (SO₃) level shall not exceed 0.4% by mass.

The acid-soluble chloride as NaCl ($C1 \times 1.65 = NaCl$) level in aggregate as a percentage by mass shall not exceed the limits given on the following table:

Concrete Type	Coarse Aggregate	Fine Aggregate
Mass with OPC or MSRPC	0.10%	0.10%
Reinforced with OPC or MSRPC	0.05%	0.10%
Mass with SRPC	0.05%	0.05%
Reinforced with SRPC	0.02%	0.05%

These limits shall be subject to the overall limit given elsewhere for the concrete as mixed.

4.2.7 Water

The Contractor shall make his own arrangements and obtain approval for the provision of fresh water for the manufacture and curing of concrete.

For mixing concrete and mortar water shall be fresh and free from all sediment and dissolved or suspended matter which may be harmful to the manufacture of concrete as specified

The Contractor shall state the sources from which he proposes to obtain water and submit evidence to show that an adequate supply is assured.

4.2.8 Admixtures

The use of non-corrosive admixtures in concrete may be ordered or approved by the Engineer according to circumstances. Concrete admixtures shall comply with the requirements of BS 5057.

Calcium chloride will not be permitted in a concrete mix under any circumstances. Retarders and workability agents based on lignosulphates may be permitted subject to the Engineers approval following trial mixes.

4.3 Concrete Mix Design

Concrete mixes shall be designed according to the recommendations given in BS 8110 to suit the strength requirements of particular applications and the provisions for durability and resistance to chemical attack appropriate to those applications. Exposure conditions as defined in BS 8110 Table 3.2, shall be taken as moderate.

The Contractor shall submit for the Engineers approval a complete schedule of mixes for all applications indicating 7 and 28 day cube strengths, maximum aggregate size, minimum cement content, type of cement and water/cement ratios.

The schedule shall be submitted at or before the time of the presentation of design calculations.

4.4 Trial Mixes

A trial mix will be approved when the requirements of BS 5328 are satisfied.

4.5 Test Cubes

Test cubes from random batches of concrete to be used in the Works are to be made in sets of 6, or otherwise as approved. Cube mould size shall be 150mm.

The Engineer may require test cubes to be taken at any time, but in general, set of test cubes will be taken at a rate not less than that indicated below.

Type of Structure	6 Cubes per m ³ Concrete
Beams and Slabs	25
Normal Foundations	50

The making, curing, testing and acceptance of test cubes will be in accordance with BS 1881 and BS 5328 as appropriate.

The Engineer will at his sole discretion, determine whether any concrete in the work represented by cube test results that fall below the specified limits can be accepted and may order that any or all of the following actions.

- (a) The taking of core samples by drilling and the compression testing of such samples.
- (b) The carrying out of load tests or other non-destructive tests on the affected concrete element.
- (c) The cutting out and replacement of such volumes as he considers necessary to properly repair the work.
- (d) The complete demolition and replacement of the affected item.

4.6 Workability

The Contractor shall carry out compaction factor, slump or other workability tests as required during concreting of permanent works in order to relate the degree of

workability of the mix with the workability of the relevant trial mix. Testing and tolerances shall be in accordance with BS 5328.

4.7 Steel for Reinforced Concrete

Reinforcing steel shall comply with BS 4449, BS 4482 or BS 4483 as appropriate.

The Contractor shall provide the Engineer with copies of the manufacturers test certificates for the type of steel to be supplied.

The Engineer may however, order independent tests on randomly selected samples of steel on site. Such tests will be at the Contractors expense.

The Contractor shall provide for the approval of the Engineer, detailed drawings with bar bending schedules for all reinforced concrete elements.

Reinforcement shall be cut, bent and fixed in accordance with the detailed drawings and with the provisions of BS 4466.

The condition, handling, fixing, lapping and welding of reinforcement shall comply with BS 8110 Part 1, Section 7.

4.8 Concrete Cover to Reinforcement

The minimum concrete cover to any reinforcing bar shall be the greater of the dimensions specified in BS 8110 Part 1, Table 3.4 (for durability) and Table 3.5 (for fire resistance).

The dimensions used shall take account of the actual concrete mix used for the works and the appropriate period of fire resistance.

4.9 Storage of Reinforcement

Steel reinforcement shall be stored under cover above ground on a concrete slab with timber racking, all to the approval of the Engineer.

4.10 Site Bent Reinforcement

Reinforcement to be cut and bent on site shall be from steel delivered to site in straight lengths. No pre-bent steel shall be re-bent without written approval from the Engineer.

4.11 Formwork for Concrete

The Contractor shall submit for the approval of the Engineer details of the method and materials proposed for shuttering each section of the work

Forms shall be constructed from sound materials of sufficient strength, properly braced, strutted and shored as to ensure rigidity throughout the placing and compaction of the concrete without visible deflection

All joints shall be close fitting to prevent leakage of grout and at construction joints the formwork shall be tightly secured against previously cast or hardened concrete to prevent stepping or ridges to exposed surfaces.

4.12 Forms for Exposed Concrete Surfaces

Forms for all permanently visible concrete surfaces shall be such as to ensure that the surface is within the tolerances hereinafter specified. Where rough shuttering is specified the use of tongued and grooved sawn timber boards will be permitted provided the resulting surface presents a neat and even appearance. No surface irregularities greater than 5 mm shall be allowed and, in the case of reinforced concrete, the full cover to steel shall be maintained.

Suitably sized chamfers shall be provided to all exposed arises unless otherwise agreed by the Engineer.

4.13 Forms for Non-Exposed Concrete Surfaces

Where the finished surface of concrete is not to be permanently exposed, the forms may be constructed of plain, butt jointed sawn timber. The tolerances for the finished concrete dimensions shall not be exceeded.

4.14 Preparation of Forms for Concreting

Before concrete is placed, the form shall be thoroughly cleaned and freed from sawdust, shavings, dust or other debris by hosing with water, compressed air or other approved means. Temporary openings shall be provided to assist in removal of the water and rubbish.

After cleaning the forms shall be coated with an approved shutter oil, which shall not be allowed to run on to reinforcement or other embedded ferrous items.

4.15 Concrete Tolerances

The lines grades and dimensions of the concrete shall conform to those detailed on the drawings within the following tolerances:-

- | | | |
|-----|-------------------------------|-------------------|
| (a) | Overall dimensions and levels | - 6 mm to + 6 mm |
| (c) | Beam sizes | - 0 mm to + 5 mm |
| (d) | Slab thickness | - 0 mm to + 6 mm |
| (e) | Wall thickness | - 0 mm to + 10 mm |

- | | | |
|-----|--|--|
| (f) | Foundations and R.C. walls and slabs below ground level | - 5 mm to + 10 mm |
| (g) | Vertical lines out of plumb | 5 mm in 5 m but not exceeding 10 mm in total |
| (h) | Formwork for beam soffits shall be erected with an upward camber of 5 mm per 3 m of span | |
-
- (j) For floors carrying switchgear, the gap under a 3 m long straight edge placed in any direction shall not exceed 3 mm.

4.16 Holes and Fixings

Where holes or fixings for equipment are required these shall be set-out to a tolerance of plus or minus 5 mm unless otherwise directed. Holes and pockets shall be formed square to the formwork. Permanent liners and formers shall not be used unless of expanded metal or similar material.

Threaded inserts and cast-in-bolts shall be fixed square to the formwork by a temporary bolt or nut and the concrete cast around them. All threads shall be cleaned of grout and projecting parts protected from rusting with bituminous paint.

4.17 Exposed Surfaces

The finished faces of all concrete work shall be sound, solid and free from honeycombing, excrescences and blemishes.

Plastering of defective concrete as a means of making good will not be permitted. Surfaces showing minor porosity shall, if the Engineer so approves, be rubbed down with cement and sand mortar of the same richness as the concrete immediately after the removal of formwork

4.18 Fair Finish

Where the surface of the concrete is specified to be "fair faced" as distinct from wrought finish, it shall be rubbed smooth with a carborundum brick immediately on removal of the shuttering and while the concrete is green and all small holes shall be stopped with cement mortar of such a mix as to render the stopping invisible.

4.19 Precast Concrete

Concrete members specified to be fabricated as precast concrete units shall be fabricated with concrete of the specified class placed into a grout-tight mould. If so

required the mould shall be laid on a vibrating table and vibration applied while the concrete is placed.

With the approval of the Engineer the Contractor may be permitted to precast members which were specified to be constructed in-situ and in such cases the Contractor shall carry out the work as described above.

4.20 Concrete Cast on Ground

Before reinforced concrete is cast on ground, a minimum of 75 mm blinding concrete shall be laid on the formation level to provide a hard even surface on which to construct the reinforced concrete work.

4.21 Transporting Placing of Concrete

The method of transporting and placing of concrete shall be to the approval of the Engineer. Concrete shall be so transported and placed that contamination, segregation or loss of the constituent materials does not occur.

Concrete shall only be placed in locations and to a sequence previously approved by the Engineer. Except where otherwise directed, concrete shall only be placed following inspection and written approval by the Engineer of the cleanliness and correctness of the preparation for concreting.

Concrete shall be delivered by ready-mix trucks or other approved means and shall be deposited as near as possible to its final location in such a manner as to avoid displacement of the reinforcement, other embedded items or formwork.

4.22 Compaction of Concrete

Concrete shall be deposited in level layers of such a depth that each layer may be fully compacted throughout its depth and be fully incorporated with the layer below by the use of internal vibrators. Concrete shall be placed in such a manner as to produce a dense void free uniform mass between and around any reinforcement.

Care is to be taken to avoid excessive vibration resulting in segregation of aggregates and mortar.

Vibration shall not be applied directly or through reinforcement to sections of concrete in which the initial set has taken place.

Vibration shall not be used to make concrete with insufficient workability flow into the formwork.

4.23 No Partially Set Material to be Used

All concrete and mortar must be placed and compacted within 20 minutes of leaving the ready-mix truck.

No partially set material shall be used in the Works.

4.24 Temperature Records

The Contractor shall supply suitable maximum/minimum thermometers and shall maintain records of all ambient shade temperature adjacent to all parts of the Work where concrete is placed.

4.25 Concreting in Adverse Weather Conditions

Concreting will not be allowed to take place in the open during storms or heavy rains. At times where such conditions are likely to occur, the Contractor shall arrange for adequate protection of the materials, plant and formwork so that work can proceed under proper cover. When strong winds are likely to be experienced, additional precautions shall be taken to give protection from driving rain, dust and the evaporation of water from concrete surfaces. The Engineer may withhold approval to commence concreting until he is satisfied that adequate arrangements have been made.

4.26 Concreting at Night or in the Dark

Where approval has been given to carry out concreting operations at night or in places where daylight is excluded the Contractor shall provide adequate lighting at all points where transportation and placing of concrete is in progress.

4.27 Concreting in High Ambient Temperature

Temperature of concrete at time of placing shall not exceed 30°C. In hot weather the Contractor will be required to take precautions to limit concrete to within this limit. Such measures may include but not be limited to spraying coarse aggregate with cold water, painting plant and equipment white, providing shaded areas for aggregate stockpiles, water and plant and protecting moulds and mixed concrete from the direct rays of the sun and drying winds. The Contractor may, as directed by the Engineer be required to cool mix constituents, reinforcement and moulds and to restrict transportation time for mixed concrete to a practical minimum. The Engineer may also require the pouring of concrete to take place either in the very early morning or late afternoon to avoid the time of maximum temperature.

The necessity for such precautions will be determined by the Engineer in consideration of matters affecting the heat of hydration such as the characteristics of the mix constituents, the location and nature of the particular pour and the method of curing to be adopted.

4.28 Curing and Protection

Immediately after compaction and for at least 7 days thereafter concrete shall be protected against harmful effects of sunshine, drying winds, cold, rain or running water.

5 FINISHES TO CONCRETE ROOFS

The finishes on exposed concrete roofs shall consist of continuous 2-layer bituminous felt or other approved waterproof membrane, and 50 mm thick approved lightweight insulating material with 1000 gauge polythene sheet over. Solar protection shall be provided either by 50 mm thickness screed or light-coloured concrete tiles bedded and jointed in bitumen where access is required. The roof protection shall be fixed to resist hurricane uplift.

Roof finishes shall conform to the following basic requirements:-

- (a) The type of lightweight insulating material, the sheeting adhesives, mastic and top dressing shall have the Engineer's approval.
- (b) The method of laying the finish and the methods of securing the finish at eaves, the rainwater outlets, shall all be to the satisfaction of the Engineer.
- (c) The finish shall not allow the passage of rain or moisture into the building.
- (d) The roof slab shall be laid to a minimum fall of 1 mm per 60 mm run.
- (e) The mass of each layer of bituminous sheeting shall not be less than 2.0 kg/m² and shall have a base of fibre reinforcement.
- (f) Adequate allowance is to be made for expansion joints.

6 PIPES AND PIPEWORK FOR DRAINAGE AND CABLE DUCTS

6.1 Trench Excavation

Trenches shall be excavated to the lines and levels required to enable pipes to be laid to the correct levels on the required bedding.

They shall be of adequate width and where necessary shall be provided with sumps to ensure that jointing can be properly carried out in clean and dry conditions.

Trench bottoms shall be well compacted by ramming before any pipes are laid.

A minimum of 750 mm cover shall be provided over all pipes.

Under roads and hardstandings the minimum cover shall be 1 metre except where pipes are encased in concrete.

Where trenches pass from a footway to a roadway or at other positions where a change of level is necessary, the bottom of the trench shall rise or fall gradually. The rate of rise shall be to the approval of the Engineer.

PVC pipes shall not be encased in concrete. Where special protection to PVC pipes is required, a concrete slab shall be provided.

Trench excavation and filling shall be carried out in a manner that ensures that there is no risk of subsidence causing injury or damage to walls, roads, sewers, drains, pipes, cables and structures etc.

Excavation shall be carried out to the satisfaction of the Engineer and any authority concerned with adjacent works or services.

Unless other agreed, provision shall be made during excavation and until restoration has been completed, for reasonable access of persons and vehicles to places adjacent to the route.

6.2 Excavated Material

Material excavated from trenches shall be placed in a manner that does not interfere with site traffic or cause disruption of any sort.

If, due to insufficient space, it is found necessary to temporarily remove excavated material from site, this and the disposal of any surplus material shall be by and at the cost of the Contractor.

6.3 Trenches Under Roads

All trenches for services, drains and the like in or adjacent to the roads or surfaced areas shall be completed, backfilled and compacted before the sub-base is laid. The Contractor shall satisfy the Engineer as to the proper consolidation of all backfilling in trenches

Where in the opinion of the Engineer backfilling is unsatisfactory, it shall be removed and replaced in accordance with the Specification.

6.4 Acid/Alkali Resisting Drains

Drainage from battery rooms, shall be led to sumps outside the buildings by means of approved acid alkali resisting pipework. The sumps shall be so arranged in the drainage system that adequate neutralisation and dilution of the effluent will take place before it is passed into the general site drainage system. Jointing materials appropriate to the effluents in the pipes must be used.

6.5 Testing

All water mains shall be pressure tested to 1.5 times the working pressure. All foul drains shall be tested for water tightness in accordance with BS 8301. The Contractor shall provide all equipment, anchors and the like necessary for testing.

6.6 Sterilisation of Installation

All mains and services to be used for potable water shall be sterilised before being brought into use, in accordance with the appropriate National Code of Practice approved by the Engineer.

6.7 Septic Tanks and Soakaways

Septic tanks and soakaway shall be to the approval of the Public Health Authorities and shall be of a design suitable for the maintenance-free disposal of soil drainage. The effluent is to be of a consistently acceptable purity and discharged into the surface water drainage. Facilities are to be incorporated to enable periodic sampling of the effluent for testing, and the whole of the installation is to be to the approval of the Engineer.

6.8 Manholes and Gullies

Manholes shall be provided at every change of alignment or gradient at the head of all sewers or branches at every junction of 2 or more sewers and wherever there is a change in size of sewer. Manholes shall not be further than 100 metres apart.

Manholes and inspection chambers shall be constructed of approved precast concrete sections in accordance with BS 5911 or of concrete cast in-situ. Foundations shall be of concrete, the channels being finished smooth in concrete, or by using preformed half circle channels, haunched up to the manhole sides in neat cement. All manholes and inspection chambers shall be watertight on completion. Frames for manhole covers shall be set in cement mortar. For depths greater than 1 metre, step irons as specified shall be provided, spaced 300 mm alternately vertically and 250 mm horizontally. Gullies shall be approved precast units of concrete in accordance with BS 5911 with gratings and frames. Precast manholes and gullies shall be surrounded with at least 150 mm of concrete brought up to the underside of the frames.

6.9 Covers, Gully Gratings and Frames

Manhole covers, road gully gratings and frames shall comply with BS 497 or be approved by the Engineer and shall be obtained from approved manufacturers and shall be supplied coated in accordance with the appropriate Standard unless otherwise directed. The types used must suit their use and location, but in general they must be heavy duty.

6.10 Step-Irons

Step-irons, which shall comply with BS 1247 shall be built into the walls of manholes, chambers and the like in a manner approved by the Engineer.

In brickwork or in-situ concrete walls the step-irons shall be built in as the work proceeds. In the case of manholes constructed with precast concrete rings step-

irons shall be inserted into the rings by the manufacturer and shall be positioned as required.

6.11 Rodding Drainage Pipelines

Provision is to be made for rodding all pipelines. For this purpose manholes for buried pipelines shall be not greater than 100 metres apart. Pipelines above ground level shall have access plates on each bend or junction. Each rain water down pipe is to have an access plate 750 mm above ground level.

6.12 Excavation for Cable Ducting

The bottom of every trench shall be carefully levelled and rammed. Where it is necessary to change level, the bottom of the trench shall rise or fall gradually as the Engineer may direct, but in no case at a slope greater than that given by the specified permissible deflections at joints. A minimum cover of 1 metre shall be provided.

6.13 Preparation of Trench Bottom to Receive Ducts

Except where ducts are to be encased in concrete, pockets shall be taken out of the bottom of a trench at all points where joints occur so that the barrels of the ducts rest on solid ground. Plain barrelled pipes are to be bedded to the Engineer's approval.

6.14 Sand as Bed and Surround to Ducts

Except where ducts are to be encased in concrete, sand is to be packed and well tamped round the duct until it is covered to a depth of 750 mm above the upper surface of the duct. Filling above this level is to be approved excavated material free from large stones. In multiple duct runs the interstices between the ducts are to be filled with sand and compacted and the cover of 750 mm is to be above the uppermost ducts. The sand used shall be the same quality as approved for use in making concrete.

6.15 Linearity

The line of cable ducts shall be kept as straight as possible. Where it becomes necessary to deflect ducts from a straight line or vary the depth, large radius bends may be used subject to the Engineer's approval.

6.16 Laying of Ducts

Telephone and electrical cable ducts shall be laid and jointed in accordance with the manufacturer's instructions or with such instructions as may be issued by the Engineer.

6.17 Multiple Runs of Ducts

Electrical cable ducts in multiple runs whether encased in concrete or not, shall be laid at approved centres vertically and/or horizontally. The minimum concrete encasement where required is to be 150 mm. The final jointing of ducts in multiple runs shall be done in the trench, i.e. the duct shall be lowered and jointed singly and not in groups, and duct joints shall be staggered by approximately half the duct length in alternate lines.

6.18 Cutting of Ducts

The Contractor shall do any necessary cutting of the pipe ducts according to the requirements of the work. Except where cables are to enter the duct at an angle, the ends shall be cut at right angles to the length of the duct. The inside edges of cut ducts shall be thoroughly rounded off or so dressed before being placed in position that there can be no possibility of damage to cables from the edges of the ducts.

6.19 Bellmouths

All electrical cable ducts entering draw pits shall be provided with approved bellmouths.

6.20 Cleaning and Testing of Ducts

On completion of all electrical cable ducting, 2 mops of appropriate size connected one to each end of an iron mandrel shall be passed twice through each way to clean the conduit and to remove any foreign matter which may have entered. All proving tests shall be carried out in the presence of the Engineer and if any obstruction or other defect be discovered it shall be removed or rectified forthwith to his satisfaction.

6.21 Draw Wires

Each electrical cable duct whose length exceeds 3 metres shall be provided with a draw-wire, which shall be of galvanised steel or approved artificial fibre cord. The length of draw-wire installed shall be such that 1 metre of draw-wire extends from each end of each duct. After the ends of ducts have been sealed the free ends of the draw-wire shall be neatly coiled or otherwise stowed as directed by the Engineer.

6.22 Sealing of Electrical Ducts

As soon as every duct or set of ducts has been proved and its draw-wire installed, the ends of the duct or its bellmouth where provided, shall be sealed to a depth of 5mm with an approved sealer, and a single coat of bitumastic paint shall then be applied over the end of the ducts and the seal.

6.23 Concrete Cable and Pipe Trenches

In-situ concrete or reinforced blockwork trenches, as approved by the Engineer, are to be provided inside and outside the powerhouse and workshop buildings. The trenches are to have falls in the floor and must be drained at regular intervals.

All trenches shall have trench covers suitable for their location and loading. Any beams supporting covers must be as shallow as possible to avoid interfering with the pipes and cables in the trench. Trench covers shall be provided with lifting eyes, and all edges shall have a 10 degree inward taper to ensure easy removal.

Once the trench covers have been made they are to be laid and fitted and then removed to store until all trench cabling, piping, etc. is finished. On completion of services all covers are then relaid any covers which become damaged before completion must be replaced at the Contractor's expense.

Trench covers and bridging beams for covers, except where heavy duty, shall be light enough for 2 men to lift.

Where trench covers and removable beams are reinforced, they shall be suitably marked to indicate the bottom face.

6.24 Excavation for Cables

Cables are to be laid to lines and levels as approved by the Engineer. Their depth below ground level will depend upon the voltage associated with the cables but in all cases the excavation must provide a clear trench. Sand filling below, around and above the cables will always be required and protection covers or tiles will be placed in position over the sand filling before final backfilling to the ground level. The line of the cable trenches shall be marked with suitable posts.

7 ROADS AND SURFACING

7.1 Compaction of Sub-grade

The area of the Works shall be cleared of any material or obstructions which in the opinion of the Engineer might adversely affect the stability of the fill or pavement, and the top layer removed to a depth of 300 mm (or more if the design so requires).

The formation shall be compacted to a dry density of at least 95% of the maximum dry density as determined in BS 1377: Test 13 (BS 'Heavy' compaction) and a CBR of 15%.

Compaction shall be carried out by means approved by the Engineer. All construction equipment must operate over the full width of the formation to ensure uniform compaction.

7.2 Sub-Base

Sub-base material shall be Type 2 as specified in the Department of Transport Specification for Highway Works Part 3 Clause 804.

7.3 Road Base

Road base material shall consist of crushed rock or crushed slag and the aggregate shall have the grading as shown in table 8/4 of the Department of Transport Specification for Highway Works Part 3.

7.4 Laying and Compacting

The wet-mix macadam shall be laid and compacted at the optimum moisture content $\pm 0.5\%$ as determined in compliance with BS 5835.

The compaction thickness of each layer shall not be more than 200 mm. Any areas of compacted material having a loose surface deficient in fines shall be removed and replaced with properly graded material.

7.5 Bitumen Macadam

Bitumen for bitumen macadam shall be of Grade 60/70 penetration in accordance with BS 3690 and shall have a known specific gravity and a known temperature/viscosity relationship.

Bitumen for priming coat shall be MCO cut-back bitumen, RCO emulsion, other approved cut-back bitumen or emulsion.

Bitumen for tack coat shall be an approved emulsion or MC 2 cut-back bitumen.

Bitumen for surface dressing shall be MC 5 or similar cut-back bitumen.

The aggregate for binder course shall consist of hard clean durable crushed rock complying with the quality requirements of BS 4987.

7.6 Mixing and Laying Bitumen

The mixing and laying of bitumen macadam shall unless otherwise specified be generally in accordance with the requirements of BS 4987. Recommendations made in this British Standard shall be taken as a requirement unless otherwise specified herein.

The material shall be protected to minimise heat loss during transit so that it shall not be discharged into the paver at a temperature less than 120°C.

Hand laid work shall conform to all the requirements of this specification except those relating to the manner of operation of pavers.

After spreading the mix shall be thoroughly compacted to the thickness shown on the drawings by rolling to a density of not less than 98% of the maximum density of the approved mix designed in the laboratory i.e. the Job Mix for the particular layer.

7.7 Horizontal Alignment, Surface Levels and Surface Regularity

The horizontal alignment of the road as constructed shall not deviate more than ± 15 mm from the true alignment as given by the dimensions on the drawings. Wearing courses shall also be measured transversely for irregularities by a 3m straight edge placed at right angle to the centre line of the road. The maximum permissible deviation in this case shall not exceed 6 mm.

7.8 Testing of Bitumen Macadam

Unless otherwise specified the sampling and testing of bitumen macadam shall be carried out in accordance with the requirements of BS 598.

7.9 Final Surfacing

The bitumen macadam binder course shall be kept clean and uncontaminated so long as it remains uncovered by a wearing course. Should the binder course become contaminated the Contractor shall make good by cleaning to the satisfaction of the Engineer and if this is impracticable by removing the layer and replacing it to specification.

When all heavy plant has been delivered and all soft, fatty or otherwise objectionable areas of the road have been reinstated and made good to the satisfaction of the Engineer, the wearing course shall be laid.

7.10 Kerbs

Kerbs, channels, edgings and quadrants shall be cast generally to BS 340. They shall be cast to the required radii for all curves less than 12 metres.

Raised kerbs shall be laid with a 6 mm gap and pointed with 1 to 3 cement mortar above road level only. Concrete bedding and backing to kerbs shall be cast in-situ.

In the case of precast kerbs 1 joint in 10 shall be left unpointed and 6 mm compressible insert provided, and a construction joint formed in the haunching at this point for expansion. Similarly expansion joints are to be formed in in-situ kerbs before bituminous macadam is laid.

8 BLOCKWORK

8.1 Standards

Precast concrete blocks shall conform to BS 6073 and shall be manufactured using aggregates conforming with BS 882 or BS 1047.

8.2 Workmanship

The concrete blocks, mortar, ties, damp-proof courses and all related materials shall be to the Engineer's approval. All concrete blocks shall be properly cured.

The walls to be fair-faced shall have the vertical joints pointed flush and the horizontal joints struck pointed as the work proceeds. Particular attention shall be paid to each course being level and the vertical joints aligned so that the finished appearance is first class.

Horizontal damp-proof courses shall be provided underneath all blockwork walls and shall be bedded on mortar. Vertical damp-proof courses shall be provided at all door reveals.

Wall ties shall be approved galvanised mild steel or stainless steel butterfly type and shall be of size 150 mm x 25 mm. Wall ties shall be used in all external cavity walls at centres not exceeding 450 mm in the vertical and 450 mm on the horizontal, and shall be staggered.

Mortar for blockwork shall consist of 1 part cement to 6 parts of sand by volume. The Contractor may use a plasticiser with mortar subject to the approval of the Engineer, provided it is used in accordance with the manufacturer's instructions.

The concrete blocks, mortar and water used for mixing, shall be free of harmful soluble salts which could form excessive efflorescence.

The Contractor shall make provision for pockets and chases etc, required in connection with plumbing, electrical and other similar installations.

Fair-faced blockwork shall be kept perfectly clean as the work proceeds and no rubbing down of wall surfaces will be allowed.

9 WINDOWS AND DOORS

9.1 Standards and Codes

The following British Standards and Codes of Practice are referred to in this part of the Specification; however the list should not be considered exhaustive.

BS 729	Specification for Hot Dip Galvanising
BS 1245	Specification for Steel Doors and Frames
BS 4255	Specification for Non-Cellular Gaskets
BS 4873	Specification for Aluminium Alloy Windows

9.2 General

Windows shall conform to the requirements of BS 4873.

Gaskets shall conform to BS 4255 and shall be secured by a suitable adhesive which shall be to the Engineer's approval.

Steel doors and frames shall conform to the requirements of BS 1245.

9.3 Doors

Hollow Metal Flush Doors

Single doors shall generally be standard pattern fabricated from steel sheet faces not thinner than 18 SWG with internal continuous vertical interlocking or truss type stiffeners spot welded at centres not exceeding 150 mm. Edge channel reinforcement, not less than 3 mm thick shall be provided to the door perimeter, spot welded to each face sheet to centres not exceeding 75 mm. Channels and face sheets shall be continuously butt welded at the edges. Stile edges shall flare away from stops 3 mm in 50 mm. Swing doors shall have rounded meeting stiles. Openings for glazing shall be provided as shown on the drawings.

Door Frames

Galvanised steel door frames shall comply with the requirements of BS 1245. They shall be fabricated from steel not thinner than 16 SWG, press brake formed true and sharp to profiles and widths shown on the drawings. Heads and jambs shall be fitted by tongue and slot or equal approved arrangement, with face mitres. All parts shall be accurately fitting and fully welded, ground seamless and to a smooth surface.

Adequate temporary or permanent reinforcement as necessary shall be welded to frames for protection during delivery and/or to ensure permanent alignment.

Frames shall be fabricated to provide at least 3 fixings for each jamb, which shall be secured to the frame by approved methods. Head frames greater than 1 m span shall be provided with 2 similar intermediate fixings. Frames shall be accurately shop mortised for strike plate and hinges and reinforced with plates not thinner than 10 SWG and welded to the frames. Dust-proof plastic guard boxes shall be provided behind all cut-outs. Floor knees and guides, adjustable between 0 and 75 mm shall be from 12 SWG steel plate. Approved reinforcing plates shall be provided for door closers, holders, checks, brackets and other surface mounted ironmongery as specified or shown on the drawings. Any frames to be installed after construction of masonry walls shall be fitted with a removable recessed stop to permit 6 mm expansion bolting of frame to masonry. Bolting points shall be reinforced with 12 SWG steel plate to prevent buckling.

Ironmongery and Door Furniture

Hinges shall be galvanised steel or bronze.

Locks shall be approved longitudinal mortice type, of steel construction with replaceable type core and fitted to doors in an approved manner. 2 bronze keyhole plates shall be provided with each mortice lock, secured to the door to the approval of the Engineer. Locks shall be certified as to performance in accordance with BS 5872. Locks to all external doors shall be 'mastered' in common with other buildings and particulars of the key pattern shall be furnished to the Engineer.

Push plates shall be bronze of an approved pattern.

Door closers shall be approved pattern pneumatic, of bronze finish with fixings appropriate to the type of door to which it is to be fitted. No hold-open arms shall be fitted unless specifically called for, and these shall be fitted with fusible links unless otherwise indicated on the drawings.

Doors not fitted with locks shall be provided with approved steel mortice latches.

Door lever handles shall be of approved bronze pattern.

External doors shall be fitted with heavy duty storm bolts.

Internal doors utilised as fire doors shall have no lock and be fitted with an approved metal counterweight operator with top spring bolt and keeper.

All doors must have plastic signs with the room name screwed to them. The signs shall be in black lettering on a white background and will be subject to approval by the Engineer. The list of signs will be provided by the Engineer.

9.4 Windows

The window frames are to be of salt resistant aluminium alloy.

Windows except in kitchen or toilet areas shall be of a non opening type but with facilities for removal from the inside for cleaning and maintenance.

Double glazed windows shall be provided to the external walls of all building, the outer pane being 6mm wired glass.

9.5 Workmanship

Joints, corners, mitres etc., shall be accurately machined, filed and fitted and rigidly framed together at joints and contact points. Work shall be carefully matched to produce perfect continuity of line and design. Joints and connexions in exterior metal shall be watertight and, unless otherwise indicated on the drawings or approved, shall have hairline joints. Welds on exposed surfaces shall be ground

smooth and shall blend, after finishing, with adjacent parent metal. Threaded connexions shall be made up so tightly that the threads are entirely concealed by the fittings. Caulking with approved sealants shall be provided where required. All materials shall be provided with the necessary approved fixing lugs, anchors, sleeves, etc., for fixing to blockwork.

9.6 Installation

Doors, windows and frames shall be fixed and fitted truly vertical and tested for swing and alignment prior to fitting locks or latches. Generally all ironmongery shall be delivered fitted to doors and windows in such a manner as to permit final adjustment after installation of the main members. All lugs and other fixings to frames shall be built into the blockwork or concrete as the work proceeds.

10 GLAZING

Sheet glass shall be provided to all windows. Toilets, washrooms and kitchens shall be glazed with obscure glass

10.1 Standards and Codes

The following British Standards and Codes of Practice are referred to in this Specification, however, the list should not be considered exhaustive.

BS 952 Glass for Glazing

BS 6262 Code of Practice for Glazing for Buildings.

10.2 Materials

Glass

Glass shall comply with the requirements of BS 952 and be free from defects. All glass shall be delivered in proper containers with maker's name, guarantee, type of glass and thickness attached.

Sheet glass shall be 3 mm ordinary quality. Obscure glass shall be roughcast min 5mm thick. Wired glass shall be 6 mm thick wired Georgian. Polished plate glass shall be 6 mm thick glazing glass.

Glazing in entrance screens and doors shall be 6 mm thick toughened glass.

Tinted or solar reflective glass shall be used for the outer layer of glass in windows in external walls.

10.3 Workmanship

Glazing panels shall fit within rebates in the frame without pinching or leaving gaps larger than 2mm.

Prior to glazing, rebates shall be cleaned and primed.

The Contractor shall clean the glass inside and out on completion and replace any cracked and broken glass.

11 BUILDERS WORK

All builders work carried out in connection with the installation of the plant specified above shall be carried out and made good in a neat and workmanlike manner to the approval of the Engineer such that the quality and standard of the finished work is at least equal to the existing construction.

Making good shall be of identical construction to the affected area and the Contractor shall provide all necessary material including flashings, gaskets and the like to match the existing work.

SECTION 23

ENVIRONMENTAL REQUIREMENTS

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ENVIRONMENTAL REQUIREMENTS

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SECTION 23
ENVIRONMENTAL REQUIREMENTS

1. GENERAL

The design of the station is to be such that it causes the minimum intrusion on the environment surrounding it. Particular attention must be paid to minimising noise and smoke emission and the drains from all areas where oil contamination can occur must be passed through the existing oil water separator.

The Contractor shall, where applicable, abide by the LUCELEC Environmental Policy Statement, attached as an Appendix to this Section.

2. NOISE AND VIBRATION

2.1 External Noise Levels

The noise emitted by the Plant including the four existing generator units in 'B' Station under all conditions of operation shall not exceed the following levels when measured at a distance of 100 metres from any wall of the power station building. Sound pressure levels measured in octave bands shall not exceed the following values in decibels referred to $2 \times 10^{-5} \text{N/m}^2$:-

Octave Band	31.5	63	125	250	500	1000	2000	4000	8000
Centre Frequency (Hz)									
Octave Band Sound	80	75	68	61	59	57	61	64	46
Pressure Level (dB)									

The noise level is defined as the mean of the maximum readings of the noise emitted by the Plant as would be measured on the slow response of the sound level meter which complies with the performance of IEC 60651 Type 1. Measurements shall be made at a height of 1.2 m above ground level and at least 4 m away from any wall or large obstruction and within line of sight of the radiating plant as far as is possible. The 'A' Station plant will be shut down during these measurements.

The noise level will be as would be measured under conditions of low background noise and low wind velocity.

It is preferred that Plant shall be designed, as far as possible, to avoid a discernible tonal content. Where a particular tone or tones are audible, the noise being assessed for compliance with this Specification will be increased by 5 dB in the relevant octave band(s).

2.2 Internal Noise Levels

- (a) The noise level within the filter cleaning room, fuel injection workshop, valve grinding room, welding area shall not exceed NR65 when:-

- (i) four diesel generator units in the existing 'B' Station are operating at full rated output and:
 - (ii) one diesel generator unit in the new 'C' Station is operating at full rated output and:
 - (iii) all other plant are operating normally
- (b) The noise level within the 415V switchroom, battery room and rainwater storage area shall not exceed NR70.
- (c) With all engines running normally in the 'B' Station the noise level within the engine hall shall be measured at various locations to be agreed. The noise level measurements shall then be repeated with all engines running normally in the 'B' Station and Unit no. 9 running in 'C' Station. The noise level at each location shall not increase by more than 3 dBA.

2.3 Vibration

Due to the distance of unit no. 9 from the 'B' Station control block, the level of continuous vibration of structures in the control room and offices is not expected to increase following the installation of unit no. 9. The Contractor shall take two sets of vibration readings as follows:-

- (a) With all plant operating normally in 'A' and 'B' Stations only.
- (b) With all plant operating normally in 'A', 'B' and 'C' Stations.

The vibration readings shall not be found to increase between the readings taken in (a) and (b) above.

For guidance the limiting values applied to the existing control room and offices as recommended in BS 6472: 1984 using a multiplying factor of 4 are as follows:-

- (a) For vertical motions:-

A peak velocity of 0.55 mm/s for frequencies in excess of 8 Hz.

An rms acceleration of 20 mm/s² for frequencies between 4 and 10 Hz.

- (b) For horizontal motions:-

A peak velocity of 1.5 mm/s for frequencies above 2 Hz.

Every precaution shall be taken in the design of plant mountings, supports and connections to ensure that the plant, equipment and civil engineering works are not subjected to vibration that could give rise to concern about the integrity of any part of the new or existing power station buildings.

3 SMOKE POLLUTION

The exhaust stacks of the diesel engines shall be terminated sufficiently high above the eaves of the power station roof and the diameter of the termination pipe shall be such as to ensure that the exhaust plume is carried well clear of the Site under all normal conditions of operation and of weather.

4. OIL SEPARATION

Oil/ Water interceptors/ separators shall be capable of achieving a water discharge containing not more than 20 mg/litre of oil.

APPENDIX

**ST LUCIA ELECTRICITY SERVICES LTD
ENVIRONMENTAL POLICY STATEMENT**

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specs\Contract Documents\Contract as Issued\Volume 2\Section 23
Environmental Requirements.DOC

ST LUCIA ELECTRICITY SERVICES LIMITED
ENVIRONMENTAL POLICY STATEMENT

Civil Works - Design

The location and design of civil works should be such that there is no impact on the surrounding environment except for visual aspects, noise and exhaust emissions.

The design of buildings and plant should be aesthetically pleasing and be appropriate to the surrounding environment. Particular attention must be given to surface drainage to ensure that no erosion of the surrounding areas can occur after completion of the work.

Where significant quantities of oils or chemicals are to be used or stored, such areas must be drained to traps or separators. Serious consideration should be given to the installation of a second state catchment area in the event of overflowing of traps or separators by accident or neglect.

Sewage disposal shall be via a public sewer or an adequately designed septic tank.

Civil Works - Construction

Civil works shall be carried out so that there is minimal impact on the environment external to the work site. All spoil, debris and waste material produced or accumulated during construction shall be collected and disposed of in approved sites.

Particular attention shall be given to the avoidance of contamination of water courses or aquifers by chemicals, oil or silt. Where necessary temporary catchment areas or ponds shall be constructed to retain such effluents pending controlled disposal.

Measures shall be put into place to prevent the discharge into the air of significant amounts of smoke, dust cement chemicals or effluents during the construction phase. Water spraying shall be utilized in dry and dusty conditions and during building demolition work.

Construction plant shall be adequately silenced and maintained to minimize noise and vibration during the construction phase.

The transfer of mud or loose debris onto public highways shall be prevented by the use of wheel washing arrangements and tarpaulins to cover exposed loose materials spoil or debris.

Sewage disposal shall be via public sewers, or chemical toilets, or adequately sized septic tanks. Any such temporary facilities to be pumped out or removed on completion of the works.

Measures shall be taken to recover and preserve artefacts of archaeological or historical interest. Such finds shall be reported to the appropriate authorities.

M & E Design

Noise emission external to buildings shall be kept to a minimum by the best practicable means. Buildings shall be designed to absorb noise and prevent noise breakout as far as is reasonable.

Exhaust emissions shall be kept to a minimum by the choice of fuel and the employment of best currently available technology. Fuel used will be low sulphur fuel.

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A facility for collecting, storing and disposing of oils or chemicals where such are present, must be provided in the original design preferably via high temperature incineration or other approved means, unless adequate facilities already exist.

All new prime movers shall be equipped with a lubricating system which utilizes continuous purification by centrifuges with additional oil recovery and separation of water and sludge via a second stage centrifuge.

All oil and diesel storage areas shall be contained within secure bunded areas, as shall transformers larger than 1MVA.

The use of substances banned in North America or Europe will not be permitted. The use of significant quantities of substances considered dangerous to the environment either during use or when ultimately disposed of will only be allowed if there is no viable alternative. In such cases strict use and disposal procedures will be followed.

The design of existing plant and installations shall be periodically reviewed with a view to upgrading to current standards in a cost effective manner.