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When a binary transmitter or limit value is used for several drives or groups the protection must be effected separately or be subdivided into logical groups so that any fault arising is confined as far as possible to a drive or group.

All measuring circuits must be separately protected. If, the analogue signal will be distributed by analogue signal conditioning and distribution modules, the MCBs shall be located on these modules.

If analogue signal distribution and limit value modules functions are arranged physically adjacent to one another, the limit value modules can also be protected with the corresponding measuring circuit.

All closed loop circuits, including their drives and thyristor controllers, if any, must be protected separately, but if the control circuit protection fails, the capability of controlling the drive manually must be retained.

2.13 INDICATORS

All indicators mounted on control desks or panels shall be flush mounted.

The minimum size for indicators mounted on the various sections of the panels shall be:

- Non-urgent indicators 96 x 96 mm
- Important indicators 144 x 144 mm
- Mimic diagrams preferably 48 x 48 mm.

Indicators shall typically operate on 0 - 20 mA. Where digital indicators are used these shall be provided with at least 4 digit indications. The minimum accuracy tolerance for these indicators shall be 1.5% of span.

Indicators mounted on local gauge boards shall be of circular type and shall have a minimum case diameter of 10 mm, preferably 16 mm. All local indicators shall be housed in robust dust and moisture proof cases suitable for open air installation. The read-out window for indicators, recorders and similar equipment shall be non-reflecting, anti-static and minimize parallax errors.

All control instruments shall be rectangular or square type, with the exposed metal portions of all cases having the same finish, trim and general appearance. Instrument and meter scales shall be white with black markings.

Instrument cases shall be dust-proof.

Each instrument shall have a zero adjustment device so that the zero position of the pointer can be adjusted without removing the cover. For frequency measurement purposes it is not permissible to use reed type frequency meters except for the synchronizing equipment.

2.14 ELECTRONIC EQUIPMENT

Where possible, plug-in type printed circuit boards shall be used.

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External connections to the boards shall preferably be by plug and socket connection.

All electronic components, including integrated circuits, transistors, resistors, capacitors and inductors shall be selected in order to ensure long life and stable operation. Indication lamps used in conjunction with electronic circuits shall preferably be light emitting diodes.

All relay equipment shall use modern plug-in type circuit boards, containing standard type miniature relays, which can be plugged-in and easily replaced on sockets on the circuit boards. Only a few types of standard relays shall be used. All relays shall be of the encapsulated type. External connections to the boards shall preferably be by plug and socket connection.

For time delay relays solid-state relays are preferred. Time-setting shall be effected preferably by means of setting dials on the front panel.

2.15 SWITCHES AND RELAYS

Switches mounted in the control panels shall be of the miniature or subminiature type.

The function of the push-button shall be clearly shown and labelled.

Discrepancy switches or push-buttons shall be provided for the operation of switchgear and the initiation of drives. Discrepancies between the switch position and the plant state shall be indicated by an integral light, which shall illuminate the switch in a flashing mode of operation.

Indicating instruments having maximum and/or minimum contacts shall not be used for any main system. All surfaces used for electrical contacts shall be silver, gold or silver alloy. If the Contractor wishes to use other metals they shall give clear reasons for the selection of contact material.

Interfacing between low-voltage electronic control circuits and power circuits shall be accomplished by interposing relays. All relays shall be of the encapsulated type.

2.16 MEASUREMENT OF ELECTRICAL PARAMETERS

Remote indicators for electrical quantities such as power, voltage, current frequency, etc. will be of the milli-ampere type.

Solid state electronic type transducers will then be provided to convert the output of current and voltage transformers into an impressed direct current in the range 0 - 20 mA.

2.17 WIRING, CABLING TERMINALS

The general requirements for wiring and cabling shall be as specified.

In particular wiring within panels etc. shall be supported on trays and shall be segregated according to voltage level. Wiring carrying AC and DC voltage shall also be segregated.

All panels, cubicles and racks shall be factory wired. Where they must be supplied in more than one section, electrical connections between the sections shall be via terminal strips provided for this purpose.

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Spare cores shall be terminated at terminal strips so as to give a maximum length of core and shall be ferruled to indicate that they are spare cores. All spare cores shall be earthed.

Terminal strips shall be of the screw type. Screw type terminals shall have a metal insert between screw and conductor.

Terminal strips within panels shall be set at an angle to afford easy identification and access.

2.18 LABELING AND SCALES

The identification and lettering of scales, dials and inscription, i.e. name plates, labels, etc. shall be in English.

The metric system shall be used for all scales.

The identification system as per the relevant clauses in the Specifications shall be adopted.

The identification and classification of all measuring points must be shown on diagrams to be produced by the Contractor and entered in the respective lists.

2.19 DIAGRAMS, LISTS AND CHARTS

2.19.1 LOGIC DIAGRAM

A logic diagram shall be used for representation of remote and logic controls and interlocking circuits.

2.19.2 SINGLE LINE DIAGRAM

The single line diagram shall portray the essential electrical equipment and connections. All circuits are represented by a single line only. The single line diagram shall contain all required technical information on the equipment represented, e.g. voltage, ampere, output, code designation etc.

Single line diagrams shall be drawn such that they are easy to read and shall contain as far as possible all technical information of the equipment represented. Except for the general single line diagram showing the basic design and connections, all diagrams shall be prepared according to the classification system.

2.19.3 CIRCUIT DIAGRAM

This diagram is resolved into separately drawn "current paths", each showing all components. The individual circuits shall be drawn in a straight line sequence.

Wherever applicable, schematic and circuit diagrams shall be combined in one drawing set.

The current paths shall be numbered consecutively from left to right. All switch and relay elements shall be shown in the de-energized condition. For easy reference all contacts of contactors or relays shall be completely defined below their corresponding coils. Interconnections to other circuit diagrams shall be clearly marked by means of dotted line separations and the corresponding functional designation.

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Circuit diagrams shall contain all terminals and designations. Terminals grouped together to terminal strips of switch-boards, distribution cabinets and/or panels, etc. shall be shown on the circuit diagram on one fictitious horizontal line surrounded by demarcation lines.

The representation of electrical equipment and control circuits shall not be terminated at the limits of the scope of supply, but shall be extended beyond this limit by all switchgear, protective measuring and monitoring equipment required for full comprehension of the whole circuit. All terminal and function designations of equipment to be supplied by others shall be included also and marked clearly.

This rule shall also apply to the equipment in the scope of the Contractor but of different nature like for example power supplies for control panels.

2.19.4 INTERNAL CONNECTION DIAGRAM

This diagram represents the wiring connections either within one apparatus or between several apparatus of one group. It shall contain the single components or apparatus of one group arranged in the proper positioned order including terminal and terminal strips.

2.19.5 EXTERNAL CONNECTION DIAGRAM

This diagram represents the wiring connections between groups of apparatus inside an installation or between sections of the installation. External and internal connection diagrams shall always show the full terminal strips with all terminals in the correct sequence.

The terminal connection diagram as described above shall contain, but not be limited to the following information:

- terminal numbers of technical strip with targets (terminal numbers and current paths) or incoming and outgoing cables
- cable designation
- type of cable
- number and cross-section of conductors
- assignment of conductors
- number of spare conductors.

2.19.6 INSTALLATION DIAGRAM

The installation diagram represents the spatial reference and routing of cables and the position of associated equipment, e.g. lighting fixtures, socket outlets, loudspeakers, telephones, primary elements, transmitters, terminal junction boxes, etc. on the building plan or arrangement drawing.

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2.19.7 TERMINAL CONNECTION DIAGRAM

The terminal connection diagram is a hook-up drawing/list applicable to terminal boxes, marshaling racks, switchboards etc. and shows the terminals and/or terminal strips properly numbered and identifies the conductors to be connected to the terminals by cable ID number and core ID.

2.19.8 WIRING LIST

The wiring list contains all connections within one apparatus (cubicle etc.) including all terminal numbers to be connected, the wire code and size and the bundle code.

2.20 CABLE SCHEDULE, CABLE LIST

The cable lists contain all required information as required by clause 3 of Section VII Part A.01.

Raceway diagrams/cable containment drawings shall be produced showing routing of cable racks, ladders, trunking, and trays at different elevations, suitably sectioned and numbered.

2.20.1 CABLE LIST

Cable lists shall be provided for all power and control cables containing as a minimum the information required by clause 2.4.3 of Section VII Part A.01.

2.20.2 TERMINAL LIST

The terminal list contains all connections for a terminal strip of a cubicle on both sides of the terminals, including the ID codes of wires and cables and their sizes.

2.20.3 EQUIPMENT LIST, DEVICE LIST

The equipment list contains all devices to be installed within one cubicle or apparatus or one group of apparatus, but does not include fixing materials and hardware.

2.20.4 PARTS LIST

The parts list shall contain all equipment, material and accessories installed in the respective parts of the plant and where applicable their interchangeability.

3. GENERAL REQUIREMENTS CIVIL WORKS

3.1 SITE CONSTRUCTION WORKS

3.1.1 CONTRACTOR'S ORGANIZATION

The Contractor shall set up an organization of sufficient skill levels to perform the design, construction and tests on completion at the target dates as indicated in the approved detailed schedule.

The Contractor shall submit an organization chart including the key personnel for the period of design, construction and tests on completion.

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The Contractor shall revise periodically the organization chart which shall be subject to the approval of the Employer/Project Manager.

3.1.2 DOCUMENTS FOR CONSTRUCTION SITE

The Contractor shall prepare and provide prior to commencement of Construction Works the following documents for the approval of the Employer/Project Manager:

1. All detailed construction drawings
2. Detailed construction time schedule
3. Site facilities plans
4. Construction site regulations
5. Health and safety plan and regulations
6. Environmental protection plan
7. Quality assurance plan for Construction Works
8. Fire fighting and fire protection plan.

3.1.3 SITE STORE

Site storage area shall have sufficient area so that work process is not jeopardized. It shall be fenced and guarded 24 hours a day.

All materials stored in tiers shall be stacked, racked, blocked, interlocked, or otherwise secured to prevent sliding, falling or collapse.

Maximum safe load limits of floors within buildings and structures, in pounds per square foot, shall be conspicuously posted in all storage areas, except for floor or slab on grade. Maximum safe loads shall not be exceeded.

Aisles and passageways shall be kept clear to provide for the free and safe movement of material handling equipment or employees. Such areas shall be kept in good repair.

When a difference in road or working levels exist, means such as ramps, blocking, or grading shall be used to ensure the safe movement of vehicles between the two levels.

Material stored inside buildings under construction shall not be placed within 6 feet of any hoistway or inside floor openings, nor within 10 feet of an exterior wall which does not extend above the top of the material stored.

Each employee required to work on stored material in silos, hoppers, tanks, and similar storage areas shall be equipped with personal fall arrest equipment.

Non-compatible materials shall be segregated in storage.

Bagged materials shall be stacked by stepping back the layers and crosskeying the bags at least every 10 bags high. Materials shall not be stored on scaffolds or runways in excess of supplies

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needed for immediate operations.

Structural steel, poles, pipe, bar stock, and other cylindrical materials, unless racked, shall be stacked and blocked so as to prevent spreading or tilting.

"Housekeeping." Storage areas shall be kept free from accumulation of materials that constitute hazards from tripping, fire, explosion, or pest harborage.

Vegetation control will be exercised when necessary.

3.1.4 CONSTRUCTION SUPERVISION PERSONNEL

The Contractor shall provide a construction supervisory team consisting of:

1. Senior Construction Manager
2. Construction Manager for Works Sections
3. Construction Site Engineers of various disciplines
4. Construction Inspectors.

The Senior Construction Manager shall be a highly qualified and experienced Manager who represents the Contractor on the Construction Site in all contractual, organizational and technical matters related to the entire Construction Works.

The Contractor shall prepare an organization chart for the construction supervisory team and submit it along with job and responsibilities descriptions for each position for the approval of the Employer/Project Manager.

All members of the construction supervisory team shall be nominated in writing. Only the approved persons will be accepted to perform site activities.

3.1.5 FINAL CONSTRUCTION CHECKS

At the end of the Construction Works, or of sections or coherent portions of the Works, the Contractor shall perform thorough inspections, tests and checks of these Works with regard to:

1. completeness
2. defects
3. compliance with the Contract and the approved drawings.

The Contractor shall notify the Employer/Project Manager in writing of the readiness to undertake Final Construction Checks and enclose the relevant construction or as-built drawings showing the latest status of the Works.

Final Construction Checks shall then be conducted jointly by the Contractor and Employer. The results of these checks will be recorded, if necessary deficiency lists will be prepared, and a Final Construction Check Protocol shall be signed.

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The Contractor shall remedy without delay the deficiencies of the deficiency list and apply for inspection and signing-off the deficiency list.

Prior to the commencement of the construction checks on the installation, the Contractor shall submit details of the final construction checks, which also shall prove compliance with the specifications, together with the check sheets for each of the items to be inspected for review and approval by the Employer / Project Manager.

After approval the Contractor shall perform and record the construction checks, witnessed by the Employer / Project Manager.

After successful completion of the final construction checks the Contractor shall submit a Report on Final Construction Checks and the Employer/Project Manager shall issue a Certificate of Final Construction Checks, which shall include among other documents the results of the checks including the Deficiency List.

Depending on the result, the Employer/Project Manager may grant or withhold his approval for Commencement of Test on Completion of this section or portion of the Works.

The Contractor shall remedy without delay the deficiencies of the deficiency list and apply for inspection and signing-off the deficiency list.

4. INSPECTION AND TESTING OF THE SUBSTATION & TRANSMISSION LINE

4.1 GENERAL

This section contains general requirements for inspections and tests of materials, parts, equipment and workmanship of the Plant during manufacture, assembling and erection and upon completion to demonstrate compliance with specification, codes and standards to ensure overall reliability of Plant operation and performance.

The Employer, the Project Manager and/or authorized agents shall, at all reasonable times, be allowed free and ready access to the Contractor's premises and those of the suppliers for the purpose of inspecting the specified Plant and Material and obtaining information as to the progress of the work. Failure on the part of the Project Manager/Employer, at this or any other time, to discover or reject Material or Plant or Works which do not meet specified requirements shall not be deemed an acceptance thereof nor a waiver of defects therein.

The approval of the Project Manager/Employer will not prejudice the right of the Employer to reject the Plant if it does not give complete satisfaction in service.

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The Contractor shall submit an Inspection & Test Plan (ITP) to the Employer for approval. The ITP shall cover all items of equipment to be provided under this project through the manufacturing and erection stages of the project, and shall indicate the salient points of manufacture and/or erection at which the Employer or the Employer's representative is required to attend. Stages of manufacture or erection where attendance is required by the Employer or the Employer's representative is required shall be Witness/Hold points in the process. Adequate advance notice shall be provided to the Employer by the Contractor of any forthcoming Witness/Hold points in the reports to be submitted by the Contractor as required by Section VII Part F - Specifications. Formal written notification shall be given 30 days prior to any Witness/Hold point inspection to be performed at site, and 180 days prior to any Witness/Hold point inspection to be performed at an overseas location.

Inspection and testing shall consist of:

1. Inspection and tests on raw materials
2. Factory tests and inspections:
 - a) Routine Tests
 - b) Type Tests
 - c) Factory acceptance tests
3. Inspections and tests during construction
4. Inspections at the end of construction works (Final Construction Checks)
5. Tests on Completion
6. Performance Verifications.

All costs related to the inspection and testing are deemed to be included in the contract price.

4.2 SCOPE, PROGRAM, DOCUMENTATION

All main components and equipment offered for and supplied under this Contract shall be type tested. The Contractor shall enclose in his Bid Type Test Certificates separately for each such main component and equipment offered.

Such Type Test Certificates shall be issued by internationally recognized testing organizations for type tests carried out on components and equipment which are, in the opinion of the Employer/Project Manager, of identical type or identical in all essential respects to the equipment offered.

If any of the Type Tests Certificates submitted is not applicable to the component or equipment offered, the Employer/Project Manager reserves the right to require re-testing or the inclusion of additional tests in the routine test program.

During manufacture, erection and after completion all materials, components and equipment supplied as well as works performed under this Contract may be subjected to inspection by the Employer/Project Manager, should they so require. The works may also be subjected to inspection and tests by any

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approved agencies of insurance or inspection companies, approved by the Employer/Project Manager, in accordance with the provisions of these technical requirements.

Quality assurance

The Contractor shall provide and operate a quality assurance system both in the facilities and the facilities of any sub-Contractors and at site capable of producing objective evidence that the material and equipment meet the quality requirements specified. The system shall be in accordance with the ISO 9001 family.

Before delivery to site a detailed inspection plan shall be submitted to the Employer/Project Manager for approval. It shall describe the facilities and site inspection for each major component and for the finally assembled equipment and shall include the following:

1. A schedule or flow chart indicating each inspection and the stages in the manufacturing and erection process where the Contractor proposes inspection shall be carried out
2. A short written description of the method for each inspection
3. Standards of acceptance, with references to International Standards or Codes where applicable. Where the Contractor's acceptance standards are proposed, copies of such standards shall be provided.

The Contractor shall have primary responsibility for ensuring the quality of items of equipment supplied under the Contract and remains accountable when manufacture or erection is subcontracted. It shall be therefore a condition of the technical requirements that works are only subcontracted to companies with effective Quality Assurance (QA) organization and that the Contractor monitors the quality control by the attendance at tests of experienced inspectors employed by the Contractor.

Adequate notice shall be given when the equipment is ready for inspection or test and every facility shall be provided by the Contractor and his sub-Contractors to enable the Employer/Project Manager to carry out the necessary inspection of the plant.

A detailed record of the results of all tests and inspection shall be maintained by the Contractor and copies provided to the Employer/Project Manager within a reasonable time after the tests.

Facilities for inspections and tests

The Contractor shall propose detailed programs and procedures for the inspections and tests for individual components as well as for the entire system.

The programs and procedures shall be prepared based on the "Quality Assurance System".

The detailed and final inspection and testing programs shall be submitted for the approval of the Employer/Project Manager according to the schedule of documents submittals.

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Final notification or confirmation of the inspection or test dates shall be not later than 180 days in advance.

The tests shall be performed to the agreed inspection and test plan using acceptance criteria approved by the Employer/Project Manager.

The Contractor shall provide all the test equipment and test sets required for carrying out the inspection and tests. Equipment provided for testing at site shall remain the property of the Employer.

All equipment shall have current calibration certification.

In the case of Performance Tests, the Instruments shall have been calibrated by an independent calibration authority or institute, the costs of which shall be borne by the Contractor.

The Contractor shall submit test programs for factory and site testing that is subject to approval by the Employer/Project Manager. Test methods shall be based on IEC recommendations and standards. The Contractor shall state the applied standards and test methods. A tentative test program and a test procedure shall be supplied two months before each individual test. The test procedure shall specify in detail the tests to be performed, based on the specified requirements. Detailed documentation (e.g. circuit diagrams, flow charts) of the tested system/equipment shall also be available to the Employer/Project Manager at the same time. Formats of the test report which are intended to be used shall be submitted for approval together with test program.

The Contractor shall duly consider provisions specified in the Contract Documents as minimum requirements when preparing the inspection and test plan with respect to type and extent of inspection and tests, to location, orientation and number of test samples, to frequency and amount of taking samples for statistical quality control and with respect to acceptance criteria for all QA measures.

The Employer/Project Manager will return a copy of the Contractor's proposed inspection program indicating those inspection stages for which notification is required. Notification shall be by fax and shall be sent at least 28 days prior to the intended test. If the Employer /Project Manager intends to be present at the test at least 24 hours notice will be given and if the representative does not attend on the notified date the test may proceed unless an alternative date has been requested by the Employer/Project Manager.

After completion of each and every test copies of all test records, test certificates and performance curves shall be supplied for all tests carried out in accordance with the provision of the contract, whether or not the Employer/Project Manager has witnessed them. Information given on such test certificates and curves shall be sufficient to identify the equipment and software to which the certificates refer and shall also bear the Contractors' reference and heading.

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The test reports shall indicate the tests performed, contract references, the results obtained, instruments used, names of test personnel, and provide for witnesses' signatures. They shall also be numbered and dated.

4.2.1 REJECTION OF ELEMENTS

Any item of plant or component which fails to comply with the requirements of these technical requirements in any respect at whatever stage of manufacture, test, and erection or on completion at site may be rejected by the Employer/Project Manager either in whole or part as considered necessary.

After adjustment or modification if so directed by the Employer/Project Manager the Contractor shall submit the item for further inspection and/or tests. Plant or components with defects of such a nature that the requirements of the technical requirements cannot be met by adjustment or modification shall be replaced by the Contractor at his own expense and to the satisfaction of the Employer/Project Manager.

4.3 APPLICABLE STANDARDS FOR INSPECTION AND TESTING

All equipment shall be inspected and tested in accordance with the requirements of the relevant standards and codes and the present technical requirements and data sheets.

The inspections and tests shall be in accordance with the standards used for design, manufacture and erection/construction of the respective Works or parts thereof.

If no appropriate standards are available, inspection and testing shall be made in accordance with the Manufacturer's/Contractor's standard practice.

Test procedures and test conditions shall be sent to the Employer/Project Manager for approval prior to commencement of design of such equipment.

Failure to do so can result in rejection of the tests or even of the equipment or material so tested.

The type and extent of inspection shall generally be in accordance with that specified in the standard used for design and construction of the item of equipment supplemented or amended by the provisions of the technical requirements.

Additional design tests are also to be carried out as described in the other parts of these technical requirements.

Reference to special codes and standards, where designated either directly or as "relevant", is intended to provide a measure of performance, safety, in shop and on-site testing, and methods of construction and/or installation which must be equaled or exceeded in order to be considered acceptable for use under these technical requirements. If more than a single degree of quality or accuracy is permitted within the scope of particular code or standard, the highest quality shall be applicable and the degree of accuracy commensurate with the intended function shall be selected but with the understanding in either case that the decision as to degree will be made finally along with procedures by the Employer/Project Manager.

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Works or parts thereof supplemented or amended by the provisions of the technical requirements.

In all instances, the finally accepted applicable code or standard shall be the version last published prior to the date of submission of the Bid selected as the basis for this Contract.

Where no appropriate standard is available, tests shall be carried out in accordance with the manufacturer's standard practice, which needs the approval of the Employer/Project Manager. In such cases the Contractor shall submit to the Employer/Project Manager complete data and a suggested procedure for the testing to be performed before manufacture commences. If the proposed procedure is accepted, the Contractor shall provide the Employer/Project Manager with four additional copies in English before any test is performed.

The Contractor's attention is drawn to the climatic conditions in the site area. De-rating factors are to be in accordance with the relevant IEC codes and standards or an approved equivalent.

4.3.1 SERVICES PRIOR TO AND DURING INSPECTIONS AND TESTS

In accordance with and in addition to agreed standards, the Contractor shall submit procedures for material testing, manufacture, quality control and performance testing as they apply from the procurement phase of raw materials to the finished product.

No inspection will be made or deemed valid unless the Employer/Project Manager, the Contractor and Sub-supplier are in possession of all relevant approved drawings and procedures for the item to be tested.

The Contractor on request shall supply the Employer/Project Manager with a copy of drawings and procedures at the time of the test.

All instruments and apparatus required for the inspection or used for the performance of tests shall be calibrated to an agreed standard at a laboratory of national standing. The cost of making such calibrations shall be borne by the Contractor in all cases.

4.4 TEST EQUIPMENT AND INSTRUMENTS

Test equipment, apparatus and instruments required for measurement or recording the test results shall be to an appropriate accuracy and shall be calibrated. The related costs shall be borne by the Contractor.

In the case of Performance Tests, the Instruments shall have been calibrated by an independent calibration authority or institute, the costs of which shall be borne by the Contractor.

4.5 INDEPENDENT AGENCY

Inspection and testing may be performed by an independent testing agency on behalf of the Contractor. Such an agency requires approval by the Employer/Project Manager.

The Employer/Project Manager may delegate inspections and witnessing of tests to a consultant or to any independent testing agency.

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4.6 TYPE TESTS

Only type tested electrical equipment shall be provided. The Contractor shall include in the Bid type test certificates for each main equipment item or type. Only type tested equipment will be accepted.

The Contractor shall present type test certificates issued by an independent institute.

Type tests shall have been carried out on identical equipment by an independent, lawful and reputable, internationally recognized testing laboratory, on all main equipment in accordance with the requirement of the relevant IEC standards.

Equipment type tested shall have the same code / manufacturer / country and equivalent technical parameters as the items offered in Bid.

In case relevant test data are not available, the Employer/Project Manager may ask these tests to be performed at the Contractor's own expenses.

4.7 INSPECTIONS AND TESTS DURING MANUFACTURE

4.7.1 GENERAL

As far as practicable, quality of materials, workmanship and performance of all items of the equipment furnished under the present contract shall be inspected at the places of manufacture by the Contractor's QA inspectors.

Equipment shall wherever practical be subject to tests on completion in the Manufacturer's work to prove that the reliability, operation and performance conform to the requirements of these technical requirements and the provisions of the appropriate standards.

All facilities shall be provided by the Contractor to enable the Employer/Project Manager to carry out the necessary inspection of the equipment components. The costs of all tests during manufacture and preparation of test records are to be borne by the Contractor. All costs associated with factory acceptance test attendance by the Employer will be borne by the Employer.

The Contractor shall submit for approval procedures describing the proposed test methods to be used. Type and layout of test facility, location of instrumentation, formula for calculation of results and correction to site conditions, etc. shall be included where appropriate.

All measuring instruments used in tests shall be regularly calibrated at the expense of the Contractor and records shall be available for examinations by the Employer/Project Manager.

The passing of the inspection or test will not, however, prejudice the right of the Employer/Project Manager to reject the equipment components if they do not comply with the technical requirements when erected, or give complete satisfaction in service. Where the Contractor desires to use stock material, not manufactured specially for the work, satisfactory evidence that such material conforms to the requirements of the Contract shall be submitted. In this case tests on these materials may be waived, but

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certificates are to be submitted.

Arrangements shall be made for expediting the shop inspection by having all shop assemblies or pieces covering a single shipment ready at one time.

Any packing work as well as transport to the site of the equipment concerned shall not be started before the approval of the Employer/Project Manager has been obtained and all QA certificates due at this time for the equipment concerned have been received and reviewed by the Employer/Project Manager.

Testing of control and monitoring equipment shall comply with all local laws, rules and regulations applicable and be governed by internationally recognized codes and standards.

4.8 TEST AND INSPECTION OF MATERIALS

4.8.1 GENERAL

Materials shall be tested in accordance with the specified standards approved by the Project Manager / Employer.

Unless otherwise specified, the quality of materials shall be verified generally by:

- chemical analysis (composition, stability by aggressive agents, etc.)
- mechanical tests (yield point, tensile strength, elongation, etc.)
- electrical tests (insulation properties, conductivity, resistivity, etc.)
- thermal tests (thermal constants, thermal stability, etc.).

Non-destructive tests like X-rays, ultrasonic examination, magnetic particle testing shall be applied as much as possible.

Test specimens and samples for analysis shall be plainly marked to indicate the materials they represent.

4.8.2 WORKSHOP ASSEMBLY

In addition to the quality and production control tests, the following shop assembly work and tests shall be made to check measurements, fitting and functioning.

Equipment to be furnished shall be shop assembled to a status sufficient to prove that the design and workmanship have been executed in accordance with the specifications, that the delivery is complete, and that no work remains to be done at site, which reasonably may or should be done in the workshop.

Where applicable, each item of the equipment shall be assembled completely prior to delivery.

Field joints shall be temporarily connected.

All parts shall be properly match marked, identified and doweled to ensure and, where practicable, to facilitate correct and quick field assembly.

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If the assembly shows defects in the design or manufacture or unforeseen difficulties in assembling and dismantling, these must be eliminated. If required, design alterations or corrective machining may be executed provided that no sacrifice with respect to reliability of operation or interchangeability is made and provided that the agreement of the Project Manager/Employer has been obtained.

If the corrections cannot be carried out in accordance with the terms mentioned above, the components concerned will be rejected. The decision on possible subsequent corrections is reserved exclusively to the Project Manager/Employer. Faulted equipment parts shall not be delivered.

4.8.3 THERMAL INSULATING MATERIALS

All insulation materials shall be asbestos free, vermin proof, nonhygroscopic, chemically inert both wet and dry, and fire resistant.

Materials shall be tested for bulk density, specific heat, compressive strength, fire resistance under pressure, service temperature limit.

4.8.4 INSULATED CABLES AND CONDUCTORS

IEC 60227-3

Power cables insulated and non-sheathed with thermoplastic material
based on polyvinyl chloride

IEC 60227-4

Power cables insulated and sheathed with thermoplastic material based on polyvinyl chloride

IEC 60227-5

Cables and flexible cords for electric power and lighting

IEC 60794

Optical fibre cables for telecommunication and data processing systems

IEC 60502-1, -2

Power cables with extruded insulation and their accessories for rated voltages from 1 kV ($U_m=1.2$ kV) up to 30 kV ($U_m=36$ kV).

4.8.5 INSTALLATION MATERIAL

IEC 60335-1

Safety of household and similar electrical appliances – Part 1: General requirements

IEC 60364-1

Electrical installations of buildings – Part 1: Scope, object and fundamental principles

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4.8.6 MATERIALS FOR EARTHING AND LIGHTNING PROTECTION

The materials for the installation of earthing equipment and lightning protection shall be tested in accordance with the relevant IEC regulations.

4.9 WELDING AND SURFACE COATING TESTS

4.9.1 WELDING

For all major structural welded items the Contractor shall submit the following documented proposals prior to commencement of welding:

- welding procedure specifications with qualification records
- post weld heat treatment procedures where applicable
- inspection schedule including quality requirements
- non-destructive testing procedures
- standard weld repair procedures.

All welders employed on items of plant for this Contract shall be qualified.

All welds shall be visually examined and shall be of smooth contour, free from cracks, undercuts and other significant defects. Welds shall be non-destructively tested in accordance with the construction standard applicable to the item of Plant. Where appropriate, the magnetic particle testing or the ultrasonic examinations are to be applied.

4.9.2 GALVANIZED ZINC COATINGS

Surfaces shall be visually inspected. Bare patches, lumps blisters or inclusions of foreign matter shall be cause for rejection.

4.10 PRIMARY ELECTRICAL EQUIPMENT

Type test certificates issued by an independent test authority shall be submitted.

Testing of electrical equipment shall comply with all local laws, rules and regulations applicable and be governed by internationally recognized codes and standards, which may include, but not be limited to, the following or latest edition thereof.

The test requirements for primary equipment shall be observed as specified in the schedule of technical data.

Tests for other equipment shall be tested according to the requirements specified below.

4.10.1 LAMPS AND ACCESSORIES

IEC 60081

Double-capped fluorescent lamps – Performance specifications

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IEC 61347-2-8 / IEC 61347-2-11

Ballasts for tubular fluorescent lamps – General and safety requirements

IEC 60921

Ballasts for tubular fluorescent lamps – Performance requirements

IEC 60155

Glow-starters for fluorescent lamps

IEC 60598-2-3

Luminaries – Part 1: General requirements and tests

IEC 60188

High-pressure mercury vapor lamps

IEC 61347-2-9

Auxiliaries for lamps - Ballasts for discharge lamps (excluding tubular fluorescent lamps) – General and safety requirements

IEC 60923

Auxiliaries for lamps - Ballasts for discharge lamps (excluding tubular fluorescent lamps) –Performance requirements

IEC 60400

Lamp holders for tubular fluorescent lamps and starter holders

4.10.2 ELECTRICALLY OPERATED TOOLS

The following individual tests are to be carried out on electrically operated tools:

Each tool must run on no-load at rated voltage and frequency for at least 30 minutes.

- voltage withstand test at 3000 V during a period of 1 minute: for all insulated tools provided with protective conductor connection
- voltage withstand test at 4000 V during a period of 1 minute: for double insulated tools not provided with an earthing conductor
- voltage withstand test at 500 V during a period of 1 minute: for tools rated at 24 V, 50 Hz (low voltage protection)

4.10.3 POWER INSTALLATIONS UP TO 1000 V

- IEC 60364-1 Electrical installations of buildings

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- IEC 60439-4 Low voltage switchgear and control gear assemblies - particular requirements for assemblies for construction sites

4.10.4 PROTECTION EQUIPMENT

Equipment for modular static protection systems (e.g. generator, distance, busbar protection etc.) pre-assembled in the relevant boards/cubicles etc. shall be tested in the Contractor's workshops as far as wiring and proper function is concerned. Simulated inputs (binary signals, current and voltage inputs from test power supplies) shall be used for the tests.

4.10.5 HIGH AND LOW VOLTAGE CABLES

Routine Tests, Special Tests and Type Test shall be performed according to IEC 60060-1 & IEC 60060-2, IEC 60071-1 & IEC 60071-2, IEC 60230, IEC 60811 and IEC 60840.

4.10.6 OPTICAL FIBER CABLES

Test shall be performed in accordance with IEC 60793 and IEC 60794.

4.11 CONTROL AND MONITORING EQUIPMENT

The SCS shall be tested according to the IEC 61850.

Testing of control and monitoring equipment shall additionally comply with rules and regulations applicable and be governed by internationally recognized codes and standards, which may include, but not be limited to, the following or latest edition thereof.

All control and monitoring equipment shall be tested at the manufacturer's workshops before dispatch to site.

The Contractor shall submit a comprehensive description of each test for Employer's approval. This shall include the type and classification of all test equipment and shall be submitted at least two months before the proposed date on which each test is to be carried out unless otherwise specified.

On request the correct operation of equipment with specified temperature of humidity limits shall be demonstrated by tests conducted within the limits.

4.11.1 ELECTRICAL MEASURING INSTRUMENTS

IEC 60258 (1968-01)

Direct-recording electrical measuring instruments and their accessories

IEC 61010-1

Safety requirements for electrical equipment for measuring, control and laboratory use – Part 1: General requirements

IEC 61010-3

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Safety requirements for electrical equipment for measuring, control and laboratory use – Part 3: Protocol for the preparation of conformity verification reports for the IEC 61010 series

4.11.2 ELECTRICAL REMOTE INDICATION

IEC 60338

Telemetry for consumption and demand

4.11.3 CALIBRATION TESTS

The contractor shall conduct calibration tests of the following instruments and equipment:

- all local indicators over the full range of the indicator
- all transmitters over the full range of the transmitter
- all binary transmitters over the full range including initial setting
- all analogue limit modules, function generators, flow evaluators
- all remote indicators over the full range of the indicator
- all recorders over the full range of the recorder
- one of each type of indication loop with circuit resistance of the loop increased to a value which is equal to the highest value expected, and under worst case operating conditions
- one of each type of thermocouple or resistance element
- all modules and subassemblies for measuring and control e.g. analogue limit monitors, flow evaluators, function generators
- all quantity meters
- all synchronizing units according to IEC standards.

4.12 TELECOMMUNICATION EQUIPMENT

4.12.1 GENERAL

Factory tests shall not begin without the prior delivery and approval of documentation for test procedures.

The communication system shall be tested according to all relevant parts of IEC 60870.

Special care shall be taken for the interfaces with the SCS equipment as well as the telephone and radio system.

4.12.2 TELE-PROTECTION EQUIPMENT

Equipment and system performance testing according to IEC 60834-1 and IEC 60834-2 shall be performed. In addition to IEC 60834-1, Clause 20, a measurement of transmission time shall be performed.

4.13 INSPECTION AND TESTING FOR CIVIL ENGINEERING AND STRUCTURAL

WORKS

4.13.1 GENERAL

The Contractor shall arrange for tests of all Materials to be carried out in laboratories on site or elsewhere, or in the Contractor's shop as and when directed by the Employer/Project Manager. The cost of all test equipment, samples, tests and transport for test shall be borne by the Contractor and the tests shall be performed by efficient and well qualified staff.

The Contractor must carry out all tests on material samples in order to verify their compliance with the specifications. The testing operations shall be performed in accordance with the relevant internationally acknowledged standards, code etc. and under the supervision of the Project Manager/Employer.

The test samples of materials shall be kept in a safe place and protected against damage or deterioration until completion of the works. All samples shall be submitted free of charge to the Employer or his Representatives.

The characteristics as determined in the samples which are approved shall indicate the standard to be maintained in the materials used in the execution of the works.

4.13.2 STRUCTURAL AND EQUIPMENT-SUPPORTING STEELWORKS

All steelworks shall comply with the requirements of applicable standards approved by the Project Manager/Employer.

Prior to inspection the Contractor shall arrange for the submission of shop drawings for the whole of the steelworks. All such drawings shall show the dimensions of all parts, method of construction, spacing of rivets, welding of sectional areas and all other details. Welded construction is preferred but bolted construction may be exceptionally employed, subject to Project Manager's/Employer's approval and neatness of design. Where welds are used, they shall, wherever possible, be continuous and shall overlap at any meeting face to ensure that the joint is completely sealed against corrosion.

4.13.3 CHECK TESTS ON STRUCTURES

The testing of material specimens to establish whether the materials used in the structures comply with the specification for structural material is as described in the individual technical Specifications.

The types of check tests described hereinafter are applicable to the finished parts of the structure. They may be used in routine inspection and for quality control.

If the results of the check tests show that the quality of the materials is inadequate or if other defects are revealed, the Project Manager may require a loading test to be made.

Type of check tests

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- Methods of testing concrete. The procedure used shall comply with the requirements of AS 1012.12 or of an approved standard.
- Gamma radiography. The testing shall be carried out in accordance with the requirements of an approved standard.
- Ultrasonic test. Such tests may be used to obtain approximate indications of the strength of the concrete in the structure.
- Electromagnetic cover measuring devices. Such tests may be used to verify the position of the reinforcement and shall be in accordance with the requirements of design.
- Rebound hammer test. Such tests may be used to obtain approximate indications of the strength of the concrete.

4.13.4 LOAD TEST ON STRUCTURES OR PARTS OF STRUCTURES

The Project Manager shall instruct the Contractor to make a loading test on the Works or any part thereof if in their opinion such a test is necessary.

For the purpose of testing floors, roofs and similar structures and their supports, the test shall be equivalent to one-and-a quarter times the live load for which the works or part thereof to be tested have been designed.

Wherever certain procedures for testing of parts in structures (e.g. piles) are required by standards or codes of practice, these are to be followed. All tests must be conducted in the presence of the Engineer/Project Manager.

For a test on a floor, roof or similar construction the result shall be deemed to be satisfactory if upon removal of the load the residual deflection does not exceed one-quarter of the maximum deflection after maintaining the load in position for twenty four hours. If the residual deflection exceeds this amount, the test shall be repeated, and the result shall be deemed to be satisfactory if the residual deflection after removal of the load for the second time does not exceed one quarter of the maximum deflection occurring during the second test.

If the result of the test is not satisfactory, the Project Manager/Employer shall instruct that the part of the Works concerned be taken down or cut and reconstructed to comply with this Specification, or that other measures be taken to make the Works secure. The Contractor shall at his own cost take down or cut out and reconstruct the defective work or shall execute remedial measures as instructed by the Employer or the Project Manager.

4.14 INSPECTION AND TESTING DURING ERECTION

4.14.1 GENERAL

The Contractor's scope of work includes all site test and inspection activities, e.g. all labor, materials, water, electricity, consumables, and instruments and apparatus as may be required to perform such tests

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efficiently. The Contractor is responsible for and shall include for all safety measures such as barriers, warning signs etc. required for inspection and testing while erection, pre-commissioning and commissioning is in progress and all interruption of work in this connection will be at his expense.

The Contractor is responsible for ensuring that safe procedures are adopted for the use, handling and storage of radioactive sources and an inventory of all sources supplied to the site shall be maintained.

All instruments and apparatus used for site inspection and testing shall be calibrated to an agreed standard at a laboratory of National standing to be nominated by the Contractor. The cost of making such calibrations shall be borne by the Contractor in all cases.

During the erection of all mechanical, electrical, control and monitoring equipment as well as during the civil construction the Contractor shall make the Plant items available at any reasonable time for inspection by the Project Manager and/or by the Employer, should either so require.

To assist the Employer and the Project Manager in their review of the quality of the work being performed, the Contractor's senior field representative shall provide the Project Manager/Employer with a schedule of the specific areas and items of work that will be performed during each work day on a weekly basis.

All work that is executed without notification shall, at the Project Manager's /Employer's option, be subject to removal and replacement by the Contractor at his expense.

In particular the Contractor has to mark on his implementation schedule all stages of erection or commissioning which are subject to the Project Manager/Employer's acceptance and has to notify one week in advance when such acceptance becomes due. The stages subject to acceptance shall include but not be limited to the items indicated in this Specification.

The Project Manager's/Employer's written approval of completed work stages shall be obtained before continuing with erection and should it be necessary to dismantle subsequently erected parts in order to gain access for inspection on rectification this shall be at the Contractor's expense and no claim by the Contractor for delay shall be considered.

The following checks and tests measurements for the substation and transmission line components shall be made during erection unless otherwise specified in this specification (as appropriate) in accordance with agreed standards:

- Checking for complete delivery
- Cable route and laying depth inspection
- Special filling resistance tests
- Torque testing of all screwed and bolted electrical connections
- Verification of terminals and terminal connections for correct assembly and compliance with approved for construction drawings and hook-up drawings/lists

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- Checking of earthing connections and testing of earthing resistance between the equipment and the ground grid, and overall ground grid resistance
- Measurement of insulation resistance values on all cables, and continuity and polarity tests on all cables
- Fire-proof partitioning
- Marking, inscription, and provision of all designation plates
- Safety signs and warning signs
- Settings on indicators
- Checks on wiring and cabling for compliance with the Approved for Construction circuit-drawings and plans
- Primary and secondary injection of all current and voltage transformers to verify polarity and compliance with design performance requirements
- Digital low reading ohmmeter tests across all HV conductor joints, HV equipment connections, and MV busbar joints.

4.14.2 EARTHING SYSTEM RESISTANCE MEASUREMENT

The earthing system resistance shall be measured during initial installation and immediately before commissioning, but at least once during the dry season under reasonably dry soil conditions.

The measurements are to be carried out by means of a high frequency earth resistance measuring instrument, in order to allow readings of the impulse resistance value of the earthing system.

The stand-alone grid measurement shall be performed with the earth wires from OHLs disconnected.

The measurements shall be recorded. The schedules used for the recordings shall contain in addition to the measured ohmic values, details of the surface soil and underground data at the time of tests, the soil resistivity values, and the climatic conditions at the time of the test. Tests shall not be undertaken within 24hrs of any rainfall.

4.14.3 GALVANIZING THICKNESS

The galvanizing thickness shall be tested on site after receiving the galvanized components as well as during erection. The zinc coatings shall comply with the thickness requirements defined in the Specifications.

The Contractor shall have available on site for the Project Manager's/Employer's use an instrument suitable for the accurate checking of galvanizing thickness. The measuring instrument shall be available from the time of arrival of the first consignment of steelworks until the issue of the taking over certificate. The cost of the gauge and other operating expenses are deemed to be included in the Contract Price.

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If evidence of white rust is apparent upon receipt at site of bundled steel section, the Project Manager / Employer shall order the Contractor to make such tests as he deems necessary to determine the extent of damage, if any, and the remedial measures necessary.

4.15 TESTS ON COMPLETION

4.15.1 GENERAL

After Final Erection Checks the Tests on Completion shall be performed The Tests on Completion comprise;

- Pre-commissioning tests
- Cold commissioning tests
- Hot commissioning tests which are the tests to be performed with all the control and LV voltage sources in operation from the permanent source, and shall repeat all tests undertaken in cold commissioning. When the repeat of the cold commissioning tests is successfully completed, a performance test shall be undertaken to confirm the capability of the substation to operate at the rated output.

4.15.2 PRE-COMMISSIONING TESTS

The pre-commissioning tests comprise the tests to be performed as site tests for the individual primary equipment items.

The pre-commissioning tests include the loop checks to be performed on all circuits for the control and monitoring equipment; injection tests to verify correct performance of protective devices and metering on each individual item of Plant; transformer winding tests; AC & DC voltage withstand tests; ground grid resistance tests; some of which may require sections of the control and/or LV system voltages to be available and in operation.

4.15.3 COLD COMMISSIONING TESTS

The cold commissioning tests comprise mainly the tests of subsystems and systems, which are the tests to be performed on each individual item of Plant with the control voltages in operation and may also require a temporary LV voltage source to be available for the section of equipment under test. Such tests consist of automatic changeover testing, generator load testing, OLTC operation testing, transformer cooling fan sequencing and operation, all interlocking, battery charger performance testing, function and trip testing of all circuit breakers. Examples of typical requirements are:

- Establishing the AC and DC control voltages and the relevant tests
- Local control of the 132/66/11kV equipment, interlocking, sequencing
- Start up of the substation control system, remote control of all equipment, intertrip send and receive testing to connected substations
- Tests of the protection relays

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- Tests of the communication equipment
- Checking correctness of measurements
- Testing the air conditioning system.

4.15.4 HOT COMMISSIONING

The hot commissioning tests during occur during and after energization from the permanent source and typically comprise of:

Tests during energization

- Energization of all 132/66/11/0.415kV equipment
- Check correct voltage levels and current measurements
- Synchronization tests of CBs
- Checking and verification of correct phase rotation
- Checking the operation of the voltage regulators of the power transformer and cooling fan sequencing
- Testing the functionality of the protection relays.

Tests after energization

The tests after energization comprise of:

- Performance and load testing
- Stability tests of the protection system
- Thermographic imaging of the transmission line.