

A.01

General Technical Requirements

TABLE OF CONTENTS

1. GENERAL TECHNICAL REQUIREMENTS	5
1.1 GENERAL	5
1.2 STANDARDS AND CODES OF PRACTICE.....	5
1.3 UNITS OF MEASUREMENT.....	6
1.4 HEALTH, SAFETY AND ENVIRONMENTAL.....	11
1.5 ENVIRONMENTAL PROTECTION PLAN	12
1.6 SIGNS.....	12
1.7 QUALITY ASSURANCE.....	13
1.8 CORROSION PROTECTION AND PAINTING.....	15
1.9 GENERAL REQUIREMENTS FOR GALVANIZING	20
1.10 STANDARDIZATION OF MAKES.....	24
1.11 FIRE PROTECTION FOR MATERIALS AND FOR BUILDING ELEMENTS.....	24
1.12 INSTALLATION	25
1.13 STEEL STRUCTURES AND ASSEMBLY MATERIAL	25
1.13.2 STEEL STRUCTURES.....	26
2. GENERAL ELECTRICAL REQUIREMENTS.....	27
2.1 GENERAL	27
2.2 HV SWITCHYARD EQUIPMENT.....	28
2.3 MV SWITCHGEAR.....	34
2.4 AUXILIARY WIRING	36
2.5 INTERLOCKING.....	37
2.6 ELECTRICAL STUDIES.....	37
2.7 ELECTRICAL PROTECTIVE MEASURES	38
2.8 CABLES	40
2.9 CABLE CONTAINMENT SYSTEMS.....	42
2.10 ELECTRIC OVERHEAD TRAVELLING CRANE (EOT)	43

SECTION VII: EMPLOYER'S REQUIREMENTS
A.01: GENERAL TECHNICAL REQUIREMENTS

2.11 GENERAL REQUIREMENTS FOR CONTROL AND MONITORING EQUIPMENT	47
2.12 POWER SUPPLIES AND FUSING	49
2.13 INDICATORS	50
2.14 ELECTRONIC EQUIPMENT	50
2.15 SWITCHES AND RELAYS.....	51
2.16 MEASUREMENT OF ELECTRICAL PARAMETERS	51
2.17 WIRING, CABLING TERMINALS.....	51
2.18 LABELING AND SCALES	52
2.19 DIAGRAMS, LISTS AND CHARTS.....	52
2.20 CABLE SCHEDULE, CABLE LIST.....	54
3. GENERAL REQUIREMENTS CIVIL WORKS	54
3.1 SITE CONSTRUCTION WORKS.....	54
4. INSPECTION AND TESTING OF THE SUBSTATION & TRANSMISSION LINE	57
4.1 GENERAL	57
4.2 SCOPE, PROGRAM, DOCUMENTATION	58
4.3 APPLICABLE STANDARDS FOR INSPECTION AND TESTING	61
4.4 TEST EQUIPMENT AND INSTRUMENTS	62
4.5 INDEPENDENT AGENCY	62
4.6 TYPE TESTS.....	63
4.7 INSPECTIONS AND TESTS DURING MANUFACTURE.....	63
4.8 TEST AND INSPECTION OF MATERIALS	64
4.9 WELDING AND SURFACE COATING TESTS.....	66
4.10 PRIMARY ELECTRICAL EQUIPMENT	66
4.11 CONTROL AND MONITORING EQUIPMENT	68
4.12 TELECOMMUNICATION EQUIPMENT	69
4.13 INSPECTION AND TESTING FOR CIVIL ENGINEERING AND STRUCTURAL	70
WORKS	70
4.14 INSPECTION AND TESTING DURING ERECTION	71

SECTION VII: EMPLOYER'S REQUIREMENTS
A.01: GENERAL TECHNICAL REQUIREMENTS

4.15 TESTS ON COMPLETION.....74

1. GENERAL TECHNICAL REQUIREMENTS

1.1 GENERAL

The present clauses refer to the general technical requirements for turnkey contracts for electrical substations.

The following directions, information and technical requirements for design, engineering, layout, manufacturing, erection, installation and testing shall be observed as far as they are applicable for the equipment to be delivered. The requirements stated in this Section of General Technical Requirements are valid for all sections of the technical requirements, except where different, additional and/or special requirements are specified.

The Plant shall be designed, manufactured and arranged so that it will have a functional design and a pleasant appearance.

1.2 STANDARDS AND CODES OF PRACTICE

All materials and equipment supplied shall comply in every respect with the technical codes of the International Organization for Standardization (ISO).

IEC recommendations apply to the electrical equipment.

Goods and special guarantees beyond the scope of ISO and IEC shall conform at least to one of the following standards and codes in the following priority:

1. EN standards
2. BS or ASTM
3. Other internationally accepted standards, which ensure a quality equal to or higher than the standards mentioned above, but only if these are submitted in the English language edition.

The Contractor must submit a list of standards to be applied for the equipment manufacturing testing installation and commissioning, for approval.

During the design stage the Contractor shall supply indexed lists (in English), of all standards, codes and their referred associated standards, to which the Plant and Works are to be performed.

Contractor, subcontractors, sub-suppliers and workshops are to be certified according to ISO 9000.

1.2.1 DESIGN, STANDARDIZATION, INTERCHANGEABILITY

The equipment shall be designed to facilitate inspection, cleaning, maintenance and repair. The design shall incorporate every reasonable precaution and provision for the safety of all those concerned in the

SECTION VII: EMPLOYER'S REQUIREMENTS
A.01: GENERAL TECHNICAL REQUIREMENTS

operation and maintenance of the equipment. The equipment shall be designed to operate satisfactorily under all variations of load and temperature, as may be met in normal usage under the variation in climatic conditions given.

Corresponding parts throughout shall be made to gauge and be interchangeable wherever possible.

All equipment performing similar duties shall be of the same type and manufactured in order to limit the stock of spare parts required and maintain uniformity.

1.3 UNITS OF MEASUREMENT

In all correspondence, technical schedules, drawings and instrument scales, the following units shall be used:

Quantity	Name of Unit	Symbol
Length	Meter	m
Mass	Kilogram	kg
Time	Second	s
Temperature	Degree Celsius	°C
Temperature	Degree Kelvin	K
Electric Current	Ampere	A
Luminous Intensity	Candela	cd
Area	Square meter	m ²
Volume	Cubic meter	m ³
	Liter	l
Force	Newton	N
Pressure (gauge)	Bar	bar g
Pressure (absolute)	Bar	bar
Stress	Newton per square millimeter	N/mm ²
Velocity	Meter per second	m/s
Rotational Speed	Revolutions per minute	rpm
Flow	Cubic meter per second	m ³ /s
	Kilogram per second-hour	kg/s-kg/h
	Liter per second	l/s

SECTION VII: EMPLOYER'S REQUIREMENTS
A.01: GENERAL TECHNICAL REQUIREMENTS

Density	Kilogram per cubic meter	kg/m ³
Torque, Moment of Force	Newton meter	Nm
Work, Energy or Heat	Joule	J
Heat Capacity, Entropy	Joule per Kelvin	J/K
Specific Heat Capacity	Joule per kilogram per Kelvin	J/(kg•K)
Calorific Value	Joule per cubic meter	J/m ³
	Joule per gram	J/g
Power, Radiant Flux	Watt	W
Heat release rate	Watt per square meter - cubic meter	W/m ² - W/m ³
Thermal Conductivity	Watt per meter Kelvin	W/mK
Dynamic Viscosity	Newton second per square meter	Ns/m ²
Kinematic Viscosity	Meter squared per second	m ² /s
Surface Tension	Newton per meter	N/m
Concentration	Parts per million	ppm
Electrical Conductivity	Microsiemens per meter at 25°C	mS/m
Frequency	Hertz	Hz
Electric Charge	Coulomb	C
Electric Potential	Volt	V
Electric Field Strength	Volt per meter	V/m
Electric Capacitance	Farad	F
Electric Resistance	Ohm	Ω
Conductance	Siemens	S
Magnetic Flux	Weber	Wb
Magnetic Flux Density	Tesla	T
Magnetic Field Strength	Ampere per meter	A/m
Inductance	Henry	H
Luminous Flux	Lumen	lm
Illuminance	Lux	lx

SECTION VII: EMPLOYER'S REQUIREMENTS
A.01: GENERAL TECHNICAL REQUIREMENTS

Before being packed for shipment to the Site, all items of Plant shall be carefully numbered and marked so that they can be readily assembled and erected in the correct relative positions at Site. Wherever applicable, these numbers and markings shall be punched or painted so that they shall be clearly visible.

Packing shall be done into convenient sections, so that the weight and size of sections are suitable for the transport conditions to the Site and for handling at the Site under the special conditions applicable there.

All individual pieces shall be marked with the plant identification number and the correct designation shown on the Contractor's detailed drawings and other documents (packing lists, lists in Operating and Maintenance Manuals, etc.).

All parts of the Plant shall be packed at the place of manufacture. The packing shall be suitable for shipment by sea and for all special requirements of the transportation to Site.

Where necessary, double packing shall be used to prevent damage and corrosion during transportation, unloading, reloading and during intermediate storage.

The individual packages shall have convenient weights and sizes for transport and for handling on Site. All identical members shall be packed together, if reasonably possible, in a form convenient for shipment and handling.

Small items shall be packed in boxes and large items shall be protected, where necessary, by timber, straw and sacking. Drums shall be used for cables and similar materials. All bolts, nuts, washers, etc. shall be packed in containers.

All parts shall be suitably protected against corrosion, water, sand, heat atmospheric conditions, shocks, impact, vibrations, etc. for transportation and storage.

Spare parts shall be packed for long duration storage. Items such as gaskets and seals must be vacuum sealed packed.

Each crate or package shall contain a packing list in a waterproof envelope.

All items of material shall be clearly marked for easy identification against the packing list.

All cases, packages, etc. shall be clearly marked on the outside to indicate the total weight, the position of the center of gravity and the correct position of the slings and shall bear an identification mark relating them to the appropriate shipping documents.

All stencil marks on the outside of cases shall be either of a waterproof material or protected by shellac or varnish.

All packing costs shall be included in the scope of delivery. The packing materials shall be disposed by the Contractor. The costs for the transport and unloading in the storage place as well as disposal of the packing materials shall be deemed to be included in the Contract Price.

1.3.4 TRANSPORT OF MATERIAL AND EQUIPMENT

Shipment by sea freight shall be made to the designated port of destination.

Airfreight shall be made to the destination airport, as agreed with the Employer.

Shipments are to be made in accordance with Incoterms and explained in the commercial conditions.

The Contractor shall ensure that adequate handling equipment is available to unload the heaviest piece of equipment.

Prior to shipment the Contractor shall furnish by air mail, fax, or otherwise, as agreed the shipping documents to the Employer.

When actual transport has been completed, the Employer shall be so notified.

All cases and boxes shall be clearly and boldly marked and shall be sent to the Employer as per address details indicated in the project manual or otherwise agreed with the Employer.

To facilitate custom examination, all packages and transport documents shall regardless of other markings be clearly and indelibly marked.

1.3.5 TRANSPORT ASSESSMENT

The Contractor shall prepare and submit to Employer/Project Manager, a transport assessment report.

The Contractors transport assessment report shall include but not be limited to:

- a) The intended transport route from the point of import to Papua New Guinea to Site
- b) List of all the regulatory authorities and Landowners the Contractor has consulted with, details of discussions reached and any approvals/permits issued
- c) Transporter drawing (plans/elevation) including general arrangements and sweep paths
- d) The method of transport to the final location including transport and pilot vehicles required
- e) List of any actions necessary along the transport routes such as remedial actions, strengthening, temporary routes, road closure
- f) Proposed transport plan, giving times of transport, all overnight storage locations, security requirements, etc.
- g) Where a transportation beam set is being used the additional transportation requirements should also be included
- h) Location and source of wheel sets and traction machinery
- i) No historical authority approval or adequacy of clearances for transportation shall be assumed.

SECTION VII: EMPLOYER'S REQUIREMENTS
A.01: GENERAL TECHNICAL REQUIREMENTS

1.3.6 TRAFFIC MANAGEMENT

The Contractor shall submit transport and traffic management plans for review by the Employer/Project Manager.

1.3.7 PERMITS AND APPROVALS

The Contractor shall be responsible for all permits, fees and supervision requirements for transport.

1.3.8 HEAVY LIFTS

The Contractor shall be responsible for providing all heavy lifting facilities to unload/load heavy equipment.

1.4 HEALTH, SAFETY AND ENVIRONMENTAL

1.4.1 HEALTH AND SAFETY

A Safety Manual shall be submitted by the Contractor to the Employer for approval before commencement of site work. All such safety requirements shall conform with the latest HSR regulations among others the CMD 2007.

The Health, Safety & Environmental procedures (HSE-Manual) shall comply with prudent industry practice.

The works and all plant, equipment and materials forming part of this Contract shall comply in all respects with any relevant local Statutory Regulations, By-Laws and Orders currently in force.

The Contractor shall provide documentation proving such evidence. The Employer shall have the right of refusal of the equipment if not so approved.

The Contractor shall provide a full time Safety Officer at site. Maximum safety precautions consistent with good erection practice in all site works must be afforded to personnel directly engaged on this Contract.

Particular care and additional safe-working precautions shall be taken during erection works in the vicinity of live lines and/or at places where there are parallel power lines which may be energized.

Supervision at site by a competent and experienced supervisor is a requirement.

The operation of or connections to any items of equipment once made live shall be subjected to Safety Regulations which require work permits to be issued by an authorized person before any work can be carried out.

The Contractor shall provide an alcohol and drugs policy statement.

The Project Manager shall have the right to audit safety procedures and documentation at any stage of the contract. If the Project Manager considers that any operation is in breach of safety legislation, or that

SECTION VII: EMPLOYER'S REQUIREMENTS
A.01: GENERAL TECHNICAL REQUIREMENTS

the safety of any personnel is compromised by any operation, the Project Manager shall have the right to halt the work.

1.5 ENVIRONMENTAL PROTECTION PLAN

The Contractor shall submit for the approval of the Employer/Project Manager an Environmental Protection Plan (EPP) giving a full account of potential environmental impacts and the mitigation measures which the Contractor proposes to employ. This Plan shall demonstrate that environmental concerns are addressed and adequate measures would be taken to comply with the recommendations made.

The Contractor shall be responsible for the correct implementation of the mitigation measures detailed in the approved version of this EPP Report.

Environmental Assessment Management Plan shall be strictly followed.

1.6 SIGNS

1.6.1 GENERAL

Safety colors, safety symbols and safety signs shall comply in construction, geometrical form, color and meaning with the ISO 3864-1 2011.

Signs of plant identification during the erection period shall be to the Project Manager's/Employer's approval.

The signs should be of a material, which is weather resistant and has sufficient durability under the conditions prevailing on site.

The position for the signs must be chosen so that they are within the field of vision of the persons to whom they apply. The signs should be permanently attached. Temporarily dangerous areas (e.g. construction sites, assembly areas) may also be marked by portable signs. The safety signs must be mounted or installed in such a manner that there is no possibility of misunderstanding.

1.6.2 WARNING SIGNS

Warning signs shall refer to the existence or possible existence of danger, such as:

- inflammable or explosive substances, corrosive or noxious substances, suspended loads, general danger, width/height restriction, danger of trapping, steps, slipping, falling, etc.

Appropriate black yellow strips markings should also be used where necessary.

1.6.3 PROHIBITION SIGNS

Prohibition signs are for example no smoking; no fires; no naked lights, no entry to pedestrians; no entry; do not switch on; etc.

1.6.4 PROTECTIONS, GUARDS, SUNSHADES

Moving machine parts in the open are to be provided with a suitable protection to prevent danger to the personnel. These protection devices have to be in accordance with applicable safety regulations.

1.6.5 HAZARDOUS AREAS

The Contractor shall take full account of any special requirements concerning the nature, handling and storage of fuel oils, gases etc. and make provisions to ensure the safety of the personnel and the correct area rating of any electrical equipment installed in hazardous areas.

1.6.6 MAINTENANCE ISOLATION

All major equipment shall be arranged to facilitate safe isolation from all hazards for maintenance purposes.

1.7 QUALITY ASSURANCE

The Contractor shall have a certified quality assurance system based on ISO 9000 and ISO14001 series for the activities in the scope of company.

The Contractor shall establish a Quality Assurance System under the scope of works included in the Contract.

For this purpose the Contractor shall prepare and submit Quality Plan in accordance with the guidelines provided in the draft of ISO 10013, and during the Contract Period in accordance with the latest revision of ISO 10013.

The Quality Plan shall cover all operational procedures which are all activities, services and Works of the Contractor during the Contract Period which shall include but not be limited to the following:

1. Design and development Procurement of raw materials
2. Manufacturing, testing
3. Construction/installation on site
4. Commissioning
5. Servicing/maintenance.

It is understood that all testing and inspections as specified in this document are part of the Quality Plan.

All work shall be witnessed by the Employer / Project Manager who shall have the right to observe any aspect of the work and carry out audits to check compliance with the quality documentation at any stage. The Employer / Project Manager shall have the right to halt the work in the event that significant infringements are identified to the Contract, Technical Requirements, Quality Assurance System, Quality Plan and Operational Procedures.

SECTION VII: EMPLOYER'S REQUIREMENTS
A.01: GENERAL TECHNICAL REQUIREMENTS

1.7.1 QUALITY PLAN

After Commencement Date the Contractor shall prepare a Quality Plan which shall define the operational procedures and quality control measures for the implementation of the general principles of the Quality Assurance System in the case of the present Project. This Quality Plan shall detail all tests and inspections to be carried out in case of the following activities but not limited to:

1. Type Tests (if applicable)
2. Raw materials, components and services inspections
3. Manufacturing
4. Factory Acceptance Tests
5. Site Tests
6. Commissioning.

The Quality Plan, which shall include the activities of all Sub-Contractors, shall clearly identify the following but not limited to:

1. The various significant material supply and installation phases including the Sub-Contractors and their roles
2. A listing of all the quality checks, inspections, and tests to be carried out
3. Documents describing the execution of the above quality checks, inspections and tests together with the relevant acceptance criteria.
4. A listing of the various working documents used to record results of such quality checks, inspections, and tests together with sample copies of such documents
5. Non-Conformance Reports "pro forma" together with details of the procedures to be followed in remedying such non- conformances
6. Establishment and maintenance of quality records.
7. Reference to the COVID-19 Management Plan (See Employer's Requirements Part A.02)

1.7.2 EMPLOYER QUALITY INSPECTIONS

The Employer and the Project Manager shall have the right for free access to the Contractor's and any Sub-Contractor's premises during the course of the Contract in order to carry out Quality Inspections which will include, but not be limited to the following activities:

1. Inspection of design documentation, calculations etc.
2. Witnessing the Type Tests
3. Witnessing the Routine Tests
4. Plant visits and inspections during manufacture
5. Participation at progress review meetings
6. Carrying out Quality Assurance System checks.

SECTION VII: EMPLOYER'S REQUIREMENTS
A.01: GENERAL TECHNICAL REQUIREMENTS

To facilitate such Quality Inspections, the Contractor shall provide the Employer and the Project Manager with a schedule indicating the timing of the principal quality control activities as detailed in the Quality Plan.

1.7.3 NON-CONFORMANCES

The Contractor shall provide the Employer and the Project Manager with a Non-Conformance Report for all "major non-conformances" encountered during the Contract. This Report shall contain full details of the nonconformance together with proposals for remedial action. The Employer or Project Manager shall require approving such remedial action prior to its implementation by the Contractor.

"Major non-conformances" are considered to be any departures from the requirements set out in the Technical Requirements or in the internal requirements detailed by the Contractor in his Quality Plan.

All other non-conformances such as departures from internal requirements not specified in the Contractor's Quality Plan can be considered as minor.

Such non-conformances shall also be detailed in a Non-Conformance Report.

1.7.4 FINAL QUALITY REPORT

Following completion of all quality activities carried out during the course of the Contract the Contractor shall compile a Quality Report. This report shall contain a complete record of the quality activities including, but not limited to, the following:

- The Quality Plan detailing the Quality Assurance System functions and procedures together with the detailed test and inspection program
- The Contractor's Raw Material Specifications
- Certificates of Origin of Raw Materials
- Test and Inspection Reports
- Minutes of Quality Audits
- Non-Conformance Reports
- Resolution of Non-Conformances Reports.

1.8 CORROSION PROTECTION AND PAINTING

1.8.1 GENERAL

This section is to define surface preparation, protective coatings and paint systems to be applied on equipment and structures unless otherwise specified.

All Plant and Material supplied under this Contract shall be suitable protected by an adequate painting system to withstand any deteriorating impacts caused by the climatic conditions as specified in the respective section.

SECTION VII: EMPLOYER'S REQUIREMENTS
A.01: GENERAL TECHNICAL REQUIREMENTS

Also standard material and equipment, if provided for this project, requires a painting system, which complies with this condition.

The general guides for the work shall be:

- a) These technical requirements
- b) Relevant international standards
- c) The paint manufacturer's product data sheets with related instructions
- d) The Employer shall have the right for the choice of the color from a color code to be prepared by the Contractor.

1.8.2 INSPECTION AND LIABILITY PERIOD OF CORROSION PROTECTION AND PAINT

The Contractor and/or paint Contractor shall assist the Project Manager/Employer in making any tests, or inspections when, in the opinion of the Project Manager/Employer, such inspection is necessary or required.

Defects which affect the corrosion protection and which are caused either by inadequate workmanship of application or by the coating material must be rectified by the Contractor at his cost.

The Employer reserves the right to decide when these deficiencies shall be rectified.

At commencement of painting up to a stage ensuring permanent high quality of application and thereafter upon request of the Project Manager/Employer the paint supplier shall be present at the job site to supervise the application, preparing test patches and to cover questions and problems which might arise. All related costs are deemed to be included in the contract price.

No consecutive coats of paint, except in the case of white, shall be of the same shade.

To provide proof of liability, various identified and recorded test patches shall be applied. Should any defect arise during the defects liability period, which is not reflected in the test patches, the reason will be assumed to be inadequate workmanship of application. Should the defect be reproduced similarly in the test patches and the total coated surface, the reason will normally be assumed to be inadequate quality of coating material.

1.8.3 RETAINED SAMPLES

For all coating work, samples must be taken and retained at the job site for possible reference in the event of coating failure. Retained samples must be kept at least until the Contract period has expired.

All paint film thickness quoted in the attached table "Paint Systems" refer to the dry film condition. For final acceptance, a surface area of 10 m² per 100 m² will be taken. Of the 50 single dft-measurements only 5 may be below 10 % of the specified dft. If results do not meet specification, additional coats must be applied until the specified thickness is reached. For measuring the dry film thickness, a non-destructive dry film thickness gauge shall be used.

SECTION VII: EMPLOYER'S REQUIREMENTS
A.01: GENERAL TECHNICAL REQUIREMENTS

Usually the required minimum dry film thickness has to be checked for the complete coating system. In specific cases it is necessary to measure the wet film thickness per coat, for example the prime coats.

After coating work is completed, a general final check of the coating application must be made. In certain cases (e.g. tar epoxy linings) the finished coating system shall be carefully inspected for pinholes in the paint film by commercial high voltage spark testers.

1.8.4 DEFECTS LIABILITY RELATED TO PAINTING

Defects which affect the corrosion protection and which are caused either by inadequate workmanship of application or by the coating material must be rectified by the Contractor at his cost.

The Employer reserves the right to decide when these deficiencies shall be rectified.

The Contractor shall warrant for 5 years for the corrosion protection using high quality coatings with synthetic resins.

1.8.5 WEATHER CONDITIONS FOR PAINTING

Painting shall only be done when no condensation occurs on the surface.

Therefore relative humidity shall be checked.

Painting of outdoor parts etc. is not allowed immediately prior and during sand storms, heavy winds and rain.

In hot weather precautions shall be taken to ensure that the specified dry film thickness of priming or finish coats is obtained.

Any prime coat exposed to excess humidity, rain, etc., before drying shall be permitted to dry and the damaged area of primer removed and the surface prepared and primed again.

The temperature quoted as "normal" in the "Paint System Tables" refers to the climatic conditions encountered on site.

1.8.6 SURFACE PREPARATION

General

Surface preparation should remove sufficient foreign matter to allow the type of prime paint used to wet the surface thoroughly and develop adequate adhesion.

In preparing any surface to be coated, all loose paint, dirt, grease, rust, scale, weld slag or spatter or any other extraneous material shall be removed and defects repaired, so as to obtain a clean, dry, even surface to receive the priming or finishing coat(s) as called for in the painting schedules. Sharp edges should be rounded.

SECTION VII: EMPLOYER'S REQUIREMENTS
A.01: GENERAL TECHNICAL REQUIREMENTS

All machined surfaces including flange faces shall be suitably covered to prevent damage during surface preparation.

All surfaces should be last cleaned whenever possible.

1.8.7 SURFACE PREPARATION METHODS

Bare steel surfaces should be prepared by one of the methods described below in order of preference and in accordance with EN ISO 8501-1 2007 or Steel Structure Painting Council, SSPC.

- a) White metal blast cleaning
- b) Near white metal blast cleaning
- c) Very thorough mechanical scraping and wire brushing
- d) Thorough scraping and wire brushing.

Mechanical cleaning should only be used when procedures (a) and (b) are not practicable.

In the event of rusting after completion of the surface preparation, the surface shall be cleaned again in the manner specified.

Oil, grease, soil, cement, salts, acids or other corrosive chemicals shall be cleaned from steel surfaces, by the use of solvents, emulsions or cleaning compounds.

The final wiping shall be with clean solvent and clean rags or brushes.

There shall be no detrimental residue left on the surface. Primed areas, which suffer damage must be spot blasted on site before touching up.

Protective coating shall be applied as quickly as possible after the completion of surface preparation no matter what cleaning method has been used.

No blast cleaned surfaces shall be allowed to remain uncoated overnight.

Steelworks protected by shop primer after arrival on site shall be cleaned of salt, sand, oil etc. before the first coat of paint is applied on site. Shop primer damaged during transport shall be rectified by blast cleaning and coating before application of the site coats.

Wood surfaces shall be sanded clean. All nail holes shall be puttied and sanded before priming.

Concrete: If a protective coating is required, concrete shall be allowed to cure before painting.

1.8.8 PREPARATION OF COATING MATERIALS

Primers and paints which have liveried, gelled or are otherwise deteriorated shall not be used. All ingredients in any container shall be thoroughly mixed before use and shall be agitated frequently during application to keep the primer in suspension.

SECTION VII: EMPLOYER'S REQUIREMENTS
A.01: GENERAL TECHNICAL REQUIREMENTS

Primer or paint mixed in the original container shall not be transferred until all settled pigment is incorporated into the body of liquid. Primer or paint shall be mixed in a manner ensuring the breakdown of all lumps, complete dispersion of pigment and uniform composition.

Thinners shall not be added to primers or paints unless necessary for proper application according to the manufacturer's instructions.

The type of thinners used shall comply with the manufacturer's instructions.

When use of thinners is permitted, it shall be added to the primer or paint during mixing in a good ventilated area.

1.8.9 APPLICATION

Methods

All prime coatings shall be applied by brush or airless spray or a combination of these methods, as approved by the coating manufacturer. All doors, windows, stairways, handrails (where painted), bottles, flanges and equipment supports shall be finish painted by brush.

Spray guns should not be used outside in windy weather or near surfaces of a contrasting color unless the latter is properly protected from the spray. All cold spray painting shall be done using standard equipment in accordance with accepted industry standards and methods.

Paint misplaced on items that are not to be painted shall be removed on demand of the Employer at the Contractor's expense, leaving the surface clean, unstained and undamaged.

Dry film thickness (dft)

To the maximum extent practicable, the coats shall be applied as a continuous film of uniform thickness and free of pores. Overspray, skips, runs, sags and drips should be avoided. The different coats shall not be of the same color.

Each coat of paint shall be allowed to harden before the next is applied. For epoxy paint the hardening time before the next coat shall normally be 12 - 14 hours. Suppliers' recommendations regarding hardening time of epoxy paints shall be observed.

Particular attention shall be paid to full film thickness at edges.

The minimum total dry film thickness of the paint systems shall be as recommended in the following tables 'Paint Systems'. The dft is given in microns (millionths of a meter).

1.8.10 PROTECTIVE COATINGS AND PAINT SYSTEMS

A color scheme must be established by the Contractor in cooperation with the Project Manager / Employer. The type and number of protective coats for any item requiring painting on the project shall be

SECTION VII: EMPLOYER'S REQUIREMENTS
A.01: GENERAL TECHNICAL REQUIREMENTS

in accordance with the following tables "Paint Systems" and the Project Manager/Employer's requirements.

Generally, all parts shall receive the specified prime coat(s) at the supplier's works to guarantee that no corrosion occurs during transport to the site and storage at the site. Parts, which cannot be damaged during transport shall receive the full number of coats in factory.

1.9 GENERAL REQUIREMENTS FOR GALVANIZING

Galvanizing work shall generally conform in all respects to internationally recognized standards, e.g. EN ISO 12944-5, EN ISO 1461 or equivalent standards and shall be performed by the hot dip process, unless otherwise specified.

The standards for galvanization shall be the same for the substation as for the transmission line.

It is essential that the shape of steel members and assemblies, which are to be hot dip galvanized shall conform to the requirements of the process.

Careful cleaning of welds is necessary before welded assemblies are dipped.

The welds and the surrounding metal should be cleaned separately, preferably by sand blasting.

All defects of the steel surface including cracks, surface laminations, laps and folds shall be removed. All drilling, cutting, welding, forming and final fabrication of individual members and assemblies shall be completed before the structures are galvanized. The surface of the steelwork to be galvanized shall be free from paint, oil, grease and similar contaminants.

Structural steel items shall be initially grit-blasted or by pickling in a bath and the minimum average coating weight on steel sections 5 mm thick and over shall be 915 g/m², but not less than 100 micrometers.

On removal from the galvanizing bath, the resultant coating shall be smooth, continuous, free from gross surface imperfections such as bare spots, lumps, blisters and inclusions of flux, ash or dross.

Galvanized contact surfaces to be joined by high tensile friction-grip bolts shall be roughened before assembly so that the required slip factor is achieved. Care shall be taken to ensure that the roughening is confined to the area of the mating faces.

Bolts, nuts and washers, including general grade high tensile friction-grip bolts shall be hot-dip galvanized and subsequently centrifuged. Nuts shall be tapped up to 0.4 mm oversize after galvanizing and the threads oiled to permit the nuts to be finger-turned on the bolt for the full depth of the nut.

No lubricant, applied to the projecting threads of a galvanized high-tensile friction-grip bolt after the bolt has been inserted through the steelwork, must be allowed to come into contact with the mating faces of the steelwork.

SECTION VII: EMPLOYER'S REQUIREMENTS
A.01: GENERAL TECHNICAL REQUIREMENTS

Protecting slings shall be used for off-loading and erection.

Galvanized steelwork which is to be stored during sea transport or at the works on site shall be stacked to provide adequate ventilation to all surfaces to avoid wet storage staining (white rust).

Small areas of the galvanized coating damaged in any way shall be restored by:

- cleaning the area of any weld slag and thorough wire brushing to give a metallic clean surface;
- the application of two coats of zinc powder rich paint, or the application of a low melting point zinc alloy repair rod or powder to the damaged area, which is heated to 300°C.

After fixing, bolt heads, washers and nuts shall receive two coats of zinc rich paint. Connections between galvanized surfaces and copper, copper alloy or aluminum surfaces shall be protected by suitable tape wrappings.

1.9.1 SPRAYED METAL COATINGS

Corrosion protection can also be achieved by spraying aluminum, zinc, tin, copper, lead or other suitable metals on the surfaces of structures.

Composition of coating metals, methods of surface preparation and application of coatings, requirements for thickness and adhesion and subsequent treatment shall conform, e. g. to EN ISO 2063 or equivalent.

1.9.2 WEATHERING STEELS

The requirements of Standards ASTM-A 242, ASTM-A 588 and EN 10025, EN ISO 12944 or equivalent standards shall be observed in the use of structural steel which is corrosion-inhibited, so-called weathering steels.

1.9.3 TABLE OF PAINTS

The table of painting shall be observed as included below.

SECTION VII: EMPLOYER'S REQUIREMENTS
A.01: GENERAL TECHNICAL REQUIREMENTS

	SURFACE/ LOCATION	TEMPERATURE °C	SURFACE PREPARATION	PAINT SYSTEM			PER COAT MICRONS Dft	APPLICATION		
				COAT	NO. OF COATS	GENERIC TYPE		IN SHOP	ON SITE	
1	Structural steelwork, piping (oil + water), tanks/outside surface, tower, cranes, steel floors, galleries stairways, outdoor	up to 130 °C	Sa 3	Prime	1	Solvent based inorganic zinc primer with a vol. solids content of min. 60 Vol. % of zinc reaction products acc. to volatile method, zinc dust 1.77 kg/liter. should be min. zinc dust by weight in dry film to be minimum 85%, pot life to be 12 hrs/21°C	75	x		
				Sealing	1	high build polyamine or amine adduct cured epoxy top coat total vol. solids to be min. 58 Vol. %	35	x		
				Touch up	1	Catalyzed zinc rich primer with atotal vol. solids content of not less than 45% and with a pot life of 12hrs at 21°C.	(75)		x	
				Finish	2	High build polyamide or amine adduct cured epoxy cop coat total vol. solids should be min. 58 Vol. %	125 125		x x	
				Total min. dft			360			

SECTION VII: EMPLOYER'S REQUIREMENTS
A.01: GENERAL TECHNICAL REQUIREMENTS

1.10 STANDARDIZATION OF MAKES

The works shall be designed to facilitate inspection, cleaning, maintenance and repair. Continuity of supply is a prime concern. The design shall incorporate every reasonable precaution and provision for the safety of all those concerned in the operation and maintenance of the works.

Corresponding parts throughout shall be made to gauge and be interchangeable wherever possible.

All equipment performing similar functions shall be of the same type and manufacture, to limit the stock of spare parts required and maintain uniformity of plant and equipment to be installed.

The Employer reserves the right to ask for coordination of standardization to the extent reasonably possible, and no price variation will be allowed for this procedure.

1.11 FIRE PROTECTION FOR MATERIALS AND FOR BUILDING ELEMENTS

1.11.1 FIRE PROTECTION PROVISIONS

All equipment, connections and cabling shall be designed and arranged to minimize the risk of fire and any damage, which might be caused in the event of fire. Where equipment is normally energized, corresponding precautions, such as fusing, over-voltage or over current protection, shall be provided to avoid risk of fire in the event of excessive current due to a fault on one of the components in the circuit. This is particularly important where voltages are derived from voltage dropping circuits in which failure of a component could lead to the full supply voltage being applied across other components.

Unless otherwise specified or agreed with the Employer / Project Manager, the following design principles shall be observed as minimum fire prevention requirements:

- Stuffing of cable and wall penetrations shall be performed and shall be of incombustible material to match the fire rating of the fire compartment from which the penetration exits/enters.
- Cable and pipeline ducts shall be arranged to avoid the risk that they will be flooded with flammable liquid.
- Covered floor ducts shall be easily accessible for inspection and cleaning.
- All parts of plant and equipment shall be arranged so that no corners or pits difficult to inspect and clean are formed, where flammable matter could collect.
- For the paneling of walls and ceilings, for floor covering as well as for cubicles and cabinets, incombustible materials are to be used.

1.11.2 PRE-SERVICE CLEANING AND PROTECTION OF PLANT EQUIPMENT

This clause covers mechanical and pre-service cleaning and protection of the plant items and equipment at the Manufacturer's workshop and at site that are not subsequently to be painted.

Cleaning of fabricated component items shall be carried out after fabrication and final heat treatment or welding at manufacturers' works or at site, as appropriate.

SECTION VII: EMPLOYER'S REQUIREMENTS
A.01: GENERAL TECHNICAL REQUIREMENTS

In the event of the surfaces not being cleaned to the Employer's satisfaction, such parts of the cleaning procedures or agreed alternatives as are deemed necessary to overcome the deficiencies shall be carried out at the Contractor's sole expense.

Mechanical cleaning as opposed to alternative chemical cleaning is the preferred method for workshop cleaning except where this is precluded by design or access considerations.

Machined surfaces shall be protected during the cleaning operations. For recleaning small areas, hand cleaning by wire brushing may be permitted.

Wire brushes used on austenitic materials shall have austenitic steel bristles.

Austenitic stainless steels, copper and aluminum alloys, cast iron, bimetallic and metallic/plastic items, and components fabricated by spot welding or riveting shall not be chemically cleaned. All weld areas shall be suitably stress-relieved before chemical cleaning.

All necessary equipment, provisions, chemicals etc. are to be provided by the Contractor.

The Contractor shall take overall responsibility for the treatment and disposal of wastes according to the local law and to the satisfaction of the Employer.

The Contractor shall take all necessary precautions to ensure that the internal surfaces of all plant are kept clean and free from injurious matter during erection.

1.12 INSTALLATION

Switchgear shall be designed for indoor or outdoor installation as applicable and shall be of the free-standing design, accessible from the front and the rear for operation, inspection and maintenance.

Proposed layout and elevation plans for the switchgear which shall consider the available space, shall be part of Contractor's scope. The design shall show recommended clearances for safe operation and maintenance of the equipment and also required lifting clearances for installation.

All components of the switchgear that are connected to earth potential shall be electrically bonded together and connected to a continuous earth bus that extend the entire length of the switchgear.

Connecting points for earth conductors from the plant earthing grid shall be provided at regular intervals on this earth bus.

1.13 STEEL STRUCTURES AND ASSEMBLY MATERIAL

1.13.1 GENERAL

Under steel structures are understood to be all substation gantries, building structures and frames, transmission towers with their body and leg extensions, additional cross arms –if required, the foundation stubs, and stub setting templates.

SECTION VII: EMPLOYER'S REQUIREMENTS
A.01: GENERAL TECHNICAL REQUIREMENTS

Under assembly material are understood to be all bolts, screws, rivets, nuts, washers, locking devices which are necessary for the assembly of the steel structures and their accessories as well as, for the assembling and mounting of the line equipment like insulator sets, conductor and earth wire accessories.

1.13.2 STEEL STRUCTURES

Generally, the design and stress calculation shall conform to a code or standard such as:

- IEC 60826 Design criteria of overhead transmission lines
- ISO 10721 Steel structures; calculation and construction
- EN 1993 Design of steel structures.

The local climatic conditions, load calculation, description of loading cases, as well as the applicable design method and safety factors shall be observed as specified in this specification.

The material to be used for the structures is high tensile – and mild steel sections and plates, according to internationally recognized standards (ISO 630, DIN 17100 or equivalent).

All structural steel shall be protected against corrosion by hot dip galvanizing.

1.13.3 ASSEMBLY MATERIAL

All necessary bolts, screws, rivets, nuts, washers and locking washers shall be included in the scope of supply of the Contractor with sufficient spare to cover for losses. Members of lattice steel structures including stub setting

templates shall be secured by means of bolts and nuts with approved spring washers and lock washers. All bolts and nuts shall conform respectively to ISO 898 and/or DIN 267 and shall have metric screwed threads.

Nuts and the heads of bolts shall be of the hexagonal type. Nuts – except lock nuts – shall be full bearing on one side.

Minimum size of bolts for all structural connections shall be 16 mm diameter in mild steel or 12 mm in high tensile steel. The quality of bolts shall not be less than 5.6 according to ISO 898 and/or DIN 267.

All bolts and screwed rods shall be galvanized including the threaded portions. All nuts shall be galvanized with the exception of the threads, which shall be oiled.

Where for any type of tower high tensile steel bolts are employed then bolts of this type shall be used for all connections for every type of tower on that line in order to avoid the use of mild steel bolts in error where high tensile type should be employed. High tensile steel bolts shall bear a mark on the head to allow identification of grades.

The nuts of all bolts attaching insulator set droppers, U bolts and earth conductor clamps to the towers shall be locked in an approved manner.

SECTION VII: EMPLOYER'S REQUIREMENTS
A.01: GENERAL TECHNICAL REQUIREMENTS

All washers shall be included under this contract, including locking devices and anti-vibration arrangements, which shall be subject to the approval of the Employer / Project Manager. Taper washers shall be fitted where necessary.

Nuts shall be finger tight on the bolt and will be rejected if they are, in the opinion of the Employer /Project Manager, considered to have an excessively loose or tight fit. Bolts with threads re-died after galvanizing will be rejected. Nuts and bolts of the same type shall be interchangeable and supplied from the same manufacturer.

When in position, all bolts or screwed rods shall project through the corresponding nuts, but this projection shall not exceed three threads, unless more length is required for adjustment.

The Contractor shall supply the net quantities plus 10% of all permanent bolts, screws, nuts and other similar parts and materials required for installation of the works at the site. Any such assembly material, which is surplus after the installation of the equipment has been completed, shall become spare parts and shall be wrapped, marked and handed over to the Employer.

2. GENERAL ELECTRICAL REQUIREMENTS

2.1 GENERAL

The general electrical requirements herein shall be read in conjunction with all Specifications and drawings.

The new substations design shall be suitable for high-speed and delayed, single-phase and three-phase auto-reclose operations.

The substation design shall be of robust construction, designed to prevent accidental contact being made with any live part.

The substation design shall be such as to minimize the possibility of failure due to moisture and dirt being deposited on the insulation.

Every current-carrying part of the electrical equipment, including circuit breakers, SF6, oil or air-insulated isolating equipment, busbars, current transformer chambers, cables, connections and joints shall be capable of carrying its specified rated current continuously under the atmospheric conditions existing at site, and in no part shall the temperature rise exceed the values stated or implied in the Specifications and related standards.

Every part of the electrical equipment shall also withstand without mechanical or thermal damage the instantaneous peak currents and rated short-time currents pertaining to the rated breaking capacity of the circuit breaker.

SECTION VII: EMPLOYER'S REQUIREMENTS
A.01: GENERAL TECHNICAL REQUIREMENTS

All non-current carrying metalwork associated with the electrical system that is exposed to touch shall be solidly earthed.

Voltage levels

The voltage levels applicable to the substation are specified in Section VII Part F – Specification ES-01.

LV system configuration

The LV network shall be TN-S. The point of common connection between neutral and earth shall be at the transformer neutral. No other connections between neutral and earth shall be affected beyond the point of common connection.

The neutral conductor is to be insulated in the same manner as the phase conductors. The use of constructional parts of the switchgear as a neutral conductor is not permitted.

IP ratings for electrical equipment

The IP rating for switchgear housings shall be as specified in the technical data sheets.

Electrical drawings Symbols complying with IEC 60027, IEC 60034, IEC 60037 and IEC 60117 are to be used for all drawings.

2.2 HV SWITCHYARD EQUIPMENT

2.2.1 HV CIRCUIT BREAKERS

SF6 gas insulated circuit breakers shall be single-pressure puffer or self blast suitable for outdoor installations.

Circuit breakers shall be designed to IEC 62271 and fully tested in accordance with IEC 62271-100 and with the requirements of these Specifications, and shall be capable of carrying the specified rated current continuously under the Site conditions.

All type tests shall have been either carried out by independent testing laboratories or witnessed by independent observers within the past 5 years.

2.2.2 HV DISCONNECTORS

The disconnecter switches shall be constructed and fully tested in accordance with the requirements of IEC 62271-102, and the Specifications.

The disconnecter switches shall be capable of carrying the full-load current of the circuit. Disconnectors will not be required to break current other than the charging current of open busbars and connections or load current shared by parallel circuits.

Disconnecter switches shall be so designed that they shall not open by forces due to currents passing through it, and shall be self-locking in both the "open" and "closed" positions.

SECTION VII: EMPLOYER'S REQUIREMENTS
A.01: GENERAL TECHNICAL REQUIREMENTS

Unless otherwise specified, disconnecter switches shall be provided with electrical operating mechanisms and shall be arranged for local and remote control. Electric motor operated mechanisms shall be provided with means for emergency manual operation. The mechanism shall normally open and close all three poles simultaneously.

Means shall be provided at the local control point to prevent the local and remote control apparatus from being in operation simultaneously.

The operating mechanism shall be located so that it can be maintained while the disconnecter is live.

2.2.3 CURRENT TRANSFORMERS

The oil filled current transformers shall comply with IEC 61869-1 Each current transformer shall be filled with oil as specified by IEC 60156.

The Contractor shall be responsible for the sizing, rating and other details pertaining to the current transformers. Details of the proposed current transformers shall be submitted with the tender data sheets.

The primary windings shall have a continuous and short circuit rating not less than that of the associated circuit breakers. The Contractor shall submit details of the precautions taken in the design of the primary of the transformer to prevent the mechanical and thermal stresses set up on short circuits from causing a breakdown.

Transformer circuits may be subjected to overload duties in accordance with IEC 60354; current transformers in transformer circuits shall have a rated continuous thermal current equivalent to at least the transformer long-time emergency cyclic loading capability.

Current transformers shall be of low reactance type and each core shall be electrically separated from the other windings.

The secondary windings of each set of current transformers shall be earthed at one point. Secondary terminals shall be located so that they are accessible while the equipment is live.

Where adequate earth screens are fitted between the primary and secondary windings, earthing of the secondary winding shall be via a link mounted in the related protection or instrument cubicle. Where such earth screens are not fitted a separate earth system may be necessary.

Wherever possible the connection to earth shall be on the side of the S2 terminals.

Where multi-ratio transformer windings are specified, multi-ratio primary windings will only be considered where the protection arrangement makes these suitable for all aspects of the installation.

When multi-ratio taps are specified, a label shall be provided indicating clearly the connections required for all ratios. These connections and the ratio in use shall also be shown on all connection diagrams.

SECTION VII: EMPLOYER'S REQUIREMENTS
A.01: GENERAL TECHNICAL REQUIREMENTS

Neutral current transformers shall be of the outdoor totally enclosed porcelain bushing type complete with mounting steelwork as required and terminal box for secondary connections.

For distance measuring protection, and current differential protection schemes the Contractor must state clearly the accuracy necessary for the correct functioning of the protection system offered and show that the secondary output of the current transformer is satisfactory for this purpose.

Class PX current transformers shall be specified in terms of the Turns Ratio (e.g. 1/2000) and have a secondary current rating (ISN) adequate for the primary rating (IPN) of the circuit to which it is connected. The dimensioning factor (KX) shall be selected to ensure an adequate knee point voltage (Ek), taking into account the other circuit elements and the protection function.

Line protection current transformers shall correctly transform during initial faults and following high speed three phase re-close onto faults without saturation at the system source X: R ratio (L: R) appropriate to the system voltage and shall be that used for the asymmetrical rating of the associated circuit breakers.

The voltage produced at the cores by over current or during transients on the system shall be well below the saturation voltage to ensure good transient response. The Contractor should make calculations related to the current transformer burdens and transient response according to the relevant IEC standards and submit for approval.

Where current transformers are to be mounted on apparatus provided under another contract the contractor shall be responsible for making all the necessary arrangements directly with the other contractors and for keeping the Employer informed.

Current transformers for balanced earth fault protection shall be tested to prove compliance with the requirements of IEC 61869-1.

All current transformers shall be so designed such that the requirements of Section VII Part F - Specification ES-04 are complied with. Calculations supporting the current transformers proposed shall be submitted to the Employer for review during the design stage of the project.

2.2.4 CAPACITIVE VOLTAGE TRANSFORMERS

The voltage transformers shall be high-capacitance type. The accuracy and rating shall be determined by the Contractor and shall be suitable for all devices connected thereto.

The design of capacitor voltage transformers shall be such that the accuracy shall not be affected by the presence of pollution on the external surface of the insulation, the voltage transformers shall comply with the requirements of IEC 61869.

The voltage transformers shall be designed to operate devices which require a potential source of approximately constant voltage ratio and negligible phase shift with respect to the high-voltage circuit.

SECTION VII: EMPLOYER'S REQUIREMENTS
A.01: GENERAL TECHNICAL REQUIREMENTS

All voltage transformers shall be so designed such that the requirements of Section VII Part F - Specification ES-04 are complied with. Calculations supporting the voltage transformers proposed shall be submitted to the Employer for review during the design stage of the project.

2.2.5 SURGE ARRESTERS

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

Surge arresters for reactor protection shall discharge energy that could cause stress to the shunt reactor, and shall maintain the reactor voltage within safe levels.

The design of surge arresters shall be in accordance with the relevant sections of IEC 60099.

Porcelains and fittings shall be designed to comply with the applicable requirements of these specifications.

Construction

The arresters shall be of robust construction and shall be designed to facilitate handling, erection and cleaning and to avoid pockets in which water can collect.

The method of assembly of the arrester shall be such that adequate contact pressure is at all times maintained between the faces of the series non-linear resistance blocks. The design of the series gaps and voltage grading resistors shall be such that the gap setting cannot be affected by vibration, mechanical shock or change in temperature.

All joints shall be made in an approved manner such that the arrester is hermetically sealed with material, which will not deteriorate under any service conditions.

The Contractor shall provide details of grading rings that are to be provided.

This shall include details of all materials used and clearances required from grading rings to earth and to live parts of other equipment.

Where necessary by site specific requirements the arrester porcelain housing shall have increased creepage length to withstand local pollution conditions to the approval of the Employer.

Surge Counters

Surge counters shall be provided and shall be operated by the discharge current passed by the arrester. Surge counters shall be of the electromechanical type and designed for continuous service. They shall be robust and capable of passing repeatedly without damage the maximum discharge current of the arrester.

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

SECTION VII: EMPLOYER'S REQUIREMENTS
A.01: GENERAL TECHNICAL REQUIREMENTS

arrester out of service.

Surge arrestors shall meet the requirements of the Specification.

2.2.6 BUSBARS

Busbars shall be in accordance with Section VII Part F - Specification ES-01 and shall be constructed from suitably sized and rated aluminum conductor or tubular aluminum. Associated structures will be kept to the lowest possible height, whilst conforming to the requirements for safe electrical clearances.

The general construction of the busbars shall be kept as short and straight as possible and their insulated supports shall be of approved construction, mechanically strong and shall withstand all the stresses which may be imposed upon them in ordinary working due to the fixing, vibration, fluctuations in temperature, short circuit or other causes.

Safety factors shall be such that no material used for busbars, connections or for supporting the connections, where insulated or otherwise, shall be stressed to more than one-fourth of its breaking load or one-third of its elastic limit, whichever is the lesser. Provision shall be made for expansion and contraction of the busbars and connections with variations of temperature. The busbars shall be so arranged that they may be extended in length without difficulty. The design of the connectors from outdoor busbars and connections to the parts of the equipment shall be such as to permit easy dismantling for maintenance purposes.

The Contractor shall provide all necessary terminals on the switchgear for the connection to other apparatus and cables. The Contractor shall specify the busbars and connections to be provided for approval by the Employer.

The busbars and connection shall be so arranged and supported that under no circumstances, including short circuit conditions, can the clearance from earthed metalwork or from other conductors be less than distances specified by International Standards.

2.2.7 TRANSFORMERS

Transformer and reactors shall be in accordance with the requirements of Section VII Part F - Specifications ES-02 and ES-09.

The transformers shall be suitable for continuous operation on a three-phase 50 Hz high voltage transmission system as specified in the Technical Schedules.

All windings of the transformers shall be capable of withstanding short circuit for the periods of time specified in IEC 60076 when operating on any tapping position, including that corresponding to minimum effective impedance, with the fault current available at the terminals. The Contractor shall demonstrate the transformer or reactor's ability to withstand the specified short circuit conditions in accordance with IEC 60076-5.

SECTION VII: EMPLOYER'S REQUIREMENTS
A.01: GENERAL TECHNICAL REQUIREMENTS

Transformers and reactors shall meet the latest stage of development reached in design, construction and materials.

2.2.8 EQUIPMENT LOCAL CONTROL AND MARSHALLING CABINETS

The Contractor shall supply for each circuit breaker, disconnecter, transformer and reactor an approved local control or marshalling cabinet in which all auxiliary connections from the equipment shall be terminated.

All junction boxes, terminal boxes, control and marshalling cabinets shall be constructed of steel.

All main equipment shall be arranged so that it is accessible from the front of the box or cabinet.

Outdoor boxes and cabinets shall have sloped double roofs and shall be of weatherproof, vermin-proof and termite-proof construction, with adequate ventilation and draining facilities. They shall be so designed so that condensation shall not affect the insulation of the internal apparatus, the terminal boards or the cables. Anti-condensation heaters shall be provided and shall be controlled by means of an internal thermostat and hygrostat. A water-tight switch mounted on the outside of the box or cabinet shall be provided for ON/OFF control of the heater circuit.

Any internal divisions between compartments inside the boxes or cabinets shall be perforated to assist the natural air circulation.

Access shall be provided at both the front and back of cabinets 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 13-kg weight may be of the slide-on pattern; over this weight they shall be hinged.

Cabinet doors shall be fastened with integral handles rather than loose keys, and provision shall be made for padlocking each door.

Where 415, 240 Volt a.c. or 220 Volt d.c. connections are taken through a box or cabinet, they shall be adequately screened or insulated and labeled in accordance with the Specifications.

All cables shall enter boxes and cabinets at the base through separate cable glands.

Plates for supporting cable glands shall be at least 450 mm above ground level. Cable glands and conduits will project at least 20mm above the gland plate to prevent any moisture on the plate draining into cables or conduits.

Also, means shall be provided to drain water off the surface of the gland plate. The back, sides and front of the box or cabinet shall project at least 50mm below the gland plate to prevent moisture draining on to the plate and cable glands at any time.

SECTION VII: EMPLOYER'S REQUIREMENTS
A.01: GENERAL TECHNICAL REQUIREMENTS

2.3 MV SWITCHGEAR

2.3.1 GENERAL

The medium voltage switchgear shall be in accordance with the requirements of Specification ES-08.

The medium voltage switchgear shall be of the metal-clad type suitable for indoor installation as shown on the single line diagram, and shall consist of a single insulated busbar in a metal-clad busbar chamber, floor mounted unit, incorporating enclosures for the circuit breaker units, busbars, and current transformers and auxiliary wiring. An ammeter and voltmeter shall be provided on the front of the cubicle enclosure.

All switchgear shall be provided with a mimic diagram.

The switchgear shall provide a maximum degree of safety for the operators and others in the vicinity of the switchgear under all normal operating conditions, under all short circuit and internal arcing fault conditions. The interlocks provided shall prevent any maloperation. The switchgear shall be suitable for satisfactory continuous operation.

Every current carrying part of the equipment including circuit breakers, current transformers, isolating devices, busbars, connection and joints shall be capable of carrying its rated current continuously and in no part shall the permissible temperature rise be exceeded.

In addition all parts of the switchgear, including current transformers, shall be capable of withstanding without thermal or mechanical damage, the instantaneous peak and short time currents corresponding to the rated symmetrical breaking capacity of the circuit breakers.

All current ratings specified are the minimum continuous values required under the service conditions specified in Section VII Part C – Scope of Works.

The switchgear shall be designed for a service life of at least 30 years in the environment and for the duty specified on the Data Sheets.

All protection, control, indication and alarm facilities shall be grouped on a per circuit basis. All protection and control wiring shall be installed within plastic conduit.

Visible terminals of the protection and control wiring and equipment shall be covered by protective insulating covers.

Wiring connecting to apparatus mounted on doors or between points subject to relative movement shall be installed in flexible corrugated pipes and supported in insulating cleats.

All power operated equipment shall be operable either locally at the cubicle or remotely from the substation control room, but the two systems shall not be in operation simultaneously. A facility for selection of "remote" or "local" control shall be provided on the cubicle of the equipment being controlled.

SECTION VII: EMPLOYER'S REQUIREMENTS
A.01: GENERAL TECHNICAL REQUIREMENTS

Each cubicle shall be fully wired and equipped with all necessary equipment including alarms, indication, and test facilities, isolating facilities, instruments, fuses and cable terminations etc.

All circuits, equipment, control switches etc shall be clearly labeled as to their purpose and function.

Visual indicating devices shall be provided adjacent to the circuit breaker control handle or switch to show whether the circuit breaker is open or closed. To conserve power and reduce maintenance light emitting diodes (LED's) are preferred.

2.3.2 CIRCUIT BREAKERS

All circuit breakers shall comply and be fully type tested to IEC 62271-200, IEC 62271-100, IEC 60694 and IEC 62271-110, in independent testing laboratories not associated with the manufacturers, or witnessed by an independent observer.

The circuit breaker shall be trip free and fitted with an anti-pumping device.

The circuit breakers shall be suitable for satisfactory continuous operation at the specified rating at the maximum site ambient temperature. Satisfactory test evidence shall be submitted to confirm the performance of the equipment at all site conditions.

The circuit breaker shall be mounted on withdrawable trucks, complete with high integrity operating and isolating mechanisms, auxiliary contacts, manual tripping facilities, operations counter, mechanical position indicator, control wiring, auxiliary relays and contactors as required.

The operating mechanism shall be of the motor wound spring stored-energy type unless otherwise approved.

It shall be possible to manually discharge the springs.

Facilities for manual charging of the springs shall also be provided.

The circuit breaker shall incorporate a manual trip facility (preferably push button, located on the door of the panel and fitted with a guard or shroud to preclude inadvertent operation) and be capable of being manually tripped from outside if the control power fails (i.e. should trip without DC supply).

All mechanical position indicators shall be directly driven by their initiating devices.

Circuit breakers of the same type and current rating shall be interchangeable electrically and mechanically.

2.3.3 BUSBARS

The busbars shall be of copper, rated continuously as specified. The busbars and connections shall be suitably insulated.

All busbars, connections and earthing-conductors on the switchgear panel shall be of hard drawn, high conductivity copper with constant cross sectional area throughout the length. The busbars shall have heat

SECTION VII: EMPLOYER'S REQUIREMENTS
A.01: GENERAL TECHNICAL REQUIREMENTS

shrink flexible insulation sleeves. They shall be supported and secured by cast resin insulated connectors capable of withstanding stresses associated with 3 sec short time current. Each compartment shall be such that arc products cannot pass to adjacent compartments or to the front of the cubicle.

The busbars shall be arranged so that they may be extended without undue disturbance to the adjacent busbar chambers. The busbars shall be arranged in a separate compartment and high-strength insulation barriers shall be provided at each junction between the adjacent cubicles.

2.4 AUXILIARY WIRING

All cubicle and cabinet wiring shall be neatly run and securely fixed in such a manner that, wherever practicable, wiring can be easily checked against diagrams.

All wiring shall be taken to terminal boards and the wires shall not be jointed or thread between terminal points. Conductors shall be terminated in terminals of design approved by the Employer. The wiring terminals shall clamp the conductor by means of screws. Screw pressure shall be applied by a pressure plate.

Numbered ferrules shall be fitted to all wires on panels and to all multicore cable tails. Ferrules shall be of black or white insulating material with a glossy finish to prevent adhesion of dirt. They shall not be affected by moisture or oil and shall be clearly and permanently marked. Temporary marking is prohibited.

The same ferrule number shall not be used on wires forming connections not directly in series or parallel in the same panel.

All wires which, if interfered with, may cause tripping currents to flow shall be provided with red ferrules embossed with the letter 'T'.

Colour coded ferrules shall be used for phase identification on current and voltage transformer circuits.

Wherever practicable, all power circuits shall be kept physically separated from the control wiring and low-level signal wiring. Separate raceways shall be provided for above systems. The working voltage of each circuit shall be marked on the associated terminal boards.

The DC trip and AC voltage supplies and the wiring to main protective gear shall be segregated from those for backup protection and also from protective apparatus for special purposes and also from protections of other bays. Each such group shall be fed through separate fuses either 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.

All terminal boards shall be sized such that 15% spare terminals are available for future expansion.

Each alarm initiation point shall be connected to the RTU.

SECTION VII: EMPLOYER'S REQUIREMENTS
A.01: GENERAL TECHNICAL REQUIREMENTS

2.5 INTERLOCKING

The Contractor shall be responsible for the designing, supply and commissioning of all interlocking schemes to the satisfaction of the Employer. Designs are to cover the 132, 66 & 11kV switchgear, 132, 66 & 11kV transformers, ac station services, dc station services as may be affected by the equipment being supplied.

All disconnecting switches and earthing devices shall be provided with interlocking features of the mechanical sequential locking type or electromechanical bolt type, and the scheme of interlocking shall be subject to approval and shall include the hand operation of apparatus which is normally electrically operated.

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

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 electrical interlocks shall so function as to interrupt the operating supply. Failure of supply or connections to any electrical interlock shall not produce or permit faulty operation.

Electromechanical bolt interlocks shall be energized only when the operating handle of the mechanism is brought into the working position.

Visible indication shall be provided to show whether the mechanism is locked or free. Means shall be provided whereby the bolt can be operated in the emergency of a failure of interlock supplies.

The guarding and screen-work of all equipment, wherever provided, shall be interlocked with the associated circuit breaker and the isolating devices in such a manner that entrance to the guarded equipment cannot be obtained unless the circuit breaker and isolating devices are open and all equipment within the guarded area is de-energized and safe. It shall not be possible to make the apparatus live while the guarding is open.

Earthing switches are to be interlocked with the appropriate disconnect switches such that the earth switch cannot be closed unless the disconnect switches are open. Conversely, the disconnect switch cannot be closed unless the earth switch is open.

2.6 ELECTRICAL STUDIES

The Contractor shall undertake the following studies relevant to the correct functioning of the substation:

Protection settings and relay software

The contractor shall perform the protection coordination study and relay settings for the complete substation protection and submit to the Employer/Employer's representative for their review and approval.

SECTION VII: EMPLOYER'S REQUIREMENTS
A.01: GENERAL TECHNICAL REQUIREMENTS

The study/relay settings shall be performed for all involved substations considering all relevant substations voltage levels and other protection settings. Adjustment of settings for the neighboring substations shall be considered/proposed as well (adjustment for these stations will be performed by the Employer). The Contractor shall request in due time the necessary data from Employer. Data not available shall be estimated/calculated by the Contractor. It has to be considered that only limited data may be available.

For each location of the supplied relays and each relay type, the Contractor shall deliver a complete set of setup software, manuals and firmware files.

Insulation coordination study.

The contractor shall perform the insulation coordination study for the complete substation and submit it to the Employer/Employer's representative for their review and approval. The study shall be performed considering all relevant issues which can affect the insulation of the Substation and in compliance with IEC 60071. A proposed order of priorities for an insulation coordination policy is to:

- Ensure safety to public and operating personnel
- Avoid permanent damage to plant
- Minimize interruption of supplies to consumers
- Minimize circuit interruption.

The outcome of the study shall be mainly the positioning of surge arrestors, characteristics selection of surge arrestors, substation lightning shield protection, etc.

2.7 ELECTRICAL PROTECTIVE MEASURES

2.7.1 GENERAL

The overall earthing system for the substation shall be designed to meet the requirements of this Specification and shall be in accordance with "The Guide for Safety in Alternating Current Substation Grounding" as published by the Institute of Electrical and Electronic Engineers Incorporated, Publication No. IEEE 80. The Contractor shall present calculations to show the earthing system meets these requirements and can be shown to be safe in terms of touch, step and transferred potentials under normal operation and fault conditions.

The design of the earthing for the 66kV and 11kV systems shall each be considered independently. Each system shall be adequately bonded together during normal system operation.

All parts of electrical equipment with an electrical potential above 50V shall be insulated or so covered that inadvertent contact with live parts cannot occur.

All metal enclosures or housings for electrical equipment and cable containment systems shall be effectively earthed.

SECTION VII: EMPLOYER'S REQUIREMENTS
A.01: GENERAL TECHNICAL REQUIREMENTS

The touch potentials derived during the detailed design process shall be equal to, or less than, the requirements of:

- IEC 60079 and IEC 60364 or equivalent standards for installations up to 1000V approved by the Employer.

2.7.2 PROTECTION AGAINST DIRECT CONTACT

All live parts of electrical equipment which can be reached by hand shall be protected against direct contact either by means of insulation or due to constructional design, position or arrangement, or by means of special devices.

2.7.3 USE OF EXTRA LOW VOLTAGES (ELV)

The operational voltage of tools and lighting equipment required to operate in metallic containers or tanks shall not exceed 50V. Centre tapped isolating transformers shall be used for ELV supplies.

2.7.4 EARTHING, EQUIPOTENTIAL BONDING AND LIGHTNING PROTECTION

Earthing and equipotential bonding

The earthing system and equipotential bonding shall comply with:

- IEC 60364
- IEC 60479

and shall be in accordance with Section VII Part F - Specification ES-01.

Lightning protection

All switchyards and buildings shall be provided with a lightning protection system.

The lightning protection system shall meet the requirements of IEC 62305 or NFPA 72, and shall be in accordance with the requirements of Section VII Part F - Specification ES-01.

Switchyard equipment earthing

All non-current carrying conductive parts of the installation within the scope of the Contract shall be connected to the main earthing system.

All steel sections or frames shall be provided with at least two earthing connections for every section which is fabricated from parts bolted together.

The earthing connections shall be located at the ends of the section. Bolted connections between structural sections are considered to be electrically non conducting.

The Contractor shall provide earthing straps on both sides of the bolted connection and a minimum of two final connections shall be made to the main earthing grid system for each steel structure.

SECTION VII: EMPLOYER'S REQUIREMENTS
A.01: GENERAL TECHNICAL REQUIREMENTS

To ensure that electrolytic action is avoided when connecting different materials, material transition plates shall be inserted. All connecting materials shall be corrosion-proof and suitable for the conditions prevailing at the place of installation.

2.7.5 ELECTROMAGNETIC COMPATIBILITY (EMC)

Measures compatible with the requirements of IEC 61000-5 shall be taken to ensure that during operation no malfunction or damage to equipment occurs due to the unintentional generation, propagation and reception of electromagnetic energy by conductive coupling, inductive coupling or capacitive coupling.

Measures shall consist of earthed housings, screening of cables, decoupling or filtering, and emission suppression.

Surge suppression shall be provided at all low-voltage main distribution boards.

Over voltage protection shall be an integral function of the power supply for both central and distributed power supplies to electronic cubicles.

2.8 CABLES

2.8.1 GENERAL

Cables and the installation of cables shall be in accordance with the requirements of Section VII Part F - Specification ES-11. All cables provided under this project shall be suitable for satisfactory continuous operation at the design rating at the maximum site ambient temperature as specified.

All cables provided under this Contract shall be of type and finish approved by the Employer.

Where cables pass through holes in floors immediately beneath oil filled equipment, the Contractor shall be responsible for plugging the holes with approved silicon foam fire seals or other approved materials after the cables have been installed and the cost thereof is deemed to be included in the contract price quoted for the cables.

All cables must be laid neatly and in such a way that they can be withdrawn, replaced or renewed easily.

All cable over-sheaths shall be free from defects and impervious to water.

Control, protection and indication multi-core cables shall be installed with a minimum of 15 per cent (15%) spare conductors.

Cables which must move with connected apparatus, or due to thermal expansion, shall be flexible and shall have sufficient slack to freely permit the movement.

2.8.2 CABLE LAYING AND ROUTING REQUIREMENTS

In outdoor substation areas cables shall typically be laid on cable trays/ladders in reinforced concrete cable trenches. Exceptions are subject to the approval of the Employer. All cable trenches shall be of

SECTION VII: EMPLOYER'S REQUIREMENTS
A.01: GENERAL TECHNICAL REQUIREMENTS

adequate to dimension to accommodate the cables anticipated for the final stage of development of the substation. Cables must be carefully arranged, ordered and secured.

All cables laid in concrete trenches shall be armored water-proof type.

Where cables enter or pass through ducts or trenches, adequate space shall be provided for the later installation of a further 15 per cent (15%) of additional cables. Openings to floors and foundation pads shall be large enough to allow free movement of the cable during installation. Trenches and ducts shall be sealed where they enter a building to prevent the entry of moisture, gases and vermin into the building.

Under exceptional circumstances direct burial may be permitted by the Employer. Where direct burial of cables is permitted, cables are to be laid into the ground in a prepared cable trench on a sand bedding. Cables are to be separated from each other according to voltage level. The cables must be laid at a minimum depth of 0.8 m, then covered with a sand layer over the cables. Above the final layer of sand plastic protective cable tiles shall be provided, and above the plastic cable tiles warning tapes shall be provided.

Where cables have to pass under roads, cable ducts consisting of concrete encased PVC pipes with a suitable bore are to be provided. All direct burial cable routes must be marked by cable markers.

Where cables enter a cubicle, marshalling box, kiosk or control panel, cable glands shall be provided.

Manufacturer's restrictions on the bending radius of cables and pulling tensions shall be strictly adhered to, and sharp bends which might damage the cable or cause difficulty in pulling shall be avoided.

Within all buildings suitable cable containment shall be provided for all cables. The cable containment provided shall consist of cable trays, ladders, trunking and conduit. Cables installed on cable tray or ladder shall be secured to the cable containment with corrosion resistant cable ties. No more than one cable may be fastened by a single cable tie, except where trefoil formation is required. A conduit and trunking fill factor of 40% shall not be exceeded.

Cable tray or ladder risers near gangways or in electrical rooms which are exposed to possible mechanical damage are to be protected up to a height of 1 meter above floor level ground by suitable metallic protection.

2.8.3 MEDIUM VOLTAGE (MV) POWER CABLES

The design of the MV cables shall be to IEC 60502. MV cables shall be screened, stranded, single-core or three-core cables with XLPE insulation.

The cables shall be provided with a red, non-fading PVC outer over-sheath.

Three-core cables shall be with individually screened cores. Single core MV cables shall be AWA and three core MV cables shall be SWA.

The cables shall be terminated with accessories as specified.

SECTION VII: EMPLOYER'S REQUIREMENTS
A.01: GENERAL TECHNICAL REQUIREMENTS

2.8.4 LV POWER CABLES

Low voltage power cables shall be standard single and multicore cables with copper conductor.

Connections between the low voltage side of 11/0.415kV transformers and the 0.415 kV main distribution cabinets shall be made with single core cables.

Over-sheath

The PVC or PE over-sheath on LV cables shall be oil resistant, UV resistant and shall be fire retardant where installed internally. LV cables shall have a black over-sheath. The sheath shall be embossed with the manufacturer's name, the voltage level U_o/U in kV and the cable type.

2.8.5 INSTRUMENT TRANSFORMER CABLES

Instrument transformer cables shall connect to one source only, e.g. a single winding of a voltage or current transformer. Each winding of the instrument transformer shall be connected to the appropriate relay or device in the Control Building by a separate cable.

2.8.6 CABLE CONNECTIONS AND CABLE JOINTS

For the connections of cable cores with a cross section of 1.5 mm² or larger, compression type cable lugs shall be provided. The terminals shall be designed to ensure that no pinch-off of the cable cores occurs. If cables with a flexible cable core are used, the stripped ends of the cores shall be equipped with a core sleeve before connection.

Where cable ends are stripped, the cable ends shall be firmly attached to the internal rails of the equipment with corrosion-resistant fastenings.

Cable joints will only be accepted where the length of cable run exceeds the cable manufacturer's standard drum length. All such joints shall be approved by the Employer and the joint location shall be clearly marked on the "As-Built" drawings.

2.9 CABLE CONTAINMENT SYSTEMS

Cable containment and supporting structures shall be in accordance with Specification.

The Contractor shall submit calculations to confirm that fill factors as specified are not exceeded.

The Contractor shall submit calculations verifying the spacing and size selected for supports, hangers and rods and to confirm that manufacturer's deflection limitations of cable tray, ladder and trunking are not exceeded.

All cable containment shall consist of pre-fabricated elements. Field fabricated bends, Tee's, etc. will not be accepted without the prior approval of the Employer.

All cable containment systems and parts thereof shall be hot-dip galvanized as specified.

SECTION VII: EMPLOYER'S REQUIREMENTS
A.01: GENERAL TECHNICAL REQUIREMENTS

Cables laid on trays or ladder, or contained in trunking shall be carefully arranged and ordered. No cable installations are to commence until the containment system applicable to the cables to be installed is complete.

All external cable containment consisting of tray or ladder shall be covered.

The cables trays and ladders shall be designed in such that there is a minimum of 15% free space on all trays and ladders when the installation is complete.

2.10 ELECTRIC OVERHEAD TRAVELLING CRANE (EOT)

No EOT is required under this contract.

General

This contract includes the supply of all materials and works for a crane with all operating machinery, structural steel, control equipment including cables and all other parts and accessories required for proper and safe operation.

The crane shall be complete, including, crab, hoisting machinery with motor and brakes, all lubricating devices, ropes, sheaves, hooks, flood lights, control apparatus including switchgear, runway rails, push-button controls, interlocks, limit switches, governors, protecting and alarm devices and all electric connections (cables and live rails including insulators) between all parts supplied.

Construction Features

The design of the travelling crane has to guarantee fail-safe and satisfactory operation and has to be easy to access for service, inspection and repair.

A safety factor of 1.5 times of the maximum load is to be taken into account for all stress calculations to allow shock loading.

Adequate guards shall be provided to protect personnel from accidents caused by moving mechanism, live terminals, live conductors, etc.

The guards shall be removable for inspection and maintenance without disturbing any other part of the plant.

The Contractor shall supply suitable nameplates, giving details of the lifting capacity of the travelling crane. These nameplates shall be clearly visible to anyone who may use the cranes. The nameplates shall be inscribed in English.

Operating machinery and other exposed parts shall be suitably housed so that the exterior of the travelling crane will consist of smooth surface and pleasing lines.

Structure

SECTION VII: EMPLOYER'S REQUIREMENTS
A.01: GENERAL TECHNICAL REQUIREMENTS

The minimum plate thickness for the steel construction shall be 7 mm, unless otherwise demonstrated suitable by the Contractor.

Crane Rails

Travelling crane rails shall be provided by the Contractor. It is the Contractor's responsibility to propose either a single girder or double girder EOT.

Should a double girder EOT be proposed joints between rails on opposite runway girders for the cranes shall be staggered with respect to each other and to the wheelbase of the cranes.

All joints of rails shall be welded. Rail joints shall not be located over the runway girder splices. Provision for rail expansion shall be made at the end stop locations only.

Guiding of rails on the girders should be carried out with rail clamps to distance adjustment. Welded clips are not allowed.

End stops shall be designed and located to limit the maximum crane travel.

The end stops shall be capable of stopping the travelling crane fully loaded and travelling at the rated speed.

Crane Bridge

The travelling crane bridge shall consist of two girders rigidly attached to the end trucks. Gusset plates shall keep the crane in alignment.

Welded joints shall be used for the main structure of the crane, bolted joints shall be avoided whenever possible.

- In load bearing members, if a bolted joint is necessary, black bolts shall not be used.
- The strength of welded joints or joints made by friction grip bolts in structural members shall not be less than the net strength of the member.
- Friction grip bolts shall comply with BS 3139 and shall be fitted in accordance with the recommendations of BS 3294.
- The calculated strength of other bolted joints in structural members shall be not less than the net strength of the member plus 25 per cent. The calculated stress in screws, bolts and welds shall not exceed the appropriate permissible stress given in BS 2573.

The travelling crane girders shall be welded in structural steel box sections, with wide flange beams, standard "I" beams or reinforced beams. Girders must be symmetrical and line-of-sight must be considered along with girder design, as well as suspended crane supports. Trellis girder shall be prohibited.

SECTION VII: EMPLOYER'S REQUIREMENTS
A.01: GENERAL TECHNICAL REQUIREMENTS

The girders shall be designed to withstand all vertical loads and horizontal forces that may arise under service conditions. The vertical deflection of the girders, caused by the safe working load and the weight of the crab in the central position shall not exceed 1/1000 of the span.

The larger of the following load combinations shall control the design of the girders:

- The sum of the maximum stresses due the dead load, the weight of the trolley, the rated load, and the impact allowance.
- The sum of the maximum stresses due to the dead load, the weight of the trolley, the rated load, and an allowance for the lateral load due to acceleration and deceleration of the travelling crane.

The bridge girders shall be security braced to the end carriages to prevent cross racking. It must be impossible for the travelling crane to fall from the gantry in the event of derailment. The carriages shall be of the bogie type and shall be equipped on each end with spring buffers (bumpers).

Electrical Parts

The travelling crane and hoists shall be so designed that adequate access for maintenance of the electrical control and operating gears is provided with suitable access facilities to enable removal of parts for maintenance and repair.

The power supply shall be provided via adequately protected contact wires along the crane track and a suspended cable on the crane girders.

The supply to the contact wires shall be via a manually operated load break isolating switch mounted at a convenient height above floor level, the switch being capable at being locked in the open position. Red indicating lights shall be arranged at collector level to show when the isolator is closed.

Motors shall be provided with quick action brakes; controllers, resistors, magnetic contractors and overload protection switches. Heavy dust and splash-proof limit switches shall be provided to prevent over hoisting, over transversal and over travelling motions.

Motors

All motors shall be totally enclosed, wound rotor type or variable speed drives specifically designed and built for crane service.

Motors shall be equipped with sealed antifriction, grease lubricated bearings, with provision for grease renewal.

Motors shall have tapered shaft extension on the brake end for easy removal of the brake wheel.

Push Button Control Station

SECTION VII: EMPLOYER'S REQUIREMENTS
A.01: GENERAL TECHNICAL REQUIREMENTS

The push button control station shall be suspended by means of flexible galvanized wire rope and connected to the crane control panel by means of flexible multicore cable. The arrangement shall permit movement of the control station along the entire length of the bridge at all levels of operation.

The push button control station shall have a cast aluminium housing and shall have mechanical protection class of IP 44. The Control station shall contain besides all necessary individual push buttons for controlling operation of all crane motors, an emergency push button of the lockable type. This shall function as a master switch to cut off all power supply to the crane control panel, by switching off the master magnetic contactor.

Overload Relays

Each motor shall be protected by overload relays adjustable for values between 150 and 300 per cent of the full load motor current.

Switchgear

The power supply from the main collectors shall be controlled by means of a 3-phase, manually operated circuit breaker, and a 3-pole master magnetic contactor provided with under-voltage and phase reversal protection.

The operating coil of the contractor shall be wired in series with the auxiliary contacts of the adjustable, instantaneous relays in the circuit of each hoist and each travel motor, and in the circuits of all limit switches.

The circuits shall be so arranged that, on the functioning of an overload relay or the tripping of the limit switch, the flow of power to the crane will be interrupted.

Circuit Breaker Cabinets

The main circuit breaker, lighting supply circuit breaker, master contractor, relays and protective devices shall be enclosed in a suitable steel cabinet with hinged doors. The main circuit breaker shall be so arranged that it can be operated without opening the cabinet door and that it can be locked in the open position.

Limit Switches

Limit switches shall be provided to control the upper limits of travel of all hoist motors and at each end of travel for the bridge and trolley. Switches shall be of the totally enclosed safety type operated by the crane carriage, hooks or hook blocks.

Tools

One steel toolbox shall be provided, containing complete set of ordinary and special tools needed for overhauling and repair of cranes furnished. General list of such tools shall be indicated in Tenderer's offer, and shall be detailed and submitted by the Contractor to the Employer for checking and approval.

SECTION VII: EMPLOYER'S REQUIREMENTS
A.01: GENERAL TECHNICAL REQUIREMENTS

2.11 GENERAL REQUIREMENTS FOR CONTROL AND MONITORING EQUIPMENT

2.11.1 GENERAL

This section covers general requirements for the design of the control and monitoring equipment and as far as applicable for interfaces.

The requirements of Specifications are to be strictly observed with regard to design and execution.

The control and monitoring equipment to be provided shall be suitable for faultless and safe control and supervision of the entire plant during all phases of operation.

Measuring points and measuring equipment for interlocking and protection purposes shall be separate and not be combined with measuring equipment for the automatic control equipment. Signals to be processed in several systems, e.g. remote and logic controls, event recording system etc. shall be suitably repeated and mutually decoupled to avoid interaction.

The material of all equipment shall fully meet the requirements regarding safety and operational conditions of the media to be measured. Instrument piping to transmitters and sample piping shall be of stainless steel.

All the equipment shall be suitable for the location in which it is to be mounted and in particular all outdoor equipment shall be suitable for the climatic conditions of the site as specified in scope of work.

Spare capacity of 15% shall be provided for terminals and multi-core control cables.

2.11.2 CONTROL PANELS, CUBICLES AND RACKS

Panels, cubicles and marshaling racks shall be free standing and shall be constructed of folded sheet steel of adequate thickness to provide rigid support for the control and monitoring equipment which shall be mounted thereon.

Panels shall be mounted on galvanized steel channel base frames. Panels and cubicles designed for personnel access shall be provided with metal floors and shall be suitably ventilated. Doors shall be provided with a lock which may be opened by a person within the panel without the use of a key.

It shall be possible to open all panels associated with one unit by the use of one master key. Adequate lighting and power points for hand tools shall be provided.

The overall height of cubicles, panels and racks housed in the relay room shall not exceed 2.25 m and the color shall be subject to the approval of the Engineer/Employer.

All instruments and control devices shall be easily accessible and capable of being removed for maintenance purposes.

SECTION VII: EMPLOYER'S REQUIREMENTS
A.01: GENERAL TECHNICAL REQUIREMENTS

Cable connections to panels and cubicles shall be equipped with suitable seals so as to prevent the ingress of dust or vermin or the propagation of possible fires. After installation sealing of all cable penetrations is required.

2.11.3 CUBICLES

In the relay rooms all equipment for voltages exceeding 60V is to be accommodated in separate cubicles or is to be installed within the cubicles in such that clear separation is achieved and separate connection terminals are used.

Cubicles which are installed in non air conditioned rooms shall be provided with temperature and humidity controlled heating elements. Each thermostat and hygostat shall have an adjustable set-point, which shall be adjusted during the commissioning period to such a value that no moisture shall occur on the equipment, and during periods of high ambient temperature the temperature rating of the equipment is not exceeded.

2.11.4 MARSHALING RACKS

Closed type racks are to be used for the marshaling and termination of low voltage control cables.

These shall be constructed of rigid, angle section steel. The height of terminals above floor level shall not exceed 1.8 m. Upon completion of terminations all open type marshaling racks shall be enclosed by sheet-metal covers.

2.11.5 VENTILATION

Heat dissipation of cubicle mounted equipment shall be kept as low as possible.

Components generating a heat shall be adequately spaced from their mounting boards and from other components to permit free flow ventilation.

Natural cooling is preferred. The approval of the Employer must be obtained in all cases where it is intended to incorporate forced cooling.

If the use of forced cooling cannot be avoided, means shall be provided for indicating and alarming any significant reduction in air flow, and the equipment shall be so protected that no damage occurs due to failure of the forced cooling. The full requirements of the performance specification shall be maintained until the protective device operates. The Contractor shall state how long the equipment can remain in operation at maximum ambient temperature without forced cooling, when submitting the design for approval. Air blown through equipment for cooling shall first be passed through an efficient dust filter. Multi-stage filters, arranged to permit the removal of individual filters for cleaning are preferred.

The cubicles shall be equipped with high temperature alarm (lamp and potential-free contact).

SECTION VII: EMPLOYER'S REQUIREMENTS
A.01: GENERAL TECHNICAL REQUIREMENTS

2.12 POWER SUPPLIES AND FUSING

All monitoring and control equipment inside the substation shall be connected to the auxiliary power supply system.

The Contractor shall ensure that voltage drop limitations are not exceeded on long runs.

The main power supply MCBs shall be located in functional groups within power distribution cubicles.

The MCB ratings and time characteristics shall be such that in all cases a fault within an individual item or module will cause the MCB associated with that item to open and thus disconnect that item from the power supply,

before the main MCB for the group is affected.

Failure of a main MCB shall affect the protected zone only and not the entire substation.

Failure of a main control MCB shall be indicated in the control area by means of an alarm. This alarm shall state the identity of the failed main MCB.

Failure of an individual module or component MCB shall be indicated by a common alarm, which shall state the cubicle type in which the MCB has failed and an individual signal in the respective control module shall be initiated.

The design of the electrical power supplies and protection system must ensure that any faults in modules or other devices, which may block sequence logic interlocks, automatic control systems or other control systems are restricted to the system in which the fault has occurred.

All electronic devices shall be protected against transient voltage levels, which would otherwise damage the device.

Drive command modules or devices, which take over their function must be separately fused with MCBs.

Interlocks and protection logic for drives can be protected by MCBs together with the drive command module if the logic is used only for the particular control circuit of the drive concerned. Otherwise it must be protected with the logic of the associated sub-group.

Lamp amplifiers for status indications, alarm indications and criteria call-up (non-fulfilled control criteria) shall be protected by MCBs in groups independently of the logic equipment.

Binary signal conditioning and analogue limit value modules should be protected separately, but may also be protected by MCBs with the corresponding drive control of the drive control level as long as the signals are used only for remote and logic controls (interlocking, protection) of the drive concerned.