TECHNICAL SPECIFICATION

مـونـکـو ایــران
Monenco Iran

MONENCO – IRAN CONSULTING ENGINEERS COMPANY

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Note 1: N.A: Not Applicable

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SECTION 1

SUMMARY OF WORK

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1. Description of the Project

Extension of 400kV switchgear in 400/132/20kV substation in the Kerman province for the Kerman Regional Electric Company (K.R.E.C.), affiliated to the Ministry of Energy, Islamic Republic of Iran.
This project consists of the design, manufacture, factory testing, transportation, insurance, custom clearance, inland transportation, offloading, delivery, supervision over erection, commissioning, preparation of Remained civil works, design, drawings and calculation.
A brief description of the project is as follows:

- Non-Complete One breaker and half Breaker Scheme Bay
- Client will supply CTs, CVTs, DSs/DSEs, CB and Lightning Arresters and contractor is responsible to deliver them to the site from client's store.
- Moving the shunt reactor, which is near existing 400kV switchyard to the extension bay, is in the contractor's scope of work. In addition, the contractor should install, test and commission this reactor.
- There is a 400kV reactor bay in the existing switchgear, which is connected to the 400kV busbar. The contractor should dismantle neutral reactor from this bay and use it in the extension bay. All of the costs of this work are in the contractor's scope of work.
- The project is the force one project, which should be completely done in few months.
- Other contractor will do main part of civil works. Therefore, the contractor should be well informed about civil contractor and coordinate the project.

2. Scope of Work

The work to be performed under this contract has noted above and shall include all equipment and connections required for the satisfactory operation of the substation.

The following items of work shall include as a part of this contract:

a) Transportation of equipments, which are supplied by clients from store and bring them to site location.

b) Checking consultant detailed drawings and checks them before construction and installation.

c) Contractor should be coordinated with civil contractor in site.

d) Installation, test and commissioning of all equipments is in the contractor's scope of work.

e) Contractor should do supply of earthing system.

f) All connection cable, interface cubicles , fully equipped with cable terminals , auxiliary relays , racks , etc. , shall be supplied by the Contractor . The Contractor shall give all drawings, cable schedules, and connection diagrams for the complete interfacing system.

g) Supervision before erection

h) Remained Civil works

i) Storage of equipment at site &client's warehouse

j) Erection and site testing of the equipment

3. Works Not Included

The following items of work associated with the project, do not form part of this contract and will be done by the Owner:

a) Connection of terminal tower to gantry

b) Supply of Shunt and neutral Reactors.

c) Main Civil Works.

4. Location and Access to Site

Location and access road to the site is as follows:

About 30 KM after ARG Jadid town, Bam, Kerman, Iran

5. Description of Major Equipment

The major equipment of the works includes the following items:

- Circuit breakers
- Disconnectors and grounding switches
- Current transformers
- Voltage transformers
- Surge arresters
- Line traps and line matching units

- Steel structures
- Buswork and insulators
- Cable systems (LV power and control)
- LVAC and LVDC systems
- Earthing systems
- Control and protection systems
- Lightning protection system
- Outdoor and indoor lighting
- Emergency DC indoor and outdoor lighting

6. Items to Be Supplied By Owner

Owner will supply the following items:

a) Shunt Reactor
b) Neutral Reactor
c) CTs
d) CVTs
e) CB
f) DSs/DSEs
g) Lightning Arresters

7. Schedule of Timings

The Contractor shall perform the works in accordance with schedule of timings, which shall be submitted by himself and approved by the Engineer.

The work shall be completed within Five (5) months from the date of signature of the contract.

8. Drawings

Drawings issued with forming part of the tender documents are listed below. The arrangement of feeders, equipment and distances between them may be changed, but the total area will be limited to the shown fences.

	Name of Drawing	DWG. No.
1		
2		
3		
4		
5		
6		
7		
8		
9		

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SECTION 2

GENERAL REQUIREMENTS

MONENCO – IRAN CONSULTING ENGINEERS CO.

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1. General

The work to be done under the contract includes the supply of materials, labor, equipment, permits, etc. necessary for the complete construction of the works shown on the contract drawings and as specified herein. The Contractor is fully responsible for mutual compatibility and adequacy of all substations equipment in any respect.

All of the equipment shall bear and operate properly in climatic and all site conditions without any deterioration and damage.

Doors of panels shall be close fitting and ventilating openings shall be suitably screened to prevent entrance of insects, rodents and dust.

All cable entrances to equipment shall be tightly sealed with gland plates.

Each indoor / outdoor cabinet or cubicle, containing electrical equipment shall be provided with a thermostatically controlled heater to combat moisture condensation and with a light fixture The heaters shall be located such that there is effective ventilation and local overheating is avoided.

All instruments shall be adequately tropicalized.

2. Measurement and Payment

The contractor shall be responsible for the correctness of his figures, and properly correct, without charge, any work that does not fit, and furnish new work if necessary. No extra charge will be allowed on account of differences between the actual dimensions and the measurements indicated on the drawings.NO material and equipment shall be deemed delivered, until the Contractor has already received the required approval of the Engineer for the source, design, tests and inspection, shipping methods, etc.

Payment for the works will be made in accordance with schedule of quantities and prices of volume 1 of the tender documents and Release of the holdback to be after expiration of the statutory limitation period.

3. Accounts

Keep accounts and records in such form and detail as shall be satisfactory to the Owner and furnish the Owner or his authorized representatives with all such information about accounts as he may require.

4. List of Publications and Standards

Publications, standards and codes referred to in this specification form part of this specification to the extent specified herein. Names and addresses of issuing bodies are as follows in alphabetical order :

- American Institute of Steel Construction (AISC)
- American National Standards Institute (ANSI)
- American Standards Association (ASA)
- American Society of Heating, Refrigerating and Air Conditioning Engineers(ASHRAE)
- American Society for Testing and Materials (ASTM)
- American Welding Society (AWS)
- British Electricity Boards Standards (BEBS)
- International Special Committee on Radio Interference (CISPR)
- Deutsche Industrie Norm (DIN)
- International Electrotechnical Commission (IEC)
- Institute of Electrical and Electronics Engineers (IEEE)
- Insulated Power Cable Engineers Association (IPCEA)
- Institute of Standards and Industrial Research of Iran (ISIRI)
- International Organization for Standardization (ISO)
- National Electrical Manufacturers Association (NEMA)
- Steel Structures Painting Council (SSPC)
- Standards – Energy Ministry of Iran

The requirements of the specification are based on conformance with the reference standards. For acceptance of equivalent codes and standard, English version of these standards shall be submitted to the owner for approval.

Work on this contract may comply with standards and codes other than the ones specified, provided that all of the following conditions are met :

- They are listed in the Contractors bid
- A copy of alternative standards and codes in the English language is submitted within the bid or not more than 2 weeks after award of the contract.
- The detailed technical requirements of this specification are met.
- Be approved by the Engineer.

In the event of conflict, the standards and codes of this specification shall govern.

In case of conflict between performance or design characteristics of the foregoing codes and standard agencies the matter shall be referred to the owner for resolution. Unless otherwise noted, the code or standard edition in effect at the time of contract award shall apply.

5. Environmental Conditions

The meteorological information is mentioned in SECTION 2 data sheet.

6. Delivery of Equipment

Upon shipment, the contractor shall notify the employer and the insurance company by cable or telex of the full details of the shipment including contract number, description of goods, quantity, the vessel, and the bill of lading/airway bill number and date, port of loading, date of shipment, port of discharge, etc. Deliver materials and equipment after approval of sources and performance of inspection.

All necessary precautions shall be taken to protect materials and equipment from damage and contamination during storage and transportation.

Store equipment in such a manner that prevent losses.

To facilitate easy storage, all parts shall be clearly marked.

The Contractor shall submit to the Engineer for approval, a specification including packing, shipping, storage and markings used by manufacturers, suppliers and shipping companies.

Group properly the smaller objects and equipment for indoor installation.

Do not leave any indoor equipment with epoxy resin or equal insulation under direct sunlight.

The equipment of each substation shall be packed separately and marked distinctly and clearly, so that mix up with the equipment of other substation is prevented.

Before leaving the Contractor's works, all apparatus and fittings shall be painted or stamped at least in two points with distinguishing number and / or letter in accordance with the number and / or letter in the approved drawings and material list.

The erection marks on galvanized material shall be stamped before galvanizing and shall be clearly legible after galvanizing.

All markings shall be legible and weatherproof.

Where tags are used, they shall be durable, securely attached and duplicated.

Marking strips and nameplates shall be of plastic laminate or anodized aluminum. Paper labels shall not be used.

7. Equipment Data

The tenderers shall fill the equipment data in the Schedule of Technical Information, including data relevant to manufacturer's name and country, type designation, etc.. and submit this data along with their proposals.

These data will be finalized during tender evaluation and contract negotiations and will be enclosed to the contract documents.The Contractor shall manufacture and supply the equipment based on Engineer's approved data.

Any deviation and modification in respect to the approved data, shall not be permitted, unless the Contractor obtain written Engineer's approval in advance. For this purpose Contractor shall explain in writing the reason for this substituation and submit complete data in this respect in six copies. The Engineer has the right to accept or not to accept this substituation.

In case any substituation accepted as explained above, no additional cost will be paid to the Contractor, but, based on the Engineer's recognition and reasons, if new equipment is found to have a lower price, the contract price shall be reduced accordingly.

8. Inspection

Inspection and testing during manufacture and at site should be considered as follows:

- Inspection and Testing during Manufacture

The whole of the grid station shall be subject to inspection and test by a designated agency appointed by the purchaser during manufacture, erection and on completion.

- Tests at Site

Also, before any part of the plant or equipment is commissioned for use, it shall be subjected to mechanical, electrical, operational and other tests as required to prove its compliance with the specification. All official tests shall be witnessed by the owner's site engineer.

The Owner has the right to have representative for inspecting all shop and assembly work associated with this project.The Contractor shall furnish the

Engineer a list of suppliers and the materials or equipment to be furnished by them for use in the works within sixty (60) days of the effective date of contract. The list shall be furnished in sufficient time to permit inspection and testing of materials and equipment.

All mill or shop orders shall quote the pertinent requirements of the technical specification and shall bear a suitable notation advising the suppliers of inspection requirements. If so requested by the Engineer, the Contractor shall furnish five (5) copies of designated mill and shop orders.

No materials or equipment shall be shipped until all mill and shop tests, analyses, and inspections are completed, and results of tests or analyses are accepted.

All inspections and tests will be witnessed in such a manner as not to unduly delay the work. The Engineer reserves the right to charge the Contractor any additional cost of inspection and testing when materials and equipment are not ready at the time such inspection and testing is requested by the Contractor or when reinspection or retesting is necessitated by rejection.

Materials incorporated or to be incorporated in the works shall be tested during the progress of the work as requested by the Engineer, and samples of such materials shall be furnished by the Contractor for testing when requested by the Engineer. All tests witnessed by the Contractor shall be witnessed by the Engineer unless the requirement therefore is waived in writing, or unless certified test results are required to be submitted to the Engineer. The Contractor shall give the Engineer reasonable advance notice of all such tests. The Engineer may perform additional tests of materials tested by the Contractor, and the Contractor shall furnish samples for his purpose as requested.

Whenever a specification or test method of the ANSI, NEMA, IEEE, IEC, BS, ASTM, AWS, or other authority is made applicable to materials, the Contractor shall test the materials in accordance therewith, shall submit to the Engineer certified copies of test results, and shall not use such materials until test results have been approved by the Engineer. The requirement for test results may be waived in writing by the Engineer. Wherever reference is made in the drawings or specification to one of the above specifications of test methods, and the number or other identification of the specification or test method,representing the year of its adoption or latest revision is omitted, the reference shall be to the specification or test method in effect on the date of the invitation to tenderers. The number of certified copies of test results shall be as specified in section 3 of the specification.

If so ordered in writing by the Engineer, the Contractor shall remove, tear out, or disassemble, in whole or in part, any completed portion of the works to permit its inspection. If such portion of the works is found to be defective or unauthorized, the Contractor shall bear the costs of removal, tearing out, or disassembly, and the provisions of this article shall apply. If Such portion of the works is found to meet specification requirements, if shall be replaced, reassembled, or otherwise restored by the Contractor to its original condition and its removal, tearing out, or disassembly and replacement, reassembly, or restoration will be considered extra work.

Neither the inspection nor lack of inspection of any portion of the works nor the presence or absence of the Engineer during performance of any of the works shall waive any of the requirements of the drawings and specification or relieve the Contractor of any of his obligations thereunder, and defective work, materials and equipment may be rejected not withstanding their prior inspection or lack of inspection by the Engineer, and not withstanding their conformance with the drawings and specification at the time of any prior inspection.

Any work, material, or equipment not conforming with the requirements of the drawings and specification will be considered defective, and except as otherwise provided below, will be rejected by the Engineer, whether in place or not.

Upon rejection, the Contractor shall correct defective work, materials, or equipment, or shall remove and replace them with work, materials and equipment conforming with the requirements of the drawings and specification, as ordered by the Engineer. Corrected material and equipment shall be used in the work only upon the written approval of the Engineer.

Any work done beyond the lines and grades shown on the drawings or established by the Engineer, or any extra work done without written authority will be considered unauthorized and will not paid for. Such work shall be removed, or removed and replaced with authorized work, or otherwise corrected as ordered by the Engineer.

The Contractor shall remove, tear out, or disassemble any portion of the works when necessary to give access to defects in the works or unauthorized work, and shall replace,reassemble or otherwise restore it to its original condition following correction, replacement, or removal of the defective or unauthorized portion of the works. If so ordered in writing by the Engineer, the Contractor shall remove, tear out, or disassembly, any portion of the work of other Contractors, when necessary for the above purpose,

and shall replace, reassemble, or otherwise restore it to its original condition, all at the expense of the Contractor.

If the Contractor fails to comply promptly with any order of the Engineer given under this article, the Owner may cause the defective works,materials, or equipment or unauthorized work covered by the order to be corrected, removed and replaced or removed, as the case may be, and the costs thereof shall be borne by the Contractor and any amount thereof may be deducted from any money due or that may become due to him under the contract. If shipment to the Contractor of any item or part is required, the costs of such shipment shall be borne by the Contractor.

Any decision of the Engineer under this article shall be final and conclusive.

9. Consideration

9.1. Reliability Considerations

A prime objective in the operation of an electric power system is to provide reliable service within acceptable voltage limits. Information on reliability may be found in ANSI Std. C84.1-1995, “Electric Power Systems and Equipment-Voltage Rating (50 Hz).” Cooperatives that design substations to operate within the voltage levels specified in this ANSI Standard should have reasonably reliable substations.

9.2. Operation Considerations

For simplicity and ease of maintenance, substation equipment arrangements, electrical connections, signs, and nameplates should be as clear and concise as possible. Information on safety signs can be found in ANSI Std. Z535.2, “Environmental and Facility Safety Signs.”

A substation may occasionally experience emergency operating conditions requiring equipment to perform under abnormal situations. Depending on the length of time, the provision of unusual current carrying capacity of some equipment or connections should always be considered and appropriately accounted for in the design.

9.3. Safety Considerations

It is paramount that substations be safe for the general public and for operating and maintenance personnel. Practical approaches include the employment and training of qualified personnel, appropriate working rules and procedures, proper design, and correct construction. The safeguarding of equipment also needs to be considered in substation design.

Personnel working standards are prescribed by regulations issued by the Occupational Safety and Health Administration (OSHA). In addition, various states may have standards the same as or stricter than those of OSHA. The engineer is expected to follow the regulations appropriate to the jurisdiction in which a substation is built.

9.4. Maintenance Considerations

Grid station design needs to allow maintenance to be accomplished with a minimum impact on a grid station's operation. Allocation of adequate working space is necessary.

In selecting equipment, consider the service intervals recommended by the manufacturers and past experience in using a particular manufacturer's equipment.

10. Quality Control

The Contractor shall provide and maintain quality control programs as specified below, for the manufacture of equipment, to ensure compliance with quality standards of the specification. Within thirty (30) days of the signature date of contract, the Contractor shall furnish to the Engineer five (5) copies of his complete quality control and procedures manual, and description of the organization to be used on this contract.

Throughout the period of the contract until shipment from points of manufactures,the Engineer or other authorized representatives of the Owner will monitor the Contractor's methods, procedures, and processes in all phases of the work for compliance with the quality control program, provisions.Before beginning the work, the Contractor shall designate to the Owner and Engineer in writing one employee or member of this organization who shall have authority to act in all matters relative to the quality control provisions of the contract.

Failure of the Contractor to maintain the quality control program throughout all phases of the work will be considered a failure of the work to conform to the specification.

The quality control program shall provide for at least the following controls :

10.1. Design

All drawings and production information shall clearly set forth the standards of quality such as materials to be used, required machining finishes, welding procedures, and coatings to be applied.

An effective system shall ensure rapid dissemination of specification and drawing changes throughout the manufacturing organization and provide for immediate removal of obsolete information from use. All the latest applicable drawings and changes shall be available at the time and place of inspection.

A list of all drawings shall be maintained showing the status of each, including submittal, dates reviews and revisions.

10.2. Purchased Material Control

Effective quality control shall be exercised over all outside purchased materials to ensure that the materials meet specification requirements. This control shall consist of either inspection at source of manufacture,

verification of certified data furnished by the supplier or inspection upon receipt. Records of purchased materials inspection shall be maintained and be available for inspection by the Engineer or other authorized representative of the Owner.

10.3. Tools and Gages

Precision tools, gages and measuring instruments necessary to verify material conformance to specifications shall be available before beginning production. Adequate physical control and safeguarding of tools and gages shall be provided to prevent their misuse and damage when not in use. A schedule shall be established and maintained for periodically checking and calibrating all precision tools and gages against master standards.

This procedure shall include the maintenance of records to verify the checking of precision tools and gages as scheduled.

Master standards used for checking shall be periodically certified for accuracy against standards traceable to an international bureau of standards and evidence of certification shall be made available upon request. New and reconditioned precision tools and gages shall be calibrated before being released for use.

10.4. Manufacturing Control

The Contractor's inspection organization shall be independent of the line production staff, shall report directly to top management, and shall be vested with controlling authority. Before beginning producing, the quality control program shall provide for determination of those points throughout the manufacturing process where inspection or tests are required to ensure adequate control of quality, and accordingly establish and maintain such in-process inspection operations as are necessary. Inspectors shall be provided with instructions clearly detailing what characteristics to inspect, what standards of acceptance to use and what action to take as a result of inspecting finding.

The inspection status of material shall be identified at all times by markings on the material, tags or other suitable means. Evidence of performance of special processes shall also be indicated in a like manner. Final inspection and testing shall be sufficient to ensure compliance of the finished product with the specifications. Adequate records shall be maintained of all inspections and tests. These records shall substantiate that the required

inspections and tests have been witnessed as specified in the written instructions, and indicate the discrepancies and reasons for such discrepancies. These records shall be available and maintained as stated above.

When specification require that manufacturing operations or processes require certification by codes or certification of operations and equipment according to said codes, the program shall provide that such certification are obtained before production is stated. Evidence of such certifications shall be maintained and be available for inspection by the Engineer or other authorized representatives of the Owner.

10.5. Unsatisfactory Materials

Inspection procedures shall include adequate measures for positive segregation of unsatisfactory incoming, in-process and finished material from acceptable material and to ensure its removal from the manufacturing cycle. Such measures shall consist of positive and readily discernable identification as unsatisfactory material and physical separation from acceptable material. There shall be an established procedure for analysis and review of questionable material by a higher authority to determine its disposition.

10.6. Handling and Packing

The program shall provide for and maintain throughout the manufacturing cycle such measures as are necessary to protect incoming, in-process and finishing material from damage. These measures shall include protective packing or wrapping maintaining special environment, special handling and storage instructions and other specific methods of protection as required.

The contractor shall provide such packing of the goods as it is required to prevent their damage or deterioration during transit to their final destination as indicated in the contract. The packing shall be sufficient to withstand, without limitation, rough handling during transit and exposure to extreme temperature, salt and precipitation during transit and open storage. Packing case size and weights shall take into consideration, where appropriate, the remoteness of the goods final destination and the absence of heavy handling facilities at all points in transit.

TECHNICAL SPECIFICATION

SECTION 3

SUBMITTALS

MONENCO – IRAN CONSULTING ENGINEERS COMPANY

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1. General

This section deals with the documents required to be submitted by the Contractor with its bid proposal and also the documents to be submitted after the award of the Contract and during the course of the execution of the contract works.

2. Documents to accompany the bid

2.1. General

All the tender documents, including the Technical Specifications, Tenderer's instruction, contract agreement, tables, drawings, invitation to tender, amendments issued by the Owner/Engineer during the bid period, the Contractor’s bid proposal, etc. shall be signed and stamped by the Contractor and submitted with the tender proposal. Detailed requirements on these shall be outlined in the forms of instructions to Tenderers.

The Contractor in this bid split-up the schedules in more items, but the reverse shall not be done.

The Technical Particulars shall be used for detailing the technical guarantees and data for equipment to be delivered. The Contractor may give more details and information than indicated in the technical particulars, but not the reverse. The technical particulars forms (Data sheet) are included after corresponding sections of the technical specifications and for the general bid, in this section.

Dimension sketches for the main electrical equipment shall follow the technical particulars. Calculations and calculation methods shall be indicated for different design decisions. Outline drawings and principle diagrams shall be included for the plant.

2.2. Outline Works program

To prepare and submit a complete bar chart of work plan indicating all the periods of the equipment design, manufacturing, FOB delivery, anticipated shipping and supervision on erection and commissioning works.

The Contractor shall submit with its tender an Outline Works Program showing in bar chart form the key dates, commencement dates, durations, and completion dates of the main activities for each substation. Where the work in a substation is to be completed in more than one phase the work sequences associated with each phase shall be shown separately.

The following items shall be shown:

(1) Electrical equipment design and approval

(2) Manufacture of all equipment

(3) Equipment erection

(4) Tests on Completion

(5) Guaranteed dates for completion

The Contractor shall perform the Works in accordance with the Outline Works Programme submitted with the Tender until a detailed Works Programme is approved by the Engineer.

2.3. Works Program

Within 30 days from the date of Award of Contract the Contractor shall submit to the Engineer for approval a Works Program showing the activities and sequence needed for the orderly and coordinate performance and completion of each separate part of the Works in order to meet the major contract events set out in the approved Outline Works Programme, except as otherwise approved in writing by the Engineer.

The Works Programme shall be in bar chart form and shall be complete in all respect covering all activities relating to the Works, both on site and off site, including but not limited to design, detailed engineering, manufacture, transportation to site, delivery, erection and setting up, construction, testing, taking over and completion of all other obligations such as, but not limited to, training, maintenance, etc. The Works Programme shall show in detail the intended sequences, as well as the interrelations between the various activities.

2.4. Variations to the Works Program

The Works Program as approved by the Engineer shall become part of the Contract and the Contactor shall thereafter carry out the Works in accordance

therewith. Upon prior written application by the Contractor the Engineer may allow a reasonable variation in the Works Program provided always that:

- Such variation does not jeopardize timely completion of the Works, or sections of the Works having separate completion dates
- No interference with the operations of others performing work for the Works is caused thereby.

No change, other than as described in this Sub-clause or as authorized by a variation order in accordance with the provisions of the Contract, shall be made to the Works Program. Where a change in the programming of the Works is proposed, a revised Works program, dated and annotated with revision number, shall be submitted to the Engineer for approval. Following such approval the Works Program, so revised, shall become part of the Contract.

Approval by the Engineer of the Works Program shall not relieve the Contractor of its duties and obligations under the Contract.

2.5. Plant Outage Program

Not later than two months prior to the first plant outage required the Contractor shall submit a Plant Outage Program detailing all outages of existing plant required by the Contractor for the completion and testing of the Works.

The submitted program shall contain the following details:

(1) The plant involved in the outage (e.g. transformer, feeder cable, switchgear bay, control/protection cabinets, etc).

(2) The estimated outage duration taking account of any special requirements / limitations as stated in the Scope of Work.

(3) The estimated outage starts date.

Any failure on the Contractor's part to provide such notice may result in delays in obtaining outages with probable consequent delays to the Contract. The Employer will not be responsible for any such delays and will not accept any resulting claims nor will any extension to the completion date be given as a result. In the event that a further outage programme is necessary a similar procedure will apply.

The specific outage requirements shall be reconfirmed a minimum of 3 weeks in advance of the required start date.

2.6. Reporting Progress

The Contractor shall at all times notify the Engineer of any delays or proposed variations in its day to day schedule of operations which are at variance with the Works Program.

The Contractor shall furnish monthly, in triplicate, a detailed report in the form and content as will provide a precise assessment of actual progress against the Works Program at a date not more than seven days prior to the date of receipt of such report by Engineer.

2.7. Initial Conference and Mobilization Plan

Not later than twenty one days from the date of Award of Contract the Engineer shall call a conference with the Contractor to discuss administration of the Contract, scheduling of design, design approvals, manufacture, plant erection and other matters which may be pertinent to the completion of the Works. The Contractor's Project Manager and other key personnel as necessary shall attend this meeting.

Immediately after Award of Contract the Contractor shall submit to the Engineer its proposed Mobilization plan. This plan shall contain detailed information of all proposed mobilization activities of the Contractor and shall contain drawings and site layout plans showing work areas, parking, storage areas, utilities, roads, fences and such other information as may reasonably be required by the Engineer.

2.8. Coordination and Site Meetings

Throughout the period of the Contract the Engineer may, from time to time as he considers necessary, call a co-ordination conference on site, at its head-office or at the Contractor's works or elsewhere in order to ensure good communications and to prevent delays in the Works. The Contractor's Project Manager shall attend such conferences together with any other persons who, in the opinion of the Engineer, may be required.

At its discretion, the Engineer may, from time to time agree to the project Manager being represented by another competent person, depending on the subject matters on the agenda.

Throughout the erection period the Employer shall convene meetings with the Contractor on site, and otherwise as the Employer may decide, to discuss progress, technical and organizational matters and any other matters affecting the execution of the Contract. The Contractor shall be represented at such meetings by its Site Manager and other competent persons as may be required.

2.9. Organization and Organization Charts

The Contractor shall submit with its tender an Outline Organization Chart showing:

- Organization for planning, administration, project co-ordination
- Lines of authority, responsibility, communication, Division of responsibility between on-site and off-site organizations

Within thirty days of Award of Contract, and otherwise as and when required by the Engineer, the Contractor shall submit for the approval of the Engineer, a detailed Organization Chart showing the proposed organization as outlined in the Outline Organization Chart but including also the following:

- Names, titles and functions of all supervisory and key personnel including training instructors

The Contractor's key management and technical personnel, both on-site and off-site shall have proven competence and experience in projects of a similar nature and size.

Upon approval of the Organization Chart and proposed personnel by the Engineer, no changes shall be made without the Engineer's prior written approval and until a satisfactory replacement has been approved by the Engineer.

The Contractor shall submit for the approval of the Engineer, as requested, a holiday schedule for its site staff.

2.10. Payments Schedule

Within thirty days from the date of Award of Contract and in any event before the first payment falls due to him the Contractor shall submit a payments schedule in a from satisfactory to the Engineer showing all the expected amounts and the dates on which the Contractor shall become entitled to them

in accordance with the Contract. Such schedule shall be updated by the Contractor at regular intervals not exceeding twelve months and a copy of each updated Payments Schedule shall be submitted to the Engineer.

2.11. Shipping Plan

Within thirty days from the date of Award of Contract the Contractor shall submit for approval by the Engineer a Shipping plan covering all intended shipments to the site. Such plan shall be related to the Works Program and shall contain the following information:

- Description of items to be shipped
- Approximate tonnage and cubic size
- Port/airport of shipment
- Date of shipment
- Method of shipment
- Estimated date of arrival
- Port/airport of arrival
- Method of transport to site from the port/airport of arrival
- Intended transport document (bill of lading, airway bill, etc)

Such Shipping plan shall be kept up to date and shall be submitted to the Engineer periodically for review and approval in accordance with the Engineer's instructions. Such review and approval by the Engineer shall not, however, relieve the Contractor in any way of its obligations to secure the timely shipment of materials and equipment to the Site.

2.12. Site Safety

The Contractor shall administer and control its site activities in a manner conducive to the achievement and maintenance of adequate safety for the public, its employees, its Sub-contractors and their employees, the employer and its employees and the Engineer and its employees. This shall include regular inspection of all temporary installations and portable tools equipment.

The Contractor shall inform himself of the Employer's safety procedures and shall furnish a statement of its commitment to work to these procedures. He shall take all necessary precautions and actions to comply with regulations, and shall provide all necessary barriers and height gauges in such approved form and positions as directed by the Engineer.

The Engineer shall have power to stop the works if in its opinion they are being undertaken in an unsafe manner.

2.13. Work In Operational Areas

Work shall be carried out by the Contractor strictly in accordance with the Employer's Safety Rules and Operational Procedures and the Engineers Instructions. Necessary written permission shall be obtained from the Employer through the Engineer.

2.14. Putting Into Service

The Contractor's responsibility shall include the commissioning and putting into service of all plant. No plant shall be put into service without the written approval of the Employer or its Engineer.

2.15. Notification of Accidents/Fires or Similar Incidents

In the event of an accident, fire, or similar incident occurring on, or associated with the site, the Contractor shall immediately notify the Employer and the Engineer or their representatives.

Notification to the Employer and/or Engineer shall follow the taking of all necessary actions to deal with any of the above situations (e.g. alerting Fire Bridge in the event of a serious fire).

2.16. Schedule of deviations from the specifications (Variations/Exceptions)

Any deviations/exceptions in detail resulted from either non-compliance with the tender specifications/design, or from a change in manufacturer’s design and standards, or from any reason, shall be clearly listed by the Tenderer. The mentioned list shall indicate the section number, subsection number for each

deviation/exception and also clearly show how the proposed item differs from that specified.

In case of discrepancies between the details proposed by the Tenderer and those lists, the details proposed by the Tenderer will be considered, at the Owner's judgment, and the Tenderer shall be bound to comply with the Owner's instructions in that respect.

3. Documents to be submitted during the progress of the works

3.1. General

The Contractor shall supply, to the Owner, a complete documentation of the works. The documentation shall consist of all installation and operation drawings, operation and maintenance manuals that are required for the clients operation, maintenance, dismantling, reassembling and adjusting of all delivered parts of the work.

The work will not be considered as completed and taking over certificate will not be issued until all documentation, as specified in this section, has been delivered.

3.2. System of units & drawing sizes

a. For all documents, written or drawn, the SI system of units shall be used. (Adopted by the general Conference on Weight and Measures). All calculations and drawings shall be presented in MKSA system of unit.

b. Drawing sizes shall conform to the ISO standard, i.e. :

- A1 (595 ´ 841 mm)
- A2 (420 ´ 594 mm)
- A3 (297 ´ 420 mm)
- A4 (210 ´ 297 mm)

c. All manuals for operation, maintenance and installation shall be bilingual with English text on the right hand page and the Farsi on the left. Farsi text shall be required only for important features of operation, maintenance and installation.

d. Text on drawings, calculations and test certifications shall be in English.

e. All documents and drawings will be provided in electronic CAD file format and submitted in DVD/CD.

3.3. General Manuals

The following general manuals, covering the whole project shall be delivered:

a. A general description of the equipment in the contract.

b. Unloading, handling and storage instructions of all equipment supplied.

c. Operating and repair instructions, suitable for training of personnel.

d. General maintenance and operation instructions, describing frequencies and methods for regular inspections, for planned maintenance and for regular replacements. The instructions shall also include fault location guides.

e. Civil works related information.

f. Erection work procedures and erection equipment list (as needed for each equipment)

g. Site test procedures along with necessary instruments for each equipment

h. Commissioning instructions and program.

3.4. Design documentation

a. All layout and section drawings.

b. All design calculations regarding electrical, mechanical and civil related stresses on each item of the plant.

c. Apparatus lists including all apparatus installed, sub-divided in bays and panels. Lists shall include technical data, order number and references to schematic diagrams.

d. Cable lists including all cables within the plant. Cables shall be listed in numerical order and cable type and location of terminals shall be indicated.

e. Connection tables indicating all internal and external connections in panels and cubicles, with reference to cable numbers and Terminals.

f. Schematic diagrams covering the complete plant in a survivable way.

g. Civil works basic drawings, and related information as brought-up in related Section.

h. Upon completion of the design, the contractor shall submit detailed installation, operating and maintenance instruction manuals. The final reviewed copies of these instruction manuals shall be also available to be properly utilized during the installation, pre-commissioning, commissioning etc processes.

NOTE:

The clause 5 deals with the design documents in detail for High Voltage, Civil, Protection, Control, Metering, Electrical & Mechanical Installation, LVAC, LVDC, Cabling, Power and Auxiliary/Earthing Transformer Equipment / systems, which shall be submitted by the contractor for approval.

3.5. Equipment & apparatus documentation

a. Documents for approval shall be submitted as follows:

1. Type test documents and certificates.
2. Routine test documents and certificates.
3. Data lists with by the Engineer required amendments incorporated. The contents of the lists will be found after each apparatus specification in this document. Data lists will be regarded as binding for the manufacturer.
4. Dimension sketches. They shall be regarded as binding for the manufacturer and shall contain measures, weights and main features of the apparatus.
5. By the Engineer required detail drawings.
6. Connection diagrams, showing all internal and external connections of electrical, hydraulic or pressurized gas types.
7. List of components and details on the apparatus. They may preferably be included in the dimension sketches.

b. Catalogues, pamphlets and descriptive literature on all supplied equipment.

c. Erection, testing, operation, maintenance and service manuals, which shall be delivered in bilingual form for all apparatus. They shall include spare parts lists and description of any special tools needed for service of the equipment.

d. All other, not mentioned drawings or manuals that are deemed necessary for safe and proper handling of the delivered equipment.

3.6. Work schedules and progress reports

3.6.1. Master Schedule

Within 5 weeks of receiving order to commence works, the contractor shall submit a master schedule (in a bar format) to the Engineer. The schedule shall have clearly marked key dates. The schedule shall include, but not be limited to design, manufacture, testing, FOB delivery, erection and site testing and commissioning works-in sufficient details to provide a clear picture of the project (erection, testing and commissioning not covered by the scope of this contract only schedule of anticipated timing for these tasks shall be given).

The schedules shall allow 4 weeks for the Engineer's approval of drawings, designs and calculations. Interface points between the different schedules shall be clearly indicated.

3.6.2. Monthly progress report

The Contractor shall prepare and issue a monthly progress report to start the first month after receiving order to commerce the work. The report shall include information on the month's progress on design, manufacturing, factory testing, and FOB delivery.

The Contractor shall standardize a layout for the repeated reports that is acceptable to the Engineer.

3.6.3. Submittals

1. All drawings, data and documents submitted for review shall be accompanied by a letter of transmittal in triplicate listing the drawing or document reference, revision and title. All drawings and documents shall be covered by a drawing list for the whole contract, and the list shall be revised to show the final revision for all listed drawings.

   Drawings and documents submitted shall be identified by the following headlines:

   - Project title/name of the substation.
   - Name of the Owner.

- Name of the Engineer.
- Name of the Contractor.
- Contract number.
- Drawings, title, data and numbers.

2. The Contractor shall submit four prints of all drawings and documents with the CAD electronic files in DVD/CD, one copy shall be sent to the Owner.

3. All detail assembling designer manufacturing drawings design assumptions, design briefs and calculation works shall be submitted to review and approval (4 copies). For the documents as mentioned in clauses 3.3 to 3.6, (4) four copies shall be submitted for review and comments. The drawings/documents will be reviewed and one copy will be returned to the Contractor stamped “Commented”, “Approved as noted”, “Approved” or “Void”.

   If not stamped “Approved” the Contractor shall revise the drawings in accordance with the comments marked thereon and shall forward four (4) copies or prints for further review with Reply Sheet (Answer to comment). This procedure shall be followed until the drawings are stamped “Approved”. Changes made during progress of the work shall be clearly indicated and new copies or prints with the changes shall be submitted to the Engineer for approval before any action to be taken.

   As a main precondition for starting up the fabrication and manufacturing processes, it should be noted that only the drawings stamped “Approved” or “Approved as noted” can be utilized. It is noteworthy that, all the comments presented by the Engineer, in the “Approved as noted” stamped drawings, shall be completely and clearly applied before starting up the fabrication and manufacturing processes.

   Since Reviewing each document takes four (4) weeks for detailed analysis, it is included in the responsibility of the Contractor to consider this requirement in the scheduling of its submittals, as a main precondition.

   This “Approved” or “Approved as noted” of the Contractor’s drawings/documents shall not relieve the Contractor from responsibility for errors or omissions which may exist or occur, even though work is done in accordance with such drawings.

   After the drawings have been stamped “Approved” the Contractor shall forward for record purposes, five (5) prints of each drawing which has been stamped.

4. Where extensions of the existing substations are involved, the Contractor shall be supplied with the drawings and documents to the extent available. Additional and necessary information as may be required and arranged to be gathered by the Contractor's visit and collection at the substation site.

4. As-Built document

4.1. General

As-Built Drawings are the amended "As-designed" drawings revised to show the project as the contractor built and constructed it. The revisions from contractor markups and field inspection notes are transferred to the final As-Built set of drawings. The final As-Built drawings include modifications during construction, field requested changes, shop drawing modifications, and contractor designs.

The Contractor shall maintain 2 sets of paper drawings and specifications (marked-up prints) to track changes, additions or deletions from the original design during construction. The working As-Built marked drawings will be jointly reviewed for accuracy and completeness by the Engineer before submission to substation. At least one paper set of As-Built drawings shall be available on the substation at all times.

As-Built documents shall be prepared and included in separate sections for the design, factory testing, operation, maintenance, testing, handling, storage, erection, and site testing and commissioning works.

Each document shall include information related to each substation and each item of equipment used. The mentioned information shall include electrical, mechanical and civil aspects of the project substations.

4.2. Design documents

1. A complete set of design drawings, calculations, computer data, and related references shall be handed-over.

   The Contractor shall keep an accurate record of modifications to detailed design drawings on the most recent set of prints of the approved construction drawings.

2. After field installation, the Contractor shall transfer all changes to the latest approved construction documentation and return to the Owner for its permanent records.

The documents shall include equipment specifications for each item of the plant on the basis of the approved final Technical Characteristics. All calculations, basic design data, testing procedures, instructions manuals, dimensional drawings, complete with details, circuit diagrams, relay protection, control and metering diagrams, steel structure supports and gantries detailed drawings, equipment location drawing and spare parts lists shall be included and refer to pertinent standards which shall be made.

4.3. Installation instructions

Detailed instructions for the installation of the equipment shall be submitted together with reduced size copies of applicable drawings showing the erection sequence. The instructions and, drawings shall include information on handling and slinging the major pieces of equipment, erection tolerances and special precautions to be taken in the storage and installation.

4.4. Operation & maintenance instructions

Detailed operating and maintenance instructions, which shall include reduced size copies of applicable drawings, applicable parts lists and catalogues covering all equipment (Including switchgear equipment protection, control, aux. AC/DC, power and grounding transformers, etc.) furnished and which may be needed or useful in operation, maintenance, repairs, dismantling or assembling, and for repair and identification of parts for ordering replacements, shall be submitted.

As the after sales services (following issuance of the Final Acceptance Certificate, and submission of the Final As-Built documents), the contractor shall supply the Owner with new information and documents (if any new experience gained) on the instructions for the operation and maintenance works of the sold equipment.

4.5. Drawings and documents

The As-Built drawings and documents for the works of each substation shall be complete for each item of the plant and include but not limited to the following:

- Substation situation plan.

- Substation general layout and cable trench plan.

- Equipment foundation plan.
- Basic civil design information and calculations.
- Lighting, system drawings and documents.
- Steel structures for equipment, bus supports, gantries, related loading calculations and drawings.
- Complete equipment list.
- Instruction for transportation, handling and storage of each item of equipment.
- Substation general layout and sections complete.
- Detailed drawings for assembly of the insulators, fittings, busbars, etc.
- Instruction manuals, catalogues and drawings for installation and erection of each item of the switchgear, power and auxiliary transformer, control, metering, protection, alarm, indication, aux. AC/DC systems, diesel generator set, etc. (all outdoor and indoor equipment).
- Cable schedules and wiring diagrams, terminal lists, connection details for all substation equipment. Specifications of cables, earthing grid and station AC/DC details.
- Control and protection panels, cubicles, and racks:
    - Equipment location and arrangement diagrams.
    - Control, protection, metering, alarm and indication equipment list.
    - Cubicle cabling and circuit diagrams.
    - Equipment symbols, legend, and nomenclatures.
    - Protection and control systems detailed wiring and connection diagrams.
    - All relay protection and control equipment catalogues and instruction manuals.
    - Circuit diagrams for control, protection, metering, indication, alarm.

- Calculations and setting procedures for each relay and each protection system.

- Instruction for preparation of testing of each relay/each protective system.
- Site test procedures and circuits for each item of equipment along with the required testing equipment.
- Commissioning program and procedures.
- Test sheets for each item of equipment.
- Instructions for operation, maintenance, handling and periodic testing during operation along with related time tables.
- Spare parts list for each item of equipment.

4.6. Training documents

Detailed documents covering the whole training program along with related books and instruction manuals, etc., shall be submitted.

4.7. Quantities of the As-Built documents

1. Technical documentation guide book

   This book shall contain information on classification of all project documents. Explanatory notes shall be included for convenient use of the documents. List of volumes and their table of contents shall be included. Likewise, list of drawings and documents shall be incorporated. References to the drawings or other pertinent parts of the documents shall be given. The book shall contain subject indicates the basis of the type and different parts of the project. Information as the way to use each volume, the numbering system of different volumes of the documents, symbols, and abbreviations used on the drawings and related standards shall be included. Five (5) sets of this guide books shall be delivered.

2. Factory test reports & site test certificates

Comprehensive type and routine test reports carried out at the works and also site test reports of the equipment shall be included in a bound volume. Three (3) sets of this volume shall be delivered.

3. Operation & maintenance instruction guide book

   Operation and maintenance manuals and instructions shall be prepared and submitted on the basis of the requirements shown in clause 4 subjects related to the equipment substation operation which shall be completely separated from those of the maintenance and repairs. Six (6) sets of this volume shall be delivered.

4. Installation instruction guide book

   Installation instruction manuals, drawings and documents for different substation equipment shall be prepared on the basis of the requirements of the clause 4.

   Four (4) sets of this guide shall be furnished.

5. System design guide book

   This book shall include information on design details of different systems of the project. Further details as to the requirements of the contents of the design guide book are included in Clauses 4.2 and 4.5. Five (5) sets of this guide book shall be delivered.

6. Equipment specifications guide book

   This book shall contain the Technical Specifications of each used equipment item and summary of their functions. General drawing conveying the main characteristics of the project shall also be included. Five (5) sets of this guide shall be furnished.

7. Training documents

   All documents related to the training program, including books and instructional pamphlets, literatures and manuals shall be properly arranged and bound and delivered in six (6) copies.

5. Abbreviations and Symbols

The Abbreviations and Symbols which are applied in tender documents, such as technical specifications, drawings etc. are introduced in following table:

Abbreviation	Description	Section
µs	micro Second	General
AC	Alternating Current	General
AI	Analogue Input	General
ANSI	American National Standards Institute	General
API	American Petroleum Institute	General
ASHRAE	American Society for Heating, Refrigerating and Air Conditioning Engineers	General
ASME	American Society of Mechanical Engineering	General
ASTM	American Society for Testing and Materials	General
ITU-T	International Telecommunication Union Telecommunication Standardization Sector	General
Aux.	Auxiliary	General
BCR	Bay Control Room	General
BI	Binary Input	General
Bldg	Building	General
BO	Binary Output	General
BOM	Bill of Materials	General
BOQ	Bill of Quantity	General
CAD	Computer Aided Drawing	General
CC	Close Coil	General
CCR	Control Center Room	General
CTS	Clear to Send	General
d	Diameter	General
DAS	Data Acquisition System	General
DC	Direct Current	General
Dim.	Dimension	General
DIN	Deutsche Industrie-Normen (Deutsches Institut für Normung)	General
Doc.	Document	General
DP	Distribution Panel	General
DSP	Digital Signal Processing / Processor	General
DTT	Direct Transfer Trip	General
DWG	Drawing	General

Abbreviation	Description	Section
Elec.	Electrical	General
FAT	Factory Acceptance Test	General
GPS	Global Positioning System	General
HW	Hardware	General
I&C	Instrumentation & Control	General
I/O	Input / Output	General
IEC	International Electrotechnical Commission	General
IEC	International Electrotechnical Commission	General
IEEE	Institute of Electric and Electronics Engineers	General
IP	International Degree of Protection	General
ISO	International Standard Organization	General
JIS	Japanese Industrial Standards	General
nm	nanometer	General
kA	kilo Ampere	General
kHz	kilo Hertz	General
kV	kilo Volt	General
kVA	kilo Volt Ampere	General
kbps	kilobits per second	General
Mbps	megabits per second	General
Mech.	Mechanical	General
Min	Minimum	General
min.	Minute	General
mm	millimeter	General
ms	mili Second	General
MTO	Material Take Off	General
MVA	Mega Volt Ampere	General
NCC	National Control Centre	General
NEMA	National Electrical Manufacturer Association	General
NEMA	National Electrical Manufacturers Association	General
NFPA	National Fire Protection Association	General
NGR	Neutral Grounding Resistor / Reactor	General
No.	Number of	General
ºC	Centigrade Degree	General
OHL	Over Head Line	General
OLTC	On Load Tap Changer	General
Ph.	Phase	General

Abbreviation	Description	Section
PP	Power Plant	General
QA	Quality Assurance	General
QTY	Quantity	General
RDC	Regional Dispatching Center	General
REC	Regional Electric Company	General
Rev.	Revision	General
RTS	Request to Send	General
SAT	Site Acceptance Test	General
SC	Short Circuit	General
SCADA	Supervisory Control and Data Acquisition	General
SCC	System Control Center	General
SLD	Single Line Diagram	General
SS	Substation	General
Std.	Standard	General
SW	Software	General
TC	Trip Coil	General
TEMA	Tubular Exchanger Manufacturer Association	General
OAM&P	Operation, Administration, Maintenance and Provisioning	General
Sec.	Second / Secondary	General / General
GIS	Geographic Information System / Gas Insulated Switchgear	General / HV
BS	British Standards / Bus Section	General / LV and HV
OPGW	Optical Ground Wire	Communication
CRT	Cathode Ray Tube	Communication
DPLC	Digital Power Line Carrier	Communication
E&M	Ear and Mouth	Communication
HF	High Frequency	Communication
kbps	kilo bit per Second	Communication
MDF	Main Distribution Frame	Communication
MML	Man Machine Language	Communication
PABX	Private Automatic Branch Exchange	Communication
TDM	Time Division Multiplexing	Communication
VF	Voice Frequency	Communication
CAS	Channel Associated Signaling	Communication
PCM	Pulse Code Modulation	Communication

Abbreviation	Description	Section
DTE	Data Terminal Equipment	Communication
DCE	Data Circuit-terminating Equipment	Communication
FXO	Foreign Exchange Office	Communication
FXS	Foreign Exchange Station	Communication
FDM	Frequency Division Multiplexing	Communication
GUI	Graphical User Interface	Communication
CRC	Cyclic Redundancy Check	Communication
LCT	Local Craft Terminal	Communication
HVI	High Voltage Interface	Dispatching
RTU	Remote Terminal Unit	Dispatching
AAAC	All Aluminum Alloy Conductors	HV
AAC	All Aluminum Conductors	HV
AIS	Air Insulated Switchgear	HV
AWG	Aluminum Welding	HV
BB	Busbar	HV
CT	Current Transformer	HV
CVT	Capacitive Voltage Transformer	HV
DS	Disconnector Switch	HV
EPDM	Ethylene Propylene Diene Monomer	HV
EPM	Ethylene Propylene Monomer	HV
EPR	Ethylene Propylene Rubber	HV
ES	Earthing Switch	HV
HRC	High Rupturing Capacity	HV
HTV	High Temperature Vulcanization	HV
HV	High Voltage	HV
HVDC	High Voltage Direct Current	HV
LA	Lightning Arrestor	HV
LMU	Line Matching Unit	HV
LT	Line Trap	HV
LV	Low Voltage	HV
mH	milli Henry	HV
MV	Medium Voltage	HV
PVC	Poly Vinil Chloride	HV
SEC	Surges Withstand Capability	HV
SWGR	Switchgear	HV
TV	Tertiary Voltage	HV

Abbreviation	Description	Section
UTS	Ultimate Tensile Strength	HV
XLPE	Cross Linked Poly Ethylene	HV
dB	decibel	HV / Communication
dBm	decibels per milliwatt	HV / Communication
BC	Bus Coupler	HV / LV
LBS	Load Breaker Switch	HV / LV
NC	Normally Close	HV / LV
NO	Normally Open	HV / LV
Sw.	Switch	HV / LV
BIL	Basic Insulation Level	HV / Transformer
AAV	Automatic Air Ventilation / Ventilator	Installations
ACLD	AC Long Duration	Installations
ACSD	AC Short Duration	Installations
BOP	Bottom of Pipe	Installations
CCB	Central Control Building	Installations
CO	Clean Out	Installations
DG	Diesel Generator / Distributed Generation	Installations
DL	Door Louver	Installations
DPA	Differential Pressure Alarm	Installations
EH	Electrical Heater	Installations
EWH	Electrical Water Heater	Installations
FD	Fire Damper / Floor Drain	Installations
FDAS	Fire Detection Alarm System	Installations
FFU	Fan Filter Unit	Installations
FIX.	Fixture	Installations
FMB	Fire Master Box	Installations
FPE	Fire Powder Extinguisher	Installations
FSL	Foundation Site Level	Installations
GD	Gravity Damper	Installations
HM	High Mast	Installations
HP	High Pressure	Installations
HVAC	Heating, Ventilation, and Air Conditioning	Installations
LIC	Lightning Impulse Chopped	Installations
LP	Local Panel / Low Pressure	Installations
MAV	Manual Air Ventilation / Ventilator	Installations
MFD	Motorized Fire Damper	Installations

Abbreviation	Description	Section
MLP	Main Local Panel	Installations
MPB	Main Paging Box	Installations
MTP	Main Telephone Box	Installations
OLP	Outdoor Lighting Panel	Installations
RWD	Rain Water Drain	Installations
SIU	Split Indoor Unit	Installations
SOU	Split Outdoor Unit	Installations
SSCP	Sound System Control Panel	Installations
TIT	Temperature Transmitter	Installations
TS	Thermostat	Installations
UCB	Unit Control Building	Installations
CB	Clock Box / Circuit Breaker	Install. / General
PC	Photoelectric Cell / Personal Computer	Install. / General
ACB	Air Circuit Breaker	LV
AR	Auto Recloser	LV
AVR	Automatic Voltage Regulator / Regulation	LV
BCD	Binary Coded Decimal	LV
BCPU	Bay Control and Protection Unit	LV
BCU	Bay Control Unit	LV
CBF	Circuit Breaker Failure	LV
CCS	Close Circuit Supervision	LV
DCE	Data Communication Equipment	LV
DDE	Dynamic Data Exchange	LV
DEF	Directional Earth Fault	LV
Diff.	Differential	LV
DR	Divertor Switch	LV
DT	Definite Time	LV
EF	Earth Fault	LV
EI	Extremely Inverse	LV
EL	Earth Leakage	LV
ER	Event Recorder	LV
EWS	Engineering Workstation	LV
FR	Fault Recorder	LV
HD	Heavy Duty	LV
HI	High Impedance	LV
HMI	Human Machine Interface	LV

Abbreviation	Description	Section
HS	High Speed / High Set	LV
IDMT	Inverse Definite Minimum Time	LV
IED	Intelligent Electronic Device	LV
LCD	Liquid Crystal Display	LV
LDU	Local Display Unit	LV
LED	Light Emitting Diode	LV
LS	Low Set	LV
MC	Measuring Center	LV
MCB	Miniature Circuit Breaker	LV
MCCB	Molded Case Circuit Breaker	LV
MHz	Mega Hertz	LV
MPCB	Motor Protection Circuit Breaker	LV
MTBF	Mean Time Between Failure	LV
MTTR	Mean Time to Repair	LV
OC	Over Current	LV
ODBC	Open Database Connectivity	LV
OF	Over Flux	LV
OL	Over Load	LV
OV	Over Voltage	LV
OWS	Operator Workstation	LV
PB	Push Button	LV
PFC	Power Factor Controller	LV
PS	Plug Setting	LV
PSD	Power Swing Detector	LV
REF	Restricted Earth Fault	LV
SAS	Substation Automation System	LV
SEF	Sensitive Earth Fault	LV
DCS	Distributed Control System	LV
SMS	Substation Monitoring System	LV
SCS	Substation Control System	LV
SNMP	Simple Network Management Protocol	LV
SNTP	Simple Network Time Protocol	LV
SOE	Sequence of Event	LV
SOTF	Switch onto Fault	LV
SZ	Short Zone	LV
TCS	Trip Circuit Supervision	LV

Abbreviation	Description	Section
TMS	Time Multiplier Setting	LV
UC	Under Current	LV
UV	Under Voltage	LV
VCR	Var Control Regulator	LV
VDU	Visual Display Unit	LV
VI	Very Inverse	LV
FOC	Fiber Optical Cable	LV / Communication
LAN	Local Area Network	LV / Communication
PLC	Programmable Logic Controller / Power Line Carrier	LV / Communication
TPS	Teleprotection signaling	LV / Communication
THD	Total Harmonic Distortion	LV / Dispatching
LI	Low Impedance / Lightning Impulse	LV / HV
FF	Fuse Failure / Fire Fighting	LV / Installations
PD	Pole Discordancy / Partial Discharge	LV / Transformer
SI	Standard Inverse / Switching Impulse / System International	LV / Transformer / General
CTI	Comparative Tracking Index	Transformer
DGA	Dissolved Gas Analysis	Transformer
EMF	Electro-Motive Force	Transformer
ETR	Earthing Transformer	Transformer
MMF	Magnetic-Motive Force	Transformer
ODAF	Oil Directed Air Forced	Transformer
OFAF	Oil Forced Air Forced	Transformer
OLGM	On Line Gas Monitoring	Transformer
OLM	On Line Monitoring	Transformer
ONAF	Oil Natural Air Forced	Transformer
ONAN	Oil Natural Air Natural	Transformer
PPM	Part Per Million	Transformer
PRD	Pressure Relief Device	Transformer
TR.	Transformer	Transformer

6. List of documents

This clause deals with the design documents in detail for High Voltage, Civil, Protection, Control, Metering, Electrical & Mechanical Installation, LVAC, LVDC, Cabling, Power and Auxiliary/Earthing Transformer Equipment / systems, which shall be submitted by the contractor for approval.

Other requirements for documents included in corresponding sections of the technical specifications shall also be applied.

At least following documents shall be submitted:

6.1. Protection, DCS, Control, Metering, LVAC and LVDC Documents

No.	DOCUMENT NAME	MONENCO DRAWING NUMBER
A	**Calculations and Load List - Interlocks and Logics**	
1	DCS System Availability Calculation	MT-SUB-xxxx-yyyy-DD-08-SA-001-k
2	Interlock Logic Diagram of Auto Change Over for LVDC System	MT-SUB-xxxx-yyyy-DD-02-SB-001-k
3	110V DC Main and Distribution Load List	MT-SUB-xxxx-yyyy-DD-06-SB-001-k
4	110V DC Battery and Battery Charger Calculations	MT-SUB-xxxx-yyyy-DD-08-SB-001-k
5	110V DC System MCB and Cable Calculations	MT-SUB-xxxx-yyyy-DD-08-SN-001-k
6	48V DC System Load List	MT-SUB-xxxx-yyyy-DD-06-SB-002-k
7	48V DC Battery and Battery Charger Calculations	MT-SUB-xxxx-yyyy-DD-08-SB-002-k
8	48V DC System MCB and Cable Calculations	MT-SUB-xxxx-yyyy-DD-08-SN-002-k
9	Interlock Logic Diagram of Auto Change Over for LVAC System	MT-SUB-xxxx-yyyy-DD-02-SD-001-k
10	LVAC Main and Distribution Load List	MT-SUB-xxxx-yyyy-DD-06-SD-001-k
11	AC System MCB and Cable Calculations	MT-SUB-xxxx-yyyy-DD-08-SN-003-k
12	Inverter calculations and Load List	MT-SUB-xxxx-yyyy-DD-08-SD-001-k
13	CT, Varistor and stabilizer resistances Calculations	MT-SUB-xxxx-yyyy-DD-08-SF-001-k
14	CVT Calculations	MT-SUB-xxxx-yyyy-DD-08-SG-001-k
B	**Basic Diagrams - Pictures and Views - Technical of Material and Equipment List**	
1	LV Documents List	MT-SUB-xxxx-yyyy-DD-06-SH-001-k
2	General Single Line Diagram	MT-SUB-xxxx-yyyy-DD-02-SH-001-k

No.	DOCUMENT NAME	MONENCO DRAWING NUMBER
3	Main LVDC Single Line Diagram(110V)	MT-SUB-xxxx-yyyy-DD-02-SB-002-k
4	110V DC Distribution Single Line Diagram	MT-SUB-xxxx-yyyy-DD-02-SB-003-k
5	48V DC Single Line Diagram	MT-SUB-xxxx-yyyy-DD-02-SB-004-k
6	Main LVAC Single Line Diagram	MT-SUB-xxxx-yyyy-DD-02-SD-002-k
7	AC Distribution Single Line Diagram	MT-SUB-xxxx-yyyy-DD-02-SD-003-k
8	Interlock and Synchronizing Logic Diagram	MT-SUB-xxxx-yyyy-DD-02-SI-001-k
9	Transformer's AVR Logic Diagram	MT-SUB-xxxx-yyyy-DD-02-SJ-001-k
10	Inverter's Single Line Diagram	MT-SUB-xxxx-yyyy-DD-02-SD-004-k
11	DCS overview	MT-SUB-xxxx-yyyy-DD-02-SA-002-k
12	BCRs Panel Arrangement in DCS Substations	MT-SUB-xxxx-yyyy-DD-01-SJ-001-k
13	Protection and Measuring Single Line Diagram	MT-SUB-xxxx-yyyy-DD-02-SJ-002-k
14	Cable Support and Cable Conduit Detail drawings	MT-SUB-xxxx-yyyy-DD-02-SK-001-k
15	Cable Gallery (Indoor Trench) Detail drawings	MT-SUB-xxxx-yyyy-DD-02-SK-002-k
16	Control Room Panel Arrangement and Battery Room Layout	MT-SUB-xxxx-yyyy-DD-01-SI-001-k
17	Outdoor Panel's Arrangement	MT-SUB-xxxx-yyyy-DD-01-SI-002-k
18	Trip Table	MT-SUB-xxxx-yyyy-DD-02-SJ-003-k
19	Application Picture for HMI and DCS System	MT-SUB-xxxx-yyyy-DD-02-SA-001-k
20	Front and Internal View of LCC Panels (For GIS Substations)	MT-SUB-xxxx-yyyy-DD-12-SI-001-k
21	Front View and Internal View of Main and Distribution 110V DC Panels	MT-SUB-xxxx-yyyy-DD-12-SB-001-k
22	Front View and Internal View of 48V DC Panels	MT-SUB-xxxx-yyyy-DD-12-SB-002-k

No.	DOCUMENT NAME	MONENCO DRAWING NUMBER
23	Front View and Internal View of Main and Distribution AC Panels	MT-SUB-xxxx-yyyy-DD-12-SD-001-k
24	Front View and Internal View of Control Panels	MT-SUB-xxxx-yyyy-DD-12-SI-002-k
25	Front View and Internal View of Marshalling Panels	MT-SUB-xxxx-yyyy-DD-12-SI-003-k
26	Front View and Internal View of Protection Panels	MT-SUB-xxxx-yyyy-DD-12-SJ-001-k
27	Front View and Internal View of AVR Panels	MT-SUB-xxxx-yyyy-DD-12-SJ-002-k
28	Front View and Internal View of Event and Fault Recorder Panels	MT-SUB-xxxx-yyyy-DD-12-SI-004-k
29	Front View and Internal View of LV compartment of MV panel	MT-SUB-xxxx-yyyy-DD-12-SL-001-k
30	DCS System Equipment List	MT-SUB-xxxx-yyyy-DD-06-SA-001-k
31	Technical of Material (TOM) and List of Equipment for 110V DC Panel	MT-SUB-xxxx-yyyy-DD-06-SB-003-k
32	Technical of Material (TOM) and List of 48V DC Panel's Equipment	MT-SUB-xxxx-yyyy-DD-06-SB-004-k
33	Technical of Material (TOM) and List of AC Panel's Equipment	MT-SUB-xxxx-yyyy-DD-06-SD-002-k
34	Technical of Material (TOM) and List of Protection Panel's Equipment	MT-SUB-xxxx-yyyy-DD-06-SJ-001-k
35	Technical of Material (TOM) and List of Equipment for Control Panel	MT-SUB-xxxx-yyyy-DD-06-SI-001-k
36	Technical of Material (TOM) and List of Equipment for AVR Panel	MT-SUB-xxxx-yyyy-DD-06-SJ-002-k
37	Technical of Material (TOM) and List of Equipment for Marshalling Panel	MT-SUB-xxxx-yyyy-DD-06-SI-002-k

No.	DOCUMENT NAME	MONENCO DRAWING NUMBER
38	Technical of Material (TOM) and List of Equipment for 110V DC Charger Panel	MT-SUB-xxxx-yyyy-DD-06-SB-005-k
39	Technical of Material (TOM) and List of Equipment for 48V DC Charger Panel	MT-SUB-xxxx-yyyy-DD-06-SB-006-k
40	Technical of Material (TOM) and List of Equipment for Inverter Panel	MT-SUB-xxxx-yyyy-DD-06-SD-003-k
41	Technical of Material (TOM) and List of Equipment for LV compartment of MV panels	MT-SUB-xxxx-yyyy-DD-06-SL-001-k
42	Technical of Material (TOM) and List of Equipment for other Indoor Panels	MT-SUB-xxxx-yyyy-DD-06-SI-003-k
43	Technical Specifications (TOM) and List of Equipment for other Outdoor Panels	MT-SUB-xxxx-yyyy-DD-06-SI-004-k
44	Protection Relays List	MT-SUB-xxxx-yyyy-DD-06-SJ-003-k
45	Technical of Material and Equipment List of Event & Fault Recorder Panels	MT-SUB-xxxx-yyyy-DD-06-SI-005-k
46	Control System and BCU Equipment List	MT-SUB-xxxx-yyyy-DD-06-SI-006-k
47	Technical of Material and Ordering Code of Protection Relays and Measuring Equipment List	MT-SUB-xxxx-yyyy-DD-06-SJ-004-k
48	Technical of Material and List of Equipment for Control and BCUs Equipment	MT-SUB-xxxx-yyyy-DD-06-SI-007-k
49	Technical of Material of CT	MT-SUB-xxxx-yyyy-DD-06-SF-001-k
50	Technical of Material of CVT	MT-SUB-xxxx-yyyy-DD-06-SG-001-k
51	Alarm and Signal List	MT-SUB-xxxx-yyyy-DD-06-SM-001-k
52	Event & Fault Recorder Panels Manufacturer's Signal List	MT-SUB-xxxx-yyyy-DD-06-SI-008-k
53	Cable and Termination List	MT-SUB-xxxx-yyyy-DD-06-SN-001-k

No.	DOCUMENT NAME	MONENCO DRAWING NUMBER
54	Fiber Optic and Ethernet Cable's Technical of Material and List of Equipment	MT-SUB-xxxx-yyyy-DD-06-SA-002-k
55	Protection Relays Configuration and setting with related software	MT-SUB-xxxx-yyyy-DD-21-SJ-001-k
56	Control and BCU Relays Configuration with related software	MT-SUB-xxxx-yyyy-DD-21-SI-001-k
57	AVR Relays Configuration and setting with related software	MT-SUB-xxxx-yyyy-DD-21-SJ-002-k
58	Name Plate	MT-SUB-xxxx-yyyy-DD-37-SU-001-k
59	Tap-changer and Connection Diagram	MT-SUB-xxxx-yyyy-DD-02-SU-002-k
C	**Type Tests, Factory and Workshop Test Sheets - Test Results**	
1	DCS System Factory Acceptance Test (FAT) Procedure Document	MT-SUB-xxxx-yyyy-DD-29-SA-001-k
2	DCS System Site Acceptance Test (SAT) Procedure Document	MT-SUB-xxxx-yyyy-DD-29-SA-002-k
3	Factory and Site Test Sheet for DCS Systems	MT-SUB-xxxx-yyyy-DD-29-SA-003-k
4	Factory Test Sheet for Chargers	MT-SUB-xxxx-yyyy-DD-29-SB-001-k
5	Factory Test Sheet for Protection and Control equipment	MT-SUB-xxxx-yyyy-DD-29-SJ-001-k
6	Factory Test Sheet for AVR Relays	MT-SUB-xxxx-yyyy-DD-29-SJ-002-k
7	Test and Quality Control Report of Outdoor Panels	MT-SUB-xxxx-yyyy-DD-29-SI-001-k
8	Test and Quality Control Report of Protection Panels	MT-SUB-xxxx-yyyy-DD-29-SJ-003-k
9	Test and Quality Control Report of Control Panels	MT-SUB-xxxx-yyyy-DD-29-SI-002-k
10	Test and Quality Control Report of AVR Panels	MT-SUB-xxxx-yyyy-DD-29-SJ-004-k
11	Test and Quality Control Report of MV Panels	MT-SUB-xxxx-yyyy-DD-29-SL-001-k
D	**Installation and Commissioning Manuals - Catalogs and Certificates of Equipment**	

No.	DOCUMENT NAME	MONENCO DRAWING NUMBER
1	Inverters and Chargers Installation / Commissioning Manuals	MT-SUB-xxxx-yyyy-DD-32-SB-001-k
2	110V Batteries Installation / Commissioning Manuals	MT-SUB-xxxx-yyyy-DD-32-SB-002-k
3	48V Batteries Installation / Commissioning Manuals	MT-SUB-xxxx-yyyy-DD-32-SB-003-k
4	Event & Fault Recorder Panels Installation / Commissioning Manuals	MT-SUB-xxxx-yyyy-DD-32-SI-001-k
5	Cable and Wiring Installation / Commissioning Manuals	MT-SUB-xxxx-yyyy-DD-32-SN-001-k
6	DC Panels Installation / Commissioning Manuals	MT-SUB-xxxx-yyyy-DD-32-SB-004-k
7	AC Panels Installation / Commissioning Manuals	MT-SUB-xxxx-yyyy-DD-32-SD-001-k
8	AVR Relay Installation / Commissioning Manuals	MT-SUB-xxxx-yyyy-DD-32-SJ-001-k
E	**Schematic Diagram**	
1	LCC Panels Schematic diagram (for GIS)	MT-SUB-xxxx-yyyy-DD-02-SI-003-k
2	Main LVAC Panels Schematic diagram	MT-SUB-xxxx-yyyy-DD-02-SD-005-k
3	Distribution LVAC Panels Schematic diagram	MT-SUB-xxxx-yyyy-DD-02-SD-006-k
4	Main 110V LVDC Panels Schematic diagram	MT-SUB-xxxx-yyyy-DD-02-SB-005-k
5	Distribution 110V LVDC Panels Schematic diagram	MT-SUB-xxxx-yyyy-DD-02-SB-006-k
6	48V LVDC Panels Schematic diagram	MT-SUB-xxxx-yyyy-DD-02-SB-007-k
7	Incoming and Outgoing Feeders Control Panels Schematic diagram (Cable and O.H.L.)	MT-SUB-xxxx-yyyy-DD-02-SI-004-k
8	Incoming and Outgoing Feeders Protection Panels Schematic diagram (Cable and O.H.L.)	MT-SUB-xxxx-yyyy-DD-02-SJ-004-k
9	AVR Panels Schematic diagrams	MT-SUB-xxxx-yyyy-DD-02-SJ-005-k
10	Busbar Protection Panels Schematic diagrams	MT-SUB-xxxx-yyyy-DD-02-SJ-006-k

No.	DOCUMENT NAME	MONENCO DRAWING NUMBER
11	Transformer's Protection Panels Schematic diagrams	MT-SUB-xxxx-yyyy-DD-02-SJ-007-k
12	Transformer's Control Panels Schematic diagrams	MT-SUB-xxxx-yyyy-DD-02-SI-005-k
13	SCADA Interface Panels Schematic diagrams	MT-SUB-xxxx-yyyy-DD-02-SI-006-k
14	Marshalling Panels Schematic diagrams	MT-SUB-xxxx-yyyy-DD-02-SI-007-k
15	Power Plant Side and Power Plant Interface Panels Schematic diagrams	MT-SUB-xxxx-yyyy-DD-02-SI-008-k

6.2. High voltage Documents

No.	DOCUMENT NAME	MONENCO DRAWING NUMBER
A	**Calculations and Load List - Interlocks and Logics**	
1	Earthing system Calculation	MT-SUB-xxxx-yyyy-DD-08-SC-001-k
2	Stranded Conductor Mechanical Sizing Calculations, Sag and Tension	MT-SUB-xxxx-yyyy-DD-08-SE-001-k
3	Tube Conductor Mechanical Sizing Calculations	MT-SUB-xxxx-yyyy-DD-08-SE-002-k
4	Stranded Conductor Electrical Sizing Calculations	MT-SUB-xxxx-yyyy-DD-08-SE-003-k
5	Tube Conductor Mechanical sizing Calculations	MT-SUB-xxxx-yyyy-DD-08-SE-004-k
6	Surge Arrester Calculation	MT-SUB-xxxx-yyyy-DD-08-SP-001-k
7	Lightning Protection Calculation	MT-SUB-xxxx-yyyy-DD-08-SP-002-k
8	Capacitor Bank Calculations	MT-SUB-xxxx-yyyy-DD-08-SQ-001-k
9	HV Cable sizing calculation	MT-SUB-xxxx-yyyy-DD-08-SO-001-k
B	**Basic Diagrams - Pictures and Views - Technical of Material and Equipment List**	
1	HV equipment List	MT-SUB-xxxx-yyyy-DD-06-SH-002-k
2	General Single Line Diagram	MT-SUB-xxxx-yyyy-DD-02-SH-001-k
3	Layout and Section Diagram	MT-SUB-xxxx-yyyy-DD-01-SH-001-k
4	MV Switchgear Panels Front View	MT-SUB-xxxx-yyyy-DD-12-SL-002-k
5	Clamp and Fitting (Location and Codification) drawings	MT-SUB-xxxx-yyyy-DD-01-SE-001-k
6	Earthing System Plan drawings	MT-SUB-xxxx-yyyy-DD-01-SC-001-k
7	Earthing System Detail drawings	MT-SUB-xxxx-yyyy-DD-01-SC-002-k
8	Cable Support and Cable Conduit Detail drawings	MT-SUB-xxxx-yyyy-DD-01-SK-001-k
9	Cable Gallery (Indoor Trench) Detail drawings	MT-SUB-xxxx-yyyy-DD-01-SK-002-k

No.	DOCUMENT NAME	MONENCO DRAWING NUMBER
10	Outdoor Cable Trench Detail drawings	MT-SUB-xxxx-yyyy-DD-01-SK-003-k
10	Outdoor Cable Trench Detail drawings	MT-SUB-xxxx-yyyy-DD-01-SK-003-k
11	TOM of CB	MT-SUB-xxxx-yyyy-DD-06-SR-001-k
12	TOM of DS	MT-SUB-xxxx-yyyy-DD-06-SS-001-k
13	TOM of CT	MT-SUB-xxxx-yyyy-DD-06-SF-001-k
14	TOM of CVT	MT-SUB-xxxx-yyyy-DD-06-SG-001-k
15	TOM of SA and Counter	MT-SUB-xxxx-yyyy-DD-06-SP-001-k
16	TOM of LT & LMU	MT-SUB-xxxx-yyyy-DD-06-ST-001-k
17	TOM of PI	MT-SUB-xxxx-yyyy-DD-06-SE-001-k
18	TOM of SI	MT-SUB-xxxx-yyyy-DD-06-SE-001-k
19	TOM of Earthing System	MT-SUB-xxxx-yyyy-DD-06-SC-001-k
20	TOM of Temporary Earth	MT-SUB-xxxx-yyyy-DD-06-SC-001-k
21	TOM of Stranded and Tubular Conductor	MT-SUB-xxxx-yyyy-DD-06-SE-003-k
21	TOM of MV (HV) Cable	MT-SUB-xxxx-yyyy-DD-06-SO-001-k
23	TOM of Cable Support	MT-SUB-xxxx-yyyy-DD-06-SK-003-k
24	TOM of MV Switchgear Panels	MT-SUB-xxxx-yyyy-DD-06-SL-001-k
25	TOM of Capacitor Bank	MT-SUB-xxxx-yyyy-DD-06-SQ-001-k
26	TOM of CSE	MT-SUB-xxxx-yyyy-DD-06-SE-004-k
C	**Type Tests, Factory and Workshop Test Sheets - Test Results**	
1	MV Panels Factory Acceptance Test	MT-SUB-xxxx-yyyy-DD-29-SL-001-k
2	CB Factory Acceptance Test	MT-SUB-xxxx-yyyy-DD-29-SR-001-k

No.	DOCUMENT NAME	MONENCO DRAWING NUMBER
3	DS Factory Acceptance Test	MT-SUB-xxxx-yyyy-DD-29-SS-001-k
4	CT Factory Acceptance Test	MT-SUB-xxxx-yyyy-DD-29-SE-001-k
5	CVT Factory Acceptance Test	MT-SUB-xxxx-yyyy-DD-29-SG-001-k
6	SA Factory Acceptance Test	MT-SUB-xxxx-yyyy-DD-29-SP-001-k
7	LT Factory Acceptance Test	MT-SUB-xxxx-yyyy-DD-29-ST-001-k
8	Busywork Equipment Factory Acceptance Test	MT-SUB-xxxx-yyyy-DD-29-SE-001-k
9	HV & MV Factory Acceptance Test	MT-SUB-xxxx-yyyy-DD-29-SO-001-k
10	Earthing System Factory Acceptance Test	MT-SUB-xxxx-yyyy-DD-29-SC-001-k
11	Capacitor Bank Unit and Reactor Factory Acceptance Test	MT-SUB-xxxx-yyyy-DD-29-SQ-001-k
12	PI Factory Acceptance Test	MT-SUB-xxxx-yyyy-DD-29-SE-002-k
13	SI Factory Acceptance Test	MT-SUB-xxxx-yyyy-DD-29-SE-003-k
14	CSE Factory Acceptance Test	MT-SUB-xxxx-yyyy-DD-29-SE-004-k
15	Cable Support Factory Acceptance Test	MT-SUB-xxxx-yyyy-DD- 29-SK-001-k
16	Clamp & Fitting Factory Acceptance Test	MT-SUB-xxxx-yyyy-DD-29-SE-005-k
D	**Installation and Commissioning Manuals - Catalogs and Certificates of Equipment**	
1	CB Installation Manual	MT-SUB-xxxx-yyyy-DD-32-SR-001-k
2	DS Installation Manual	MT-SUB-xxxx-yyyy-DD-32-SS-001-k
3	CT Installation Manual	MT-SUB-xxxx-yyyy-DD-32-SF-001-k
4	CVT Installation Manual	MT-SUB-xxxx-yyyy-DD-32-SG-001-k
5	SA Installation Manual	MT-SUB-xxxx-yyyy-DD-32-SP-001-k
6	LT & LMU Installation Manual	MT-SUB-xxxx-yyyy-DD-32-ST-001-k

No.	DOCUMENT NAME	MONENCO DRAWING NUMBER
7	PI Installation Manual	MT-SUB-xxxx-yyyy-DD-32-SE-001-k
8	SI Installation Manual	MT-SUB-xxxx-yyyy-DD-32-SE-002-k
9	Earth System Installation Manual	MT-SUB-xxxx-yyyy-DD-32-SC-001-k
10	Busywork Installation Manual	MT-SUB-xxxx-yyyy-DD-32-SE-003-k
11	Capacitor Bank Installation Manual	MT-SUB-xxxx-yyyy-DD-32-SQ-001-k
12	Conductor Installation Manual	MT-SUB-xxxx-yyyy-DD-32-SE-004-k
13	Clamp & Fitting Installation Manual	MT-SUB-xxxx-yyyy-DD-32-SE-005-k

6.3. Transformer Documents

No.	DOCUMENT NAME	MONENCO DRAWING NUMBER
A	**Calculations and Load List - Interlocks and Logics**	
1	Specification of Transformers Calculation	MT-SUB-xxxx-yyyy-DD-08-SU-001-k
B	**Basic Diagrams - Pictures and Views - Technical of Material and Equipment List**	
1	Outline Diagram	MT-SUB-xxxx-yyyy-DD-12-SU-001-k
2	Cable Box and Foundation Plan	MT-SUB-xxxx-yyyy-DD-39-SU-001-k
3	Name Plate	MT-SUB-xxxx-yyyy-DD-37-SU-001-k
4	Tap-changer and Connection Diagram	MT-SUB-xxxx-yyyy-DD-02-SU-002-k
5	Part List	MT-SUB-xxxx-yyyy-DD-06-SU-001-k
C	**Type Tests, Factory and Workshop Test Sheets - Test Results**	
1	On-Load Tap-changer Test	MT-SUB-xxxx-yyyy-DD-29-SU-001-k
2	Voltage Ratio and Vector Group Measurement	MT-SUB-xxxx-yyyy-DD-29-SU-002-k
3	Winding Resistance Measurement	MT-SUB-xxxx-yyyy-DD-29-SU-003-k
4	Insulation Resistance Measurement	MT-SUB-xxxx-yyyy-DD-29-SU-004-k
5	Measurement of the Dissipation Factor of the Insulation Resistance Capacitances	MT-SUB-xxxx-yyyy-DD-29-SU-005-k
6	Measurement of No-Load Loss and Current	MT-SUB-xxxx-yyyy-DD-29-SU-006-k
7	Measurement of Short-Circuit Impedance and Load Loss	MT-SUB-xxxx-yyyy-DD-29-SU-007-k
8	Lightning and Switching Impulse Test	MT-SUB-xxxx-yyyy-DD-29-SU-008-k
9	Separate Source AC Withstand Voltage Test (Applied Voltage Test)	MT-SUB-xxxx-yyyy-DD-29-SU-009-k

No.	DOCUMENT NAME	MONENCO DRAWING NUMBER
10	Induced AC Voltage Tests	MT-SUB-xxxx-yyyy-DD-29-SU-010-k
11	Measurement of the Harmonics of the No-Load Current	MT-SUB-xxxx-yyyy-DD-29-SU-011-k
12	Measurement of Zero-Sequence Impedance	MT-SUB-xxxx-yyyy-DD-29-SU-012-k
13	Determination of Sound Level	MT-SUB-xxxx-yyyy-DD-29-SU-013-k
D	**Installation and Commissioning Manuals - Catalogs and Certificates of Equipment**	
1	Technical Data	MT-SUB-xxxx-yyyy-DD-11-SU-001-k
2	Test Document	MT-SUB-xxxx-yyyy-DD-29-SU-014-k
3	List of Enclosures	MT-SUB-xxxx-yyyy-DD-06-SU-002-k
4	General Installation Instructions	MT-SUB-xxxx-yyyy-DD-19-SU-001-k
5	Checking the Equipment after Delivery	MT-SUB-xxxx-yyyy-DD-21-SU-002-k
6	Transport-Storage	MT-SUB-xxxx-yyyy-DD-22-SU-001-k
7	Installation on Foundation	MT-SUB-xxxx-yyyy-DD-13-SU-001-k
8	Installation of Attachments	MT-SUB-xxxx-yyyy-DD-13-SU-002-k
9	Insulation	MT-SUB-xxxx-yyyy-DD-21-SU-003-k
10	Commissioning	MT-SUB-xxxx-yyyy-DD-21-SU-004-k
11	Maintenance and Inspection	MT-SUB-xxxx-yyyy-DD-21-SU-005-k
12	Transformer Oil Handling Instruction	MT-SUB-xxxx-yyyy-DD-21-SU-006-k

6.4. Electrical and Mechanical installation Documents

No.	DOCUMENT NAME	MONENCO DRAWING NUMBER
A	**Calculations and Load List - Interlocks and Logics**	
1	Lighting & HVAC Load List	MT-SUB-xxxx-yyyy-DD-06-SV-001-k
2	Lighting System Calculation	MT-SUB-xxxx-yyyy-DD-08-SV-001-k
3	Cable Sizing Document	MT-SUB-xxxx-yyyy-DD-08-SK-001-k
4	Grounding System Calculation	MT-SUB-xxxx-yyyy-DD-08-SC-001-k
5	Paging System Calculation	MT-SUB-xxxx-yyyy-DD-08-SX-001-k
6	HVAC System Calculation	MT-SUB-xxxx-yyyy-DD-08-SW-001-k
7	Fire Fighting System Calculation	MT-SUB-xxxx-yyyy-DD-08-SY-001-k
B	**Basic Diagrams - Pictures and Views - Technical of Material and Equipment List**	
1	Lighting System Layout	MT-SUB-xxxx-yyyy-DD-01-SV-001-k
2	Socket System Layout	MT-SUB-xxxx-yyyy-DD-02-SV-001-k
3	Telephone System Layout	MT-SUB-xxxx-yyyy-DD-01-SX-001-k
4	Paging System Layout	MT-SUB-xxxx-yyyy-DD-01-SX-002-k
5	Fire Fighting Equipment Layout	MT-SUB-xxxx-yyyy-DD-01-SY-001-k
6	Fire Fighting Block Diagram	MT-SUB-xxxx-yyyy-DD-02-SY-001-k
7	Lighting & HVAC System Block Diagram	MT-SUB-xxxx-yyyy-DD-02-SV-002-k
8	Telephone System Block diagram	MT-SUB-xxxx-yyyy-DD-02-SX-001-k
8	Paging System Block Diagram	MT-SUB-xxxx-yyyy-DD-02-SX-002-k
9	CCTV System Equipment Layout	MT-SUB-xxxx-yyyy-DD-02-SZ-001-k
10	CCTV Block Diagram	MT-SUB-xxxx-yyyy-DD-02-SZ-002-k

No.	DOCUMENT NAME	MONENCO DRAWING NUMBER
11	Normal & Emergency & DC Lighting Panel S.L.D	MT-SUB-xxxx-yyyy-DD-02-SV-001-k
12	Panel System riser diagram	MT-SUB-xxxx-yyyy-DD-02-SK-003-k
12	LAN System Layout	MT-SUB-xxxx-yyyy-DD-01-SZ-001-k
13	LAN System Block Diagram	MT-SUB-xxxx-yyyy-DD-01-SZ-002-k
14	Cable Route System & Section	MT-SUB-xxxx-yyyy-DD-01-SV-002-k
15	Secondary Grounding System Layout	MT-SUB-xxxx-yyyy-DD-02-SC-001-k
16	Lighting & Socket System Installation Detail	MT-SUB-xxxx-yyyy-DD-02-SV-002-k
17	Schematic Feeders For Panels	MT-SUB-xxxx-yyyy-DD-02-SH-002-k
18	Telephone & Paging System Typical Installation Detail	MT-SUB-xxxx-yyyy-DD-02-SX-003-k
19	Cold & Warm water Piping Layout	MT-SUB-xxxx-yyyy-DD-01-SW-001-k
20	Swage Piping System Document	MT-SUB-xxxx-yyyy-DD-01-SW-002-k
21	HVAC Equipment & Supply Ducting Layout System	MT-SUB-xxxx-yyyy-DD-01-SW-003-k
22	Domestic Hot Cold Water Piping	MT-SUB-xxxx-yyyy-DD-01-SW-004-k
23	HVAC Equipment & Piping Layout	MT-SUB-xxxx-yyyy-DD-01-SW-005-k
24	Exhaust and Return Air & Ventilation For Building	MT-SUB-xxxx-yyyy-DD-01-SW-006-k
25	HVAC Equipment Layout	MT-SUB-xxxx-yyyy-DD-01-SW-007-k
26	Dry & Water Fire Fighting Document	MT-SUB-xxxx-yyyy-DD-01-SY-002-k
27	Natural Fuel gas Distribution Document	MT-SUB-xxxx-yyyy-DD-01-SW-008-k
28	Service Water System Piping For Site Plan	MT-SUB-xxxx-yyyy-DD-01-SW-009-k
29	HVAC Equipment Layout For Roof Plan	MT-SUB-xxxx-yyyy-DD-01-SW-010-k
30	Sewage System Piping Layout For Site Plan	MT-SUB-xxxx-yyyy-DD-01-SW-011-k

No.	DOCUMENT NAME	MONENCO DRAWING NUMBER
31	P&ID For HVAC Document	MT-SUB-xxxx-yyyy-DD-02-SW-001-k
32	P&ID For Fire Fighting System	MT-SUB-xxxx-yyyy-DD-02-SY-001-k
33	HVAC System PFD	MT-SUB-xxxx-yyyy-DD-02-SW-002-k
34	TOM of Lighting System	MT-SUB-xxxx-yyyy-DD-06-SV-002-k
35	TOM of Telephone & Paging	MT-SUB-xxxx-yyyy-DD-06-SX-001-k
36	TOM of Main & Secondary System	MT-SUB-xxxx-yyyy-DD-06-SC-003-k
37	TOM of Lighting	MT-SUB-xxxx-yyyy-DD-06-SV-003-k
38	TOM of HVAC Equipment & & HVAC Panel	MT-SUB-xxxx-yyyy-DD-06-SW-001-k
39	TOM of Fire Fighting	MT-SUB-xxxx-yyyy-DD-06-SY-002-k
C	**Type Tests, Factory and Workshop Test Sheets - Test Results**	
1	Test Procedure For HVAC Equipment	MT-SUB-xxxx-yyyy-DD- 29-SW-001-k
2	Test Procedure For Lighting & HVAC Panel	MT-SUB-xxxx-yyyy-DD- 29-SV-006-k
3	Test Procedure For Lighting Equipment	MT-SUB-xxxx-yyyy-DD- 29-SV-002-k
4	Test Procedure For CCTV Equipment	MT-SUB-xxxx-yyyy-DD-29-SZ-001-k
5	Test Procedure For Fire Fighting Equipment	MT-SUB-xxxx-yyyy-DD-29-SY-001-k
D	**Installation and Commissioning Manuals - Catalogs and Certificates of Equipment**	
1	HVAC Equipment Data Sheet	MT-SUB-xxxx-yyyy-DD-11-SW-001-k
2	Fire Fighting System Data Sheet	MT-SUB-xxxx-yyyy-DD-11-SY-001-k
3	HVAC Equipment Catalogue	MT-SUB-xxxx-yyyy-DD-17-SV-001-k
4	Fire Fighting Equipment Catalogue	MT-SUB-xxxx-yyyy-DD-17-SY-001-k
5	Lighting & Socket Equipment Data Sheet	MT-SUB-xxxx-yyyy-DD-11-SV-001-k
6	Cable & Conduit Data Sheet	MT-SUB-xxxx-yyyy-DD-11-SK-001-k
7	Telephone & Paging Data Sheet	MT-SUB-xxxx-yyyy-DD-11-SX-001-k

No.	DOCUMENT NAME	MONENCO DRAWING NUMBER
8	Fire Fighting Data Sheet	MT-SUB-xxxx-yyyy-DD-11-SY-002-k
9	CCTV Equipment Data Sheet	MT-SUB-xxxx-yyyy-DD-11-SZ-001-k
10	HVAC Design Criteria	MT-SUB-xxxx-yyyy-DD-37-SW-001-k
11	HVAC Basis of Design	MT-SUB-xxxx-yyyy-DD-37-SW-002-k

6.5. Legend

M	T	-	SUB	-	xxxx	-	yyyy	-	DD	-	ii	-	zz	-	jjj	-	k
1	2		3		4		5		6		7		8		9		10

Item	Abbreviation	Description
1	M	Monenco Iran
2	T	Transmission and Dispatching Deputy
3	SUB	Substation
4	xxxx	Client code
5	yyyy	Cost code
6	DD	Detail Design
7	ii	Document code
8	zz	Equipment code
9	jjj	Serial No.
10	k	- I: For Information - A: For Client Approval - E: As-Built - C: For Execution
		- 0: First Issue - 1: Second Issue, First Revision - n: $(n+1)^{th}$ Issue, n^{th} Revision

- According to Monenco Document numbering instruction no. WI-151-042

Category	Description
A	Calculations and Load List- Interlocks and Logics
B	Basic Diagrams- Pictures and Views- Technical of Material and Equipment List

C	Type Tests, Factory and Workshop Test Sheets- Test Results
D	Installation and Commissioning Manuals - Catalogs and Certificates of Equipment
E	Schematic Diagram

TECHNICAL SPECIFICATION

SECTION 6

HIGH VOLTAGE DISCONNECTOR AND GROUNDING SWITCH

MONENCO – IRAN CONSULTING ENGINEERS COMPANY

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1. Description

1.1. Definition

Disconnect switches shall mean, three pole, center break, and when specified associated three pole grounding switches of specified ratings and characteristics of this section.

1.2. Work Included

Work of this section consists of design, manufacture, factory testing, transportation, supervision, erection and commissioning of disconnectors and grounding switches and all their accessories necessary for proper operation as specified including supply of mandatory spare parts.

1.3. Terminology

Technical terminology is to be as defined in International Electrotechnical Commission Standard IEC - No. 600 50.

2. Standards

Work of this section shall comply with the requirements of the latest editions of International Electrotechnical Commission (IEC) standards.

IEC publication listed below form part of this specification to the extent specified in this section:

IEC 60050	International Electrotechnical Vocabulary
IEC 60060	High voltage test techniques.
IEC 60168	Tests of indoor and outdoor post insulators for systems with nominal voltage greater than 1000V.
IEC 60265	Switches for rated voltages above 1 kV & less than 52 kV
IEC 60273	Characteristic of indoor and outdoor post insulators for systems with nominal voltages greater than 1000 V
IEC 62271-102	High voltage alternating current disconnectors & earthing switches.

3. Design Summary

All disconnectors (without ground blade) shall be outdoor, three phase and motor operated.

Disconnecting switches shall be provided complete with relays, and indicators required for remote operation and indication.

Disconnectors and grounding switches shall be provided with reversing auxiliary contacts for control interlocking and indication.

Insulators incorporated in switches shall be of the same type and interchangeable with bus support insulators described in section (12) of this specification.

Manual operation of disconnectors must be possible and carried out via a tensional drive. Number of interchangeable parts shall be maximum between different switches.

Provisions shall be made for grounding operating mechanism of each switch for safety operation.

All ground switches shall be outdoor and three phase. They shall have the same short time current rating as main switches have, and shall be equipped with reversing auxiliary contacts for interlocking. Ground switches in 400 & 230kV voltage level shall be motor operated & equipped with corona rings.

Flexible braid shall be provided at hinge end of each ground switch clamp connector to facilitate grounding. Grounding of ground switches shall be run directly to main station ground electrode and not via supporting structure steel.

Each disconnecting switch and ground switch shall be complete with its accessories, control gear, mechanism housing, handle for manual operation, etc. necessary for proper installation and operation.

When at site conditions, disconnectors remain energized for at least three years; the torque required for manual opening of them should be within strength of one man.

4. Fabrication and Manufacture

4.1. Disconnecting Switches and Ground Switches

The disconnectors and ground switches shall be of substantial construction throughout. No cast iron fittings shall be used in all switch parts and those above the top insulator cap shall be of non-Ferrous material.

Each switch pole base shall be of hot dip galvanized steel. It shall be rigid and self supporting without cross bracing between phases other than the supporting steel structure.

The disconnectors and ground switches shall be of such capacity as to be able to withstand short circuit forces and currents without any damage for further operation.

Switch contacts shall be of high pressure silvered type. Contact shall be made with a wiping action onto silver plated contacts. Design of switch shall be self-locking with reversed loop contacts to ensure that switch blades can't be opened by wind and electromagnetic forces encountered.

Structural steel supplied with switches shall be fabricated in accordance with Section (11) of this specification. Switch bases shall be constructed with sufficient rigidity for each operation.

The contractor shall thoroughly clean, prime, undercoat, and finish all un-galvanized metal parts with two coats of outdoor paint suitable for environmental conditions specified.

4.2. Operating Mechanism

Motor & Hand operated mechanism cabinets shall be weatherproof and dust proof and shall have removable or hinged covers affording easy access to all parts. Covers shall be provided with weatherproof seals.

Facility for pad locking shall be provided.

Thermostatically controlled anti-condensation heaters shall be provided with ON / OFF switches. All of the heaters in both types of mechanism (motorized or manual) shall be equipped with M.C.B.

The bottom of cabinet shall be suitable for cable entrance.

Gears shall be cadmium plated high carbon steel keyed to high strength steel shafts. All gears, bearings and bushings shall be permanently lubricated. Aluminum or cast iron gears, bearing and bushings will not be acceptable.

Switches shall be equipped with ANSI standard tinned terminal pads compatible with rating of switches.

Each disconnector mechanism shall be equipped with Remote/local/Disconnect selector switch and open / close control switch.

Each manually operated switch shall be furnished with a lever or gear mechanism switch which provides quick, simple, and effective operation of the switch by one man.

It shall be possible to isolate all incoming supplies by means of withdrawable fuses and links.

The disconnector operating mechanism shall be capable of being locked in the open position.

Facility for pad locking the manual operating mechanism in open and / or closed positions shall be provided.

Limit switches shall be provided to limit blade travel in either direction and suitable device shall be provided to assure the halting of the blade movement at the end of the stroke and to prevent over-travel.

In single pole operated disconnector beside of operating mechanism, central cubicle shall be provided that shall be included following facilities at least:

- Three pole operation of disconnector
- Three pole operation of earth switch
- Local/remote selector switch

4.3. Interlocks

Disconnect and earthing switches shall be supplied with electrical interlocks to interlock each switch with its breaker so that switches can't be operated while breakers are closed and when the line is energized so that switches may only be operated from the local position when the breaker operating position has

been selected as local. All switches shall be capable of being locked in open and closed positions.

Ground switches shall be interlocked with associated disconnecting switches both mechanically & electrically, to prevent closing under load. Ground switches shall be capable of being locked in open and closed positions.

Operational interlocking shall be achieved by electrical means in a manner that permits the equipment to perform any safe operation.

Maintenance interlocking shall be achieved by mechanical interference.

Any electrically operated interlock which fails to operate safely due to failure of the interlock supply shall make all associated bolts drop to the locked position.

Solenoids used for interlocking shall be suitable for being continuously energized at site condition.

4.4. Secondary and Control Wiring

Thermoplastic insulated, 90 °C control wiring, equivalent to 2.5 mm² stranded copper conductor and covered with a flame retardant braid shall be provided. Extra flexible wire shall be used for connections to equipment on hinged frames. Open wiring shall be neatly supported by molded cleats on the sides of cubicle and on horizontal straps behind the front panel. Wire ends shall be fitted with crimped ring type terminals and numbered ferrules. No more than two wires shall be terminated on any stud or terminals. Fuses shall be provided on incoming supplies to the panel.

Secondary and control wiring shall be terminated in control cabinet on clearly labeled terminal blocks. All external wiring shall conform to the requirements of section (13) of this specification. Wires shall be color coded as follows:

- AC phases conductors - red, yellow, blue
- AC neutral conductors - black
- Ground connections - green
- DC conductors - gray

Terminal blocks shall be stud type of unit construction, grouped and labeled according to their duty by strips securely attached to each terminal block. They shall be mounted to give easy access to terminations and to enable ferrule

numbers and labels to be read without difficulty. Terminal blocks shall have insulating barriers between points.

One spare terminal block with a minimum of ten (10) points at cable entrance to the cubicle shall be provided.

4.5. Accessories

Standard accessories shall be provided for disconnect switches. The following shall be included:

- Nameplates giving complete disconnect switch information and ratings.
- Eye bolts for lifting lugs.
- Grounding pads with connector for stranded copper cable.
- Additional contacts providing for future supervisory control and indication of switch position.

Switches shall be equipped with ANSI standard tinned terminal pads compatible with rating of switch.

Auxiliary contacts shall be provided with DC current interrupting of up to 15A in an inductive circuit with a time constant of more than 40 ms, and at 110 VDC.

5. Factory Tests and Inspections

Perform routine tests stipulated in the applicable standards to ensure material and workmanship conform to specification.

Evidence shall be submitted that type test have been performed and passed successfully according to IEC 62271 in an independent accredited laboratory. The said type test documents shall include full technical details and in general shall not be older than 5 years. All type tests shall be carried out at the manufacturers' expense.

The Contractor shall completely assemble wire and adjust disconnecting switches and ground switches at his factory for carrying out the assemble test.

Routine tests shall be carried out on the whole of the equipment.

In addition, the following functional tests shall be performed to assure accuracy in wiring and proper functioning of the equipment:

- Energizing of all low voltage control circuits using appropriate voltage supply, and testing for operation and sequence of operation.
- Continuity of all low voltage circuits.
- Dielectric strength test at 2000 volts AC of all wiring.

The Engineer is entitled to have representative(s) at the factory for determination of compliance of the switches with provisions of this specification.

All instruments and their calibration shall be to approved, and, if required by the purchaser, shall be calibrated by an approved body. All measuring, test equipment, and qualified personnel required to carry out the tests, shall be provided by the manufacturer.

The purchaser shall be notified 60 days in advance, whenever a type or routine test is going to be done, so that the test may be witnessed if required.

6. Packing, Transportation and Storage

If the transport condition differs from service conditions such as temperature, humidity and etc. , manufacturer shall be guaranty that conditions and special precautions shall be considered for the protection on insulation during transport, storage and installation, and prior to energization, to prevent moisture ingressing due for instance, to rain, snow or condensation.

Vibration during transport shall be considered.

All equipment shall be prepared for ocean or inland transport, as the case may govern, to prevent damage from handling, warehousing in open yard and during shipment. Proper labeling shall be provided on two adjacent sides to prevent crates from getting lost. The label shall include Purchaser's name, manufacturer's name, package number, Reference to bill of lading and etc.

Packages shall have sufficient strength to prevent damage during handling, warehousing and shipment.

Adequate shipping supports and packing inserts shall be provided in order to prevent internal damage during transport.

The equipment shall be thoroughly cleaned of slag, grit, dirt, moisture and other foreign matters before packing.

The size of transport units shall be as large as possible so as to reduce the amount of field installation work. Switchgear bays shall be transported as completely assembled units ready to line up into switchgear at site. Auxiliary cabinets with secondary equipment shall be transported as completely assembled units.

The packing must, if required be suitable for outdoor storage of the equipment. In this case sufficient drying agent shall be provided in the packing to absorb condensed moisture. Visible indicator of the absorber condition shall be foreseen at each packing unit.

A packing list must be provided for each individual packing unit it enables the purchaser's personnel to identify the unit clearly at site.

7. Submittals

The Contractor shall submit, in accordance with Section 3; drawings, calculations, test reports and literature pertaining to specified items of material to be supplied under this section.

8. Spare Parts

The Contractor shall be provided spare parts as per schedule of quantities and prices.

TECHNICAL SPECIFICATION

SECTION 7

CURRENT TRANSFORMER

MONENCO – IRAN CONSULTING ENGINEERS COMPANY

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1. Description

1.1. Definition

Current transformers shall mean single phase, oil immersed, hermetically sealed current transformers suitable for outdoor installation, or single phase dry type indoor current transformers.

1.2. Work Included

Work of this section consists of design, supply, transportation, supervision, installation and commissioning of current transformers as specified and as shown on the drawings including supply of mandatory spare parts.

1.3. Terminology

Technical terminology is to be as defined in International Electrotechnical Commission Standard, Section No. IEC 60050.

2. Standards

Work of this section shall comply with the requirements of latest editions of International Electrotechnical Commission (IEC) standards.

IEC publication listed below form part of this specification to the extent specified in this section:

IEC 60038	IEC Standard voltages.
IEC 61869-1	General requirement
IEC 61869-2	Additional requirements for current tansformer
IEC 60050	International Electrotechnical Vocabulary, chapter 321: Instrument Transformers.
IEC 60060-1	High Voltage Test Techniques, part 1: General Definitions and Test Requirements
IEC 60071	Insulation Co-ordination
IEC 60085	Thermal Evaluation and Classification of Electrical Insulation
IEC 60156	Method for determination of the breakdown voltage at power frequency
IEC 60947-1	Low-voltage switchgear and control gear
IEC 60270	Partial discharge measurements
IEC 60296	Fluids for electro technical applications Unused mineral insulating oils for transformers and switchgear
IEC 60507	Artificial pollution Test on High-voltage Insulators to be used on A.C. Systems.
IEC 62155	Hollow pressurized and unpressurized ceramic and glass insulators for use in electrical equipment with rated voltages greater than 1 000 V
ISO 1461	Hot dip galvanized coatings on fabricated iron and steel articles

3. Design Summary

Current transformers shall be suitable for protection and metering purposes, over the required range of load and fault duties.

Secondary windings utilized shall be grounded at one point only at associated relay panel.

Terminals shall be flat type for the primary connections and stud type suitable for terminating 10 sq. mm copper conductors for secondary connections.

The multi-ratio requirements shall be met by the use of tapping on the secondary windings.

Ground connections shall be provided suitable for stranded copper conductor.

The support insulators shall be manufactured of high quality porcelain or silicon rubber capable of passing testing procedures carried out in accordance with IEC 233 and shall have adequate strength to withstand the mechanical and thermal stresses due to short circuit current.

The silicone rubber shall be the HTV type for improved mechanical strength.

Housing of carbon based polymers, such as EPDM, EPM or silicone and Liquid silicone added to these formulations shall not be accepted.

Composite silicone rubber insulators shall give highly reliable service and performance without maintenance and live line washing with aerodynamically shaped sheds and to withstand static and dynamic stresses imposed during service conditions.

The silicon rubber insulators shall be manufactured and tested in accordance with the relevant IEC standards and comply with the requirement of CTs.

The silicon rubber to metal joints shall be such as to ensure an oil tight seal is obtained under all loading conditions imposed at the high voltage terminal, particularly during transport to site.

Maximum Partial discharge at $1.2/\sqrt{3}$ rated voltage must not exceed from 5 p.c.

Electro static shield shall be provided to prevent high current to secondary winding.

Capacitor terminal (F-terminal) for measuring of tanδ shall be provided.

4. Fabrication and Manufacture

Secondary winding turns shall be evenly distributed around core on all nominal taps.

Current transformers shall be hermetically sealed with oil level indicators, filling plugs and drain valves.

Lifting facilities for lifting completely assembled current transformers filled with oil shall be provided.

Current transformers shall be provided with a sealed membrane to prevent air from ingression oil impregnated insulation system if current transformer is placed in an abnormal position during shipment or storage.

Weatherproof terminal boxes, accessible from ground level, shall be provided to house following:

- Terminal blocks, stud and nut type.
- Shorting bars for all current transformer secondary terminals.

Secondary terminals shall be located in a position which is safely and easily accessible while current transformer is energized. All wiring shall conform to requirements of Section (13) of this specification.

Interior of terminal boxes shall be treated with an anti-condensation coating.

Bushings shall be of Brown wet process glazed porcelain or silicon rubber.

Oil shall comply with IEC 60296.

Gaskets shall be of cork, neoprene, nitrile rubber or approved equivalent.

Nuts, bolts, etc. shall be made of a solid corrosion resistant material or shall have a corrosion resistant finish.

All external surfaces, except non-ferrous metal or galvanized steel, shall be painted with one coat of primer and two coats of approved weatherproof high quality paint.

Current transformers shall withstand thermal and mechanical stresses due to short circuits.

Protective cores shall have correct transformation during initial faults and following high speed 3 phase auto reclose without saturation at the maximum fault level and relevant DC offset.

The voltage produced at the cores by fault current or during transients on the system shall be well below the saturation voltage to ensure good transient response.

A label shall be provided indicating the connections required for all ratio clearly. These connections shall also be shown at all connection diagrams.

Stainless steel rating plate, or other equivalent weatherproof and corrosion-proof material shall be provided (aluminum will not be acceptable). Fixed in a visible position showing the diagram of connections, the secondary winding resistance at 75 °C, the total weight of the current transformer and all information in accordance with IEC publication 60185 and draft IEC 60044-6. The inscription shall be made by etching, engraving, stamping or other approved methods.

5. Factory Tests and Inspections

Routine tests shall be witnessed as specified in IEC 61869.

Evidence shall be submitted that type test have been performed and passed successfully accordance to IEC 60869-1, IEC 60869-2 in an independent accredited laboratory. The said type test documents shall include full technical details and in general shall not be older than 5 years. All type tests shall be carried out at the manufacturers' expense.

Current transformers shall be factory assembled and subjected to the following tests:

- Accuracy: (Relaying accuracy may be determined by calculation from a combination of typical characteristics and experimental test data)
- Acquiring of demagnetization curves
- inter - turn over voltage test
- Measurement of partial discharges
- Power frequency voltage test on both of primary and secondary terminals
- Measurement of capacitance between primary and capacitive terminal
- Measurement of dielectric dissipation Factor (tg δ)

In addition to the foregoing, the following tests shall be witnessed on one current transformer only of each type on any one order, unless type test certificates are available for a duplicate current transformer.

- Temperature rise test
- Impulse test
- Measurement of open circuit voltage

The Engineer is entitled to have representative(s) at the factory for determination of compliance of the breakers with provisions of this specification.

All instruments and their calibration shall be to approved, and, if required by the purchaser, shall be calibrated by an approved body. All measuring, test equipment, and qualified personnel required to carry out the tests, shall be provided by the manufacturer.

The purchaser shall be notified 60 days in advance, whenever a type or routine test is going to be done, so that the test may be witnessed if required.

6. Packing, Transportation and Storage

If the transport condition differs from service conditions such as temperature, humidity and etc. , manufacturer shall be guaranty that conditions and special precautions shall be considered for the protection on insulation during transport, storage and installation, and prior to energization, to prevent moisture ingressing due for instance, to rain, snow or condensation.

Vibration during transport shall be considered.

All equipment shall be prepared for ocean or inland transport, as the case may govern, to prevent damage from handling, warehousing in open yard and during shipment. Proper labeling shall be provided on two adjacent sides to prevent crates from getting lost. The label shall include Purchaser's name, manufacturer's name, package number, Reference to bill of lading and etc.

Packages shall have sufficient strength to prevent damage during handling, warehousing and shipment.

Adequate shipping supports and packing inserts shall be provided in order to prevent internal damage during transport.

The equipment shall be thoroughly cleaned of slag, grit, dirt, moisture and other foreign matters before packing.

The packing must, if required be suitable for outdoor storage of the equipment. In this case sufficient drying agent shall be provided in the packing to absorb condensed moisture. Visible indicator of the absorber condition shall be foreseen at each packing unit.

Sealing surfaces which are exposed to the atmosphere during transport must be protected by a protective coating which can be washed off during installation.

A packing list must be provided for each individual packing unit it enables the purchaser's personnel to identify the unit clearly at site.

7. Submittals

The Contractor shall submit, in accordance with Section 3; drawings, calculations, test reports and literature pertaining to specified items of material to be supplied under this section.

8. Spare Parts

The Contractor shall be provided spare parts as per schedule of quantities and prices.

TECHNICAL SPECIFICATION

SECTION 11

SWITCHYARD STRUCTURE

MONENCO – IRAN CONSULTING ENGINEERS COMPANY

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1. Description

1.1. Definition

Substation structures are defined as structures fabricated from steel sections and hot dip galvanized after fabrication.

1.2. Work Included

Work of this section consists of design, manufacture, factory testing, transportation, supervision after installation and erection of all substations structures including any steelworks required for incorporation into the foundations as specified herein.

Substation structures are required for the following:

- Termination and support in incoming and outgoing overhead lines
- Termination and support of buswork
- Support of electrical equipment
- Anchor bolts and templates

1.3. Terminology

Technical terminology is defined in the latest edition of International Electrotechnical Commission Standard 50.

2. Standards

Work of this section shall comply with the requirements of the latest editions of "AISC, ACI, ASCE, ASTM, Iranian National Building codes, IEEE, BS, DIN, AWS" which the following standards are preferred:

IPIS (Iranian Power Industry STD.) part 318 and 1202	Optimum design of substations
AISC	American institute of steel construction manual of steel construction
ASCE	American society of civil engineers manuals and reports on engineering practice, no. 52 guide for design of steel transmission towers and 10-97 for design of latticed steel transmission structures.
ASTM A-36-77a	Standard specification for structural steel
ASTM A-123M-02-73	Standard specification for zinc (hot galvanized) coatings on products fabricated from rolled, pressed and forged steel pipes, plates, bars and strip.
ASTM A-153-73	Standard specification for zinc coating (hot dip) iron and steel hardware
ASTM A-325-76c	Standard specification for high strength bolts for structural steel joints including suitable nuts and plain hardened washers
ASTM A-394-76	Standard specification for galvanized steel transmission tower bolts and nuts

DIN 267 Part10	Fasteners technical delivery conditions hot –dip galvanized parts
IEEE STD 693	Recommended practice for seismic design of substations.
ASTM E 8M – 04	Standard test methods for tension testing of metallic materials.
VDE 0210	Regulations for the construction of overhead power lines above 1 kv.

3. Design Summary

The contractor is totally responsible for mutual compatibility and adequacy of all switchyard structures and all other corresponding equipment, in any respect.

3.1. Structural Steel

Fabricate steel structure members from structural grade, open hearth steel conforming to ASTM A36 or ASTM A572.

3.2. Bolts, Nuts and Washers

- Provide standard steel tower bolts and nuts that conform to data sheet
- Use bolts having regular hexagon heads and nuts, complete with one standard spring lock washer. Use not more than a maximum of two (2) diameters of connection bolt and two thicknesses of washer for any one structure.
- Ensure all bolts of like diameter are the same quality.
- The quality of standard steel tower bolts and nuts shall be equivalent to the ASTM standards.

3.3. Net Section of Galvanized Steel Structures

- In deducting area of bolts from gross area of a member, use a diameter of the hole that is 3 mm larger than the nominal diameter of the bolts.
- Calculate the net area of a single angle member connected through one leg only, or double angle connected on one side of a gusset plate as follows:

$$\text{Net area} = \frac{3x^2 + 4xy}{3x + y}$$

Where:

x = net area of connected leg(s)

y = net area of unconnected leg(s)

- In multi-bolt connections with more than one gauge line, the section of the connected leg should be at the least area which can be obtained by deducting from the gross sectional area of the connected leg the area of all holes cut by any straight, diagonal or zigzag line across the member. In determining the total area of the holes to be deducted from the gross section, the full area of the first hole should be counted plus a fractional part Z of each succeeding hole cut by the line of holes under consideration. Value of Z may be determined from the formula:

$$Z = 1 - \frac{S^2}{4GH}$$

Where:

S = Longitudinal spacing (stagger) in mm between two successive holes in the line of holes under consideration

G = Traverse spacing (gauge) in mm between the same two holes as for S

H = Diameter of hole (bolt diameter plus 3 mm)

- Calculate the net area of single angle tension members with bolt legs connected as described above except that, for holes in opposite legs of angles, the value of G should be the sum of the gauges from the back of the angle minus the thickness of the angle.
- In every instance ensure the net area used to determine tensile strength does not exceed 85% of the gross area.
- In determining the net section across plug or slot welds, do not consider the weld metal as adding to the net area.

3.4. Loading - Galvanized Steel Structures

Design all structures on the basis of loads described in the following paragraphs applied both to the structure itself and to the attached or supported accessories and equipment. These loads are working values. Apply the below mentioned overload factor, to give ultimate loads.

The load names are:

1- Dead Load

2- Live Load

3- Short Circuit Load

4- Line Tension Load

5- Earthquake Load

6- Wind Load

7- Ice Load

In addition, ensure the deflection of columns and girders when subjected to maximum design conditions excluding overload factors (i.e. working loads) does not exceed the following limits:

- Girders supporting disconnect switches - 1/300 of span vertically and horizontally.
- All other girders - 1/200 of span vertically and horizontally.
- Columns - 1/200 of the height.

3.4.1. Overload Factor

All structures shall be designed with a safety factor on working stress recommended in mentioned standards and not less than the following:

Table 1. minimum safety factor for load combination to structure design

Without earthquake	with earthquake
1.5	1.1

Table 2. compression buckling according to related standards

Type of members	Permissible load based upon
tension	Yield strength

Safety factor of foundation overturning should be at least 1.75.

3.4.2. Short Circuit and Line Tension Forces

Complete short circuit forces applied to the conductors and current carrying parts of equipment being supported based on the design fault level.and their values
Shall be carried out according to sec11.

The structure shall be designed such that each conductor or shield wire will have characteristics no exceeding the following:

(a) Substation Bus

- Phase conductor tension according to sag-tension calculation
- Shield wire tension according to sag-tension calculation.
- Horizontal angle (from normal to girder) 0 degree.
- Vertical angle (from horizontal) ±5 degree.

(b) Termination of the Transmission Lines.

The structures which accept the transmission, line conductors and shield wire shall be designed on the following assumptions:

- Phase conductor tension acc. to following table.
- Shield wire tension acc. to following table.
- Horizontal angle (from normal) ±15 degree.
- Vertical angle (from horizontal) ±20 degree.

Short circuit shall be taken as resulting from an electrical fault.

A flexible conductor subjected to short circuit will have a tensile force in the direction of the conductor, and a rigid conductor (tube) a force transverse to it.

The thickness of ice coating must be considered.

The density of the ice is assumed to be 900 kg/m3.

Table 3. Conductor and shield wire (for Gantry) tension according to electrical calculation

VOLTAGE LEVEL (kV)	CONDUCTOR TENSION (kgf) ((Per phase per bundle))	SHEILD WIRE TENSION (kgf) (Per each wire)
63	800	300
132	1000	500
230	1200	700
400	1500	800

3.4.3. Wind Load on structure

Calculate total max. wind pressure on structures or equipment as follows:

A) Lattice structure

$Q=0.0625\ C\ V^2\ A_{eff}$

Aeff: Effective area

C : Drag factor

V : Basic design velocity

Notice: the wind load must be applied in one face against the wind direction. And it must be distributed load shape.

wind velocity conform to value given in data sheet to referring to “Iranian National Building Code, Part 6”.

Drag Factor

$C=4.3*(1-1.16\varphi)$ for rectangular tower

$C=3.52*(1-1.16\varphi)$ for triangle tower

The solidity ratio f is equal to the effective area of a lattice structure normal to the wind direction divided by the area enclosed by the boundary of the structure normal to the wind direction.

B) Earthquake Loading

Earthquake forces shall be taken as follows:

Horizontal component

$$E_h = \frac{ABI}{R} W$$

Vertical component

E_v= 1.4 AIW →For cantilever members. (positive effect of weight should be ignored.)

E_v= 0.7 AIW → For other members

In the above formula:

Ae = Seismic factor = Ratio of maximum horizontal ground acceleration to gravity that its value given in general requirement According to part 1202 of IPIs Std., the seismic factor value shall be considered with 0.1 more than the 2800 STD value.

B_p = Amplification factor obtained from standard elastic response spectra that obtainable from data sheet

We = Instrument weight

A = Seismic factor = Ratio of maximum horizontal ground acceleration to gravity that its value given in general requirement According to 2800 STD value or response spectra.

B = Amplification factor obtained from 2800 STD value.

I = important coefficient from 2800 STD value.

R = coefficient of behavior. (R=2 for structures that act like inverted pendulum must be used.)

W = weight

The earthquake load is assumed to be transverse or longitudinal and upward or downward.

Cables in earthquake due to horizontal deflection of two neighboring apparatus and influence of this deflection on tensions should be considered.

3.4.4. Erection and Maintenance Loading

Design each member whose longitudinal axis makes an angle less than 30 degrees with the horizontal to withstand, without permanent set and independent of all other forces, a concentrated force of 150 Kg vertically applied to the longitudinal axis at any point along its length. Acceptable erection and fabrication tolerances must be according IRANIAN national building code – part 11.

3.4.5. Equipment and Live Load

Equipment loads consist of weight of equipment weight, wind on equipment, applicable ice on equipment, applicable earthquake loads, and any operating loads.

Operating Load named live load is 1KN that is weight of a serviceman and related equipment.

3.4.6. Ambient Temperature

The ambient temperature specified in section 2 (general requirement) of this technical specification shall be considered.

3.5. Loading Combination

The structures shall be capable of withstanding the forces resulting from the following loading combinations: (according to 457 code.)

3.5.1. High Wind

- High wind Load

- Conductor tension
- Dead & Live Load

3.5.2. Short Circuit with Wind

- Short circuit load
- 0.7 Wind load
- Dead & Live Load

3.5.3. Earthquake

- Conductor tension
- Full earthquake load
- Dead & Live Load

3.5.4. Short Circuit with Earthquake

- Short circuit load
- 0.6 x Full earthquake load
- Dead & Live Load

3.5.5. Ice with Wind

- Conductor tension according to bus work section.
- Normal wind

- For electrical equipment, loads should be considered according to their technical specifications.
- For gantries, tensile force due to conductors should be considered on one side.

3.6. Unit Stresses

3.6.1. General - Galvanized Steel Structures

- Any acceptable design practice may be used provided that all parts of structures are designed so that the unit stresses in members and connections produced by the most critical combination of specified design loads and when multiplied by the appropriate overload factors do not exceed values derived from the following paragraphs.
- Provide members and accessories of such size, shape and length as to preclude damage or failure from vibration, stress reversal or fatigue.
- Design secondary members for a force resulting from 2.5% of the axial compressive load in the member being restrained. Secondary members introduced to reduce the slenderness ratio of tension members need only meet the requirements of slenderness ratio.

3.6.2. Galvanized Steel Structures

- The contractor shall use one of stress formulas in applicable standards for proportioning the structure members to withstand the following stresses.
  - Compression
  - Tension
  - Bending
  - shear
  - Bearing
  - all kinds of buckling

- **Slenderness Ratio**

  Ensure maximum ratio of unbraced or unsupported length (L) measured between working points on design drawing to least radius of gyration (R) of a member do not exceed:

Structure leg member and girder chord members	120
Other members having calculated stress	200
Redundant or secondary members without calculated stress	250

  All kinds of buckling should be considered.

- **Deflection**

  The following deflection limits for columns and girders shall be limited to the following:

Table 4. Allowable deflection limits

member	allowable deflection limits
Girders supporting disconnect switches	1/300 of span, vertically and horizontally
All other girders	1/200 of span vertically and horizontally
Columns	1/200 of the total height at the top

A) Steel Tower Bolts

Design connections for bearing and shear, not friction. Do no exceed ultimate allowable stresses.

· Tensile stress on tensile stress area:

For bolts having a specified proof-load stress, do not exceed the ASTM proof-load stress (F_p) by the length measurement method. For bolts having no proof-load stress specified, do not exceed 0.6 Fu of the ultimate tensile strength.

· Shear stress on bolt shank area:

For bolts having a specified proof-load stress, do not exceed 0.7 Fp for joint length up to 40 cm and do not exceed 0.6 Fp for joint length greater than 40 cm. 0.5 Fu for all joint length. (Joint length is the distance between centers of the leading and the trailing bolts in a connection).

· Bearing stress:

Twice the proof-load stress or 1.2 Fu, whichever is the least.

3.7. Framing

· Avoid eccentric connections. Where it is economically impossible to eliminate eccentricities, give due consideration to the additional stresses introduced.

· Ensure redundant members and mutual support systems utilized to provide joint restraints or reduce the unsupported lengths of members are framed in such a manner so that no reliance on the flexural rigidity of any member is required.

3.8. Minimum Size

- Ensure the minimum thickness before galvanizing of structure legs and girder chords not be less than 5 mm and all other members not be less than 3 mm. Ensure the maximum allowed width to thickness ratio, " b/t ", of and angle leg is 20:1 in which " b " is the longest leg measured from the end of the root fillet to the extreme fiber and " t " is the nominal leg thickness.
- Provide gusset plates with a minimum thickness of 6.0 mm.
- Ensure minimum width of the connected leg of an angle is related to the diameter of the bolt being used and is not less than twice the diameter plus 12.0 mm.
- Provide a minimum diameter connection bolt of 12 mm. Use high strength quality bolts equivalent to ASTM A325.
- If more than one diameter of bolt is used on the contract irrespective of quantity, use a minimum variation in nominal diameter 4 mm.

3.9. Splices and Bolted Connections

- Ensure all field connections are bolted and the shank of all bolts extend full size completely through the connected members.
- Keep use of gusset plates to a minimum.
- Where angles are lap spliced, chamfer the heel of the inside angle to clear the fillet of the outside angle.

Bolt Diameter (mm)	Rolled Edge (mm)	Sheared Edge (mm)	Plasma Arc or Flame Cut Edge (mm)
12	18	18	24
16	22	24	30
20	26	30	36
24	30	36	42
28	34	42	48

For plates and members carrying tensile loads, ensure the distance from the centre of the end bolt to the member is not less than the values for edge distance given above and standards and the following quantity:

distance to edges	1.75 x Bolt diameter
distance between center of bolts	3 x Bolt diameter

Design splices for the maximum stresses in members with no credit given for abutting joints. Keep the number of splices to the minimum practicable.

- Detail end connection of angle members in such a manner that blocking or flattening the outstanding leg is not required.
- Locate splices as close as possible to a node point. In vertical or sloping members, place lap splices above the closest node point.
- Ensure the minimum distance from leading to trailing bolt in angle lap splices is twice the flange width of the smaller lapped member. Locate bolts in lap splices such that the centre of gravity of the bolt group is as close as practicable to the centre of gravity of the combined member in the splice.

3.10. Excess

The contractor shall supply at least 10% more bolts, nuts, lock washers and ring fills than actually required to compensate for normal field losses.

3.11. Double Angle Members

Connect all double angle members at intervals between end connections by stitch bolts. Use a maximum spacing of stitch bolts of not be more than 1.0 m for tension members. For compression members, use a spacing such that the L/R ratio of one angle between stitch bolts is not greater than the L/R ratio of the whole member and not more than 0.6 m. Connect all double angle members in at least two points between panel points.

Connect angles with connected legs longer than 100 mm with two stitch bolts and filler plate at each point (one bolt on each gauge line). Connect ungles with connected legs 100 m or smaller at each point by one bolt and ring fill which is on the inner gauge line.

3.12. Long Tension Members

Detail tension members shorter than the theoretical required length. Detail members 3 m or less 3 mm short. Detail members more than 3 m long 3 mm short and an additional 1.5 mm short for each additional 3 m or fraction thereof to a maximum of 6 mm.

3.13. Member Orientation

Orient members with the flat surface up when possible. Void all pockets or depressions which can retain water.

3.14. Ladders

Provide caged ladders to give access to all girders.

4. Fabrication and Manufacture

4.1. Marking - All Structures

Mark pieces distinctively with erection marks that are clearly visible after galvanizing corresponding to those on erection drawings. Use steel stamping dies, minimum 16 mm high, and take special care to see that all erection marks are made in such a manner as not to be obliterated in transit or in any way damage galvanizing or impair strength of member.

4.2. Welding

Welded connections shall be kept to a minimum. When necessary, weld steel before galvanizing in accordance with AWS Code of Arc and Gas Welding in Building Construction. Use shielded arc process.

4.3. Drilling and Punching

Drilled or punched holes are acceptable for material up to 12 mm thickness. Drill or sub-punch and ream material over 12 mm thickness. Remove all burrs left by the drill or punch.

Before galvanizing steel members, ensure bolt holes are not more than 1.5 mm larger in diameter than the diameter of the bolts.

Make allowance in gauge dimensions on steel members for the thickness of subsequent galvanizing and the possible formation of spelter fillets inside the angles so as to allow adequate erection clearance after galvanizing.

Accuracy place holes so that, except for tension members, no "drifting " will be necessary at site to facilitate assembly.

4.4. Bending

All bending of pieces should be done cold. However, specify hot bending where advisable on the drawings. Undertake bending in such a manner that full section is maintained and so that physical properties of steel is not impaired. Obtain agreement of Engineer for any bending by cutting and welding.

4.5. Galvanizing

- Galvanize all steel used in construction of structures after all manufacture is completed.
- Ensure the zinc coating is smooth, clean, of uniform thickness and free from defects.
- Ensure preparation for galvanizing, and galvanizing itself, does not adversely affect the mechanical properties of coated materials.
- Do not use sheradizing, or other similar process.

5. Factory Tests and Inspections

- Mechanical tests on the material used in fabrication of the structures will include ultimate tensile strength, yield strength and elongation. Mill certificates if available, may be supplied in lieu of these tests.
- The Engineer reserves the right to obtain from any lot of material being fabricated samples for independent testing by a laboratory approved by the Engineer and to reject any lot of material for which such tests fail to meet specification requirements.
- Test all welds to the satisfaction of the Engineer in accordance with applicable standards to ensure satisfactory performance in service.
- Subject all galvanized material to tests to satisfaction of the Engineer and in accordance with applicable standards in service.
- All instruments shall be approved and shall, if required by Engineer be calibrated at the expense of the contractor by an approved authority.
- Protect all material from corrosion. Treat and bundle galvanized steel to protect against the formation of wet storage stain (white rust)
- Make a trial assembly of each type of structure to prove the accuracy of details and fabrication.
- The Engineer has the right to have representative at the factory for determination of compliance of the equipment with provisions of this specification.
- Any omissions or failures on the part of Engineer to approve or reject any work or materials, at the time of inspection, shall not be construed as an acceptance of any defective work or materials. If any work of materials shall be condemned by Engineer as defective or improperly done, such work shall be removed or rebuilt, or the defects otherwise remedied, in a manner satisfactory to Engineer and consistent with the intent of these specifications.

- Engineer reserves the right to obtain from any lot of material being fabricated, sample coupons for independent testing by a laboratory approved by Engineer issuing the standards, and to reject any lot of material for which such tests fail to meet specification requirements.
- All galvanized material shall be subjected to the tests as specified in the standards.

6. Packaging

In addition to markings required for shipping purposes all containers, bundles, kegs, boxes, etc., shall be marked with the following:

1) Type of structure and location.

2) Piece mark, quantity and identification number.

3) Contractor or specification number and project title.

All parts designed for bolting together shall be shipped unassembled. All members of the same piece mark shall be bundled together, except when this results in bundles too heavy for shipping. A small bundles of different piece marks for the same type structure to form a larger more practical sized bundle ; however, each piece mark shall be separately bound within the larger bundle to provide immediate sorting.

Small parts such as clip angles, U-bolts, bolts and nuts and washers shall be in containers may be combined in larger shipping crates. In no case shall parts of one type structure be combined with parts of another type.

Bundling straps or bands, or their equivalent, and related items as well as containers and crating shall be of sufficient strength of contain and protect the contents under normal export shipping, handling a storage yard conditions. The bending material shall be galvanized or aluminized steel or other equivalent material which will not rust or otherwise deteriorate during shipping and storage and / or cause any damage to the structure members.

The containers shall be constructed in a manner which will prevent pilferage of contents from the unopened container. Transporting vehicles in which steel is shipped shall be clean and free from foreign materials which could in any way damage the steel or zinc coating.

The methods of packaging are subject to the Engineer inspection. Bundles of steel shall be stowed for ocean transportation in vessel holds and always horizontally (never on end) and sufficiently braced to prevent shifting during the voyage; also stowing shall be such that there is no damage by the handling of cargo at intermediate destinations.

7. Submittals

The Contractor shall submit, in accordance with Section 3; drawings, calculations, test reports and literature pertaining to specified items of material to be supplied under this section.

8. Spare parts

The Contractor shall be provided spare parts as per schedule of quantities and prices.

TECHNICAL SPECIFICATION

SECTION 12

SWITCHYARD BUSWORK

MONENCO – IRAN CONSULTING ENGINEERS COMPANY

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1. Description

1.1. Definition

Switchyard buswork shall mean flexible and rigid conductors, lightning protection system, shield wires, insulators and connectors (clamp and fitting).

1.2. Work Included

Work of this section consists of design, manufacture, factory testing, transportation, installation and commissioning of switchyard buswork and all accessories necessary for proper operation and supply of mandatory spare parts.

Switchyard buswork shall consist of the following for each switchyard:

- Flexible and rigid conductors
- Equipment connectors (clamps & fitting)
- Jumpers
- Post and string/composite insulators
- Suspension and flexible assemblies
- Lightning protection system
- shield wire
- Mandatory spare parts

1.3. Terminology

Technical terminology is as defined in International Electro technical Commission Standard Section IEC 60050.

2. Standards

Work of this section shall comply with the requirements of the latest edition of standard Publications listed below which form part of this specification to the extent specified in this section:

IEC 60050	International Electro technical Vocabulary

Conductors

IEC 60865	Short circuit currents calculation of effects
IEC 61232	AL-coated steel wires for stranded conductors
IEC 60889	Hard-drawn aluminum wire for over head line conductor
IEC 60114	recommendation for-treated aluminum alloy bus bar material of the aluminum-magnesium-silicon type
IEC 61089	Round wire concentric lay overhead electrical stranded conductors
DIN 40501-2:2005	Aluminium for use in electrical engineering - Part 2: Tubes, rods, bars and sections - Technical delivery conditions
IEC 1597	Overhead electrical conductors- Calculation methods for stranded bare conductors

Post insulator

IEC 60273	Characteristic of Indoor and Outdoor Post Insulator Units for systems with Nominal Voltage Greater Than 1000 V
IEC 60168	Tests on indoor and outdoor post insulators of ceramic material or glass for systems with nominal voltages greater than 1000V

String insulator

IEC 60305	Insulators for overhead lines with a nominal voltage above 1000 V – ceramic or glass insulator unit for A.C systems- characteristics of insulator unit of the cap and pin type

IEC 60383-1,2	Insulators for overhead lines with a nominal Voltage above 1000 V
IEC 60120	Dimension of Ball and Socket Couplings of string Insulator Units
IEC 60372-1	amendment 1 - Locking Devices for Ball and Socket Couplings of String Insulator Units – Dimensions and General Requirements

Composite insulator

IEC 61109	Composite insulators for AC overhead lines with a nominal voltage greater than 1000V

General

IEC 60071	insulation coordination
IPIS 234	Maintenance and insulation clearness (Iranian power industrial standards)
IPIS 212	Lightning protection (Iranian power industrial standards)
IPIS 1202	Load combination (Iranian power industrial standards)
IEEE std 998	Shielding of substation
IEC 62217:2012	Polymeric HV insulators for indoor and outdoor use - General definitions, test methods and acceptance criteria
IEC 60433	Insulators for overhead lines with a nominal voltage above 1 000 V - Ceramic insulators for a.c. systems - Characteristics of insulator units of the long rod type
IEC 61466	Composite string insulator units for overhead lines with a nominal voltage greater than 1 000 V
IEC 60437	Radio interference test on high- voltage insulators.

IEC 60507	Artificial pollution tests on high-voltage ceramic and glass insulators to be used on a.c. systems
IEC 62155	Hollow pressurized and unpressurized ceramic and glass insulators for use in electrical equipment with rated voltages greater than 1 000 V
IEC 60672	Ceramic and glass insulating materials
IEC TS 60815-1	Selection and dimensioning of high-voltage insulators intended for use in polluted conditions Part 1: Definitions, information and general principles
IEC TS 60815-2	Selection and dimensioning of high-voltage insulators intended for use in polluted conditions Part 2: Ceramic and glass insulators for a.c. systems
IEC TS 60815-3	Selection and dimensioning of high-voltage insulators intended for use in polluted conditions Part 3: Polymer insulators for a.c. systems
ASTM A 90	Standard Test Methods for Weight [mass] of Coating on iron and steel articles with zinc or zinc alloy coating
ASTM A 153	Standard Specification for Zinc Coating (Hot Dip) on Iron and Steel Hardware
ASTM A 239	Standard practice for Locating the Thinnest Spot in a Zinc (Galvanized) Coating on Iron or Steel Articles
ASTM B 317	extruded Aluminum Alloy Bar for Electrical Purposes
NEMA CC1	Electrical power connectors

In the event of conflict between standards, the governing standard shall be the one which requires the highest quality of work and materials and affords the highest degree of safety to personnel, all as approved by the Engineer.

3. Design Summary

3.1. General

3.1.1. Corona

The corona effect on the conductor surface of switchgear installation is a partial electrical discharge in the air when the electrical field strength exceeds a critical value on the conductor surface.

Conductors, connectors, joints and energized portions of conductor supports, flexible and suspension assemblies shall be free of audible and visible corona.

All of the post insulators & string insulators in 400 kV side should be equipped with corona rings.

The permissible surface field strength for outdoor installations, at IEC condition shall be as data sheet value. Flexible and rigid conductors shall be designed so that voltage stress shall not exceed permissible value at sea level and at maximum rated voltage.

3.1.2. Loadings

Main parameters for load combinations are short circuit forces, wind, ice, earthquake and dead loads.

Everyday stress condition (EDS), the value of considered tension for over head line conductors and shield wires, shall not be less than determined values in data sheet. Conductors, connections and conductor supports shall withstand forces from applicable combination of short circuits, wind, ice and earthquake as described in sections 2, and following table:

Table 1. Loading combinations for substation equipment

ITEM	LOADING COMBINATION	DESCRIPTION
1	High wind	Dead load Maximum. wind speed Minimum ambient temperature plus 20° C Without ice
2	Normal wind with ice	Dead load Normal wind speed Zero temperature With ice
3	High wind with short-circuit	Dead load 0.7 × High wind speed Minimum ambient temperature Without ice With short-circuit stress
4	High wind with short-circuit	Dead load 0.7 × High wind speed Maximum ambient temperature Without ice With short-circuit stress
5	Earthquake with short-circuit	Dead load 0.6 × Earthquake load (Vertical and horizontal) Without wind Maximum wire temperature Without ice With short-circuit stress
6	Earthquake	Dead load Earthquake load (Vertical and horizontal) Without wind Minimum ambient temperature Without ice

Thermal and electro-mechanical effects of short circuit currents shall be calculated accordance with IEC 60865.

Mechanical forces from dead load, wind, ice and earthquake shall be calculated accordance with IPIS standards.

Later load combinations with other required loads (according to steel structure section) shall be regarded at steel structure calculations.

Minimum tension which shall be considered for incoming and outgoing over head lines and shield wires shall be taken into account according to items A9, A10 of data sheet. If every phase comprises of several sub-conductors, the tension's value of all sub-conductors shall be considered.

Maximum permissible angle for incoming and outgoing over head lines shall be according to data sheet.

3.1.3. Clearances

Electrical clearances for switchyards shall be established for safety operation and maintenance of the equipment.

Basic values, horizontal, vertical maintenance clearance distances and safety zones (Height of base of post insulator from ground), clearance between phases and height of energized parts above access roads shall be in accordance with IEC60071, IPIS 234.

3.2. Stranded Conductors

Flexible conductors shall be all aluminum alloy stranded conductor (AAAC) designation A2, A3 or all aluminum stranded conductor (AAC) designation A1 as in accordance with IEC 61809.

Size of conductors (in main bus & feeders) shall be determined by Contractor with attention to electrical capacity, Surface voltage gradient, electrical and mechanical loading, radio influence voltage, audible noise and environmental conditions as specified in this section.

Electrical capacity determination shall be included continuous and short circuit current capacity for a predefined duration which has been determined in single line diagram & data sheets, without exceeding a final permissible temperature.

3.3. Tubular Conductors

Tubular Aluminum bus conductors shall comply in all aspects with ASTM B 317, also Aluminum Alloys shall be E – AL.Mg.Si in accordance with IEC 60114.

Rigid conductor shall be sized to limit deflection lower than permissible value.

The natural frequency of vibration for any span or rigid conductor shall not be equal to twice the power frequency.

Size of conductors (in main bus or in feeders) shall be determined by Contractor with attention to electrical capacity, Surface voltage gradient, electrical and mechanical loading, radio influence voltage, audible noise and environmental conditions as specified in section2.

Electrical capacity determination shall be included continuous and short circuit current capacity for a predefined duration which has been determined in single line diagram & data sheets, without exceeding a final permissible temperature.

Thermal and electro-mechanical effects of short circuit currents shall be calculated in accordance with IEC 60865.

Prior to installation, the Contractor shall satisfy the Engineer through calculations and laboratory or field tests that the substation conductor system will be protected against vibration damage.

Vibration protection may be provided by appropriate sizing of conductors and spans or, where this is not sufficient, by installing damping devices such as insertion damping cables. Damping cables size shall be approved by the engineer.

After installation of the conductor, if field trials reveal the presence of vibration, which in the opinion of the Engineer is excessive, additional, damping devices shall be installed.

All provisions for expansion and contraction of elements, due to temperature variations, as well as relative displacements to support structures, shall be considered. Expansion fittings shall be located as required.

End caps, or corona bells, shall be installed in tubular conductor to decreasing corona effect and to prevent ingress of moisture.

Rigid conductor shall be arranged in such a manner that it can be extended without difficulty.

3.4. Lightning Protection

3.4.1. General

The design shall ensure adequate protection from strokes in the surrounding fringe area by installing shielding wires at the equipment boundary lines.

Shielding shall be done according to IPIS and IEEE guides.

The effective height and the number of required shielding wires shall be established and submitted to the engineer for approval.

Horizontal shielding conductors supported by the main structures, and lightning masts (if necessary) shall be used to shield the station.

Number of guard mast shall be determined by the contractor and engineer approval.

Down lead conductors, clamps and droppers shall be corrosion resistant.

The station structures and equipment shall be effectively earthen against direct lightning stroke.

3.4.2. Shield Wire

Overhead shield wires shall be Aluminum clad steel with 7 No. 8 AWG size and be in accordance with IEC 61232.

Aluminum- clad steel wire means round wire consisting of round steel core with a uniform and continuous aluminum covering.

Aluminum-clad steel wires are divided into different classes by their conductivity grade, corresponding to standard, medium and thick aluminum covering. Preferably, shield wires shall be medium or thick grades.

Size of conductors shall be determined by Contractor with attention to electrical capacity to absorb lightning surges energy, mechanical loading, and environmental conditions as specified in data sheets.

3.5. String / Composite Insulators

3.5.1. General

Insulator strings means one or more connected insulator units and intended to give flexible support to over-head line conductors and stressed mainly in tension.

Insulator set means an assembly of one or more insulator strings suitably connected together, complete with fixing and protective devices as required in service.

Insulator strings shall consist of ball and socket insulators or be composite insulator.

Creepage distance shall not be less than minimum values indicated data sheets, there shall be no negative tolerance, and may have the positive tolerance.

String/composite insulators shall be capable to withstand dynamic and static forces from ice load, wind load, as well as from short circuit and earthquake forces, at load combinations as loading clause and also suitable for use at the elevation and under ambient air temperatures.

The safety factors to be used for insulators with regard to the mechanical failing load shall be:

- Static load : 2.5
- dynamic load : 1.5

Strength classes of insulators depend on the contractor′s load calculations but it can't be less than values of data sheets.

3.5.2. Composite insulators

Composite insulators consist of an insulating core, bearing the mechanical load protected by polymeric housing, the load being transmitted to the core by the end fitting.

Rated values of string insulators shall be in accordance with data sheets and IEC61109.

3.5.3. String insulators

The insulating parts of the ball and socket string insulators are porcelain or toughened glass.

Rated values of string insulators shall be in accordance with data sheets and IEC60305, 383, 372,120.

In designation of insulator the letter "B" means ball & socket type and "S","L" specifies a short or long spacing. Long creepage distance insulators for polluted areas are designated by a final letter "P". Also IEC 383 specifies the insulators shall be marked with the specified electro mechanical or mechanical failing load, for instance 160 BL.

Number of string insulator units shall be selected regarding following parameters:

- Creepage distance
- Arcing distance
- Overvoltage withstands level.

3.6. Post Insulators

Post insulator shall be in accordance with IEC 60168, IEC 60273 designation C.

They shall be outdoor solid core cylindrical post insulator with external fitting, having solid insulating material throughout the height of each post insulator units, that is to say, a puncture proof insulator.

The insulating material of post insulator shall be porcelain.

Rated values of post insulator shall be in accordance with data sheets and IEC60273.

Post insulators shall be capable to withstand dynamic and static forces from ice load, wind load, as well as from short circuit and earthquake forces, at load combinations as per clause load combination and also suitable for use at the elevation and under ambient air temperatures.

The safety factors to be used for insulators with regard to the mechanical failing load shall be:

- Static load : 2.5
- dynamic load : 1.25

Strength classes of post insulators depend on the contractor′s load calculations but it can't be less than values of data sheets.

Creepage distance shall not be less than minimum values indicated data sheets, there shall be no negative tolerance, and may have the positive tolerance.

3.7. Fittings

Fitting termination shall be of compression type. Fittings for tension strings shall have an identical tensile strength same as relevant string insulators.

Provision shall be made for adjusting flexible conductor tensions through the use of turn buckles.

Shield wire termination shall be of the compression type or bent leg flexible clamp with ultimate strength of not less than 2.5 times to the maximum working load of connected conductor.

Minimum slip load of dead end clamps for tension & suspension set string insulators shall be 50% U.T.S of relevant conductor .

Minimum slip load of dead end clamps for tension set shield wires shall be 95% U.T.S of shield wire.

Connection of shield wires to gantries or guard masts shall be done by utilizing U-Bolt connectors.

3.8. Connectors

Current carrying capacity of each connector shall not be less than conductors to which they are to be applied at identical temperature rises.

For the specified short circuit current and duration, the temperature rise of the connectors shall not exceed that of the conductors they connect.

The connectors shall not cause radio interference above permissible limits. Sharp edges shall be avoided in design and construction.

4. Fabrication and Manufacture

4.1. Stranded Conductor

Flexible conductors shall be all aluminum alloy stranded conductor (AAAC) designation A2, A3 or all aluminum stranded conductor (AAC) designation A1 in accordance with IEC 61809.

Mechanical and electrical properties such as electrical resistivity, density of Aluminum wires shall be in accordance with IEC60889. The aluminum content shall be not less than 99.5%.

Wires making up conductors shall be free from dirt, splints, die marks, scratches and all imperfections not consistent with best commercial practices.

The nominal diameter and tolerance on diameter shall be in accordance with IEC60889, 61089 and expressed in millimeters to two decimal places.

Conductors shall consist of round wire concentric lay, in the other words, composed of central core surrounded by one or more adjacent layers of wires being helically in opposite directions, in such way, the outer layer shall be right-handed or clockwise.

Core of conductor consists of single wire, and second lay shall have 6 wires, and similar each layer shall consist of wires multiple of 6.

Flexible conductor (and shield wire) shall be furnished on reels of sufficiently large diameter to prevent modification of the physical properties of the conductor.

The reels shall be of such design, construction and strength as to its designation without displacement, chafing or other damage incurring during shipment or field handling. The reels shall be capable of withstanding all stress due to breaking and stringing operations. Each end of the conductor shall be properly and securely fastened to the reel. In addition to marks required for shipping purposes each reel shall be marked to show serial number, type of conductor, and gross and net weights.

4.2. Tubular Aluminum Conductor

Tubular Aluminum bus conductors shall comply in all aspects with ASTM B 317, also Aluminum Alloys shall be E – AL.Mg.Si in accordance with IEC 60114.

Aluminum tubes are designated by their nominal outer diameter and wall thickness in mm.

The contractor shall order tube lengths in such a way that a minimum of joints will be needed.

Welding procedure shall be approved by the engineer and welding joint shall not decrease mechanical and electrical properties of the circuits.

The method to be proposed for welding the bus joints shall be based on the use of the coupler (Sleeves) tubes and backing - strips. All the said coupler tubes and backing - strips and other pieces that may be necessary to complete the joints shall be supplied by the contractor.

4.3. String / Composite Insulators

4.3.1. General

Insulating parts shall be made of porcelain, toughened glass or polymeric material.

4.3.2. Composite insulators

Composite suspension/tension insulators consist of a load-bearing cylindrical insulating core consisting of fiber glass.

In housing (outside the insulating core) made of polymeric material and end fitting permanently attached to the insulating core.

Dimensions and tolerances of composite insulators shall comply with values recommended in IEC 61109.

4.3.3. String insulators

String insulator units shall be accordance with IEC60305.String insulators units shall be brown glazed porcelain to match other equipment installation.

Dimensions and tolerances of ball and socket couplings shall comply with values recommended in IEC 60120.

The locking device means a split-pin, which designed for locking the minimum-size pin ball in the maximum size socket. Dimensions and tolerances of locking devices shall comply with IEC 60372.

Split pins shall be made of a copper alloy, suitable for hot line maintenance. Their design shall allow easy removal or replacement of the insulator units or fittings.

The insulators shall be designed to keep radio interference at a minimum level that has been indicated in data sheet. Result of radio interference test shall be submitted to the purchaser in accordance with IEC 60437.

Sockets shall be made of malleable cast iron, spherical graphite cast iron or forged steel.

Ferrous parts of the insulator shall be hot dip galvanized. Mean and minimum values of mass of zinc coating and its appearance on the ferrous parts of the insulators shall be in accordance with IEC60383.

Balls shall be made of steel and forged. They shall be free from folds, cracks and other defects which affect strength and functions.

Balls shall be protected with an anti-corrosion zinc sleeve covering the ball and located at the pin-cement boundary area.

All fittings and accessories shall be dimensioned for the prescribed short -circuit current and time.

Furthermore, assembly shall be carried out in such a way to ensure that insulating part shall not be subjected to any mechanical stress due to a pressure exerted by bottom edge of cap.

Free surfaces of insulating parts shall be cleaned so as to remove dirty and other impurities.

Tension and suspension insulators shall be equipped with grading ring in order to improve voltage distribution over string insulator units; also they shall be equipped with arcing devices, in order to minimize the possibility of damage to

conductors, clamps, fittings and insulators them-selves under all flashover conditions. These devices shall withstand specified BIL.

The arcing device and its fixings shall have sufficient mechanical strength.

Each insulator shall be marked with name or trademark of manufacturer and year of manufacture in accordance with IEC Publication 60383. In addition, each insulator shall be marked with specified mechanical failing load with conformity with IEC Publication 60383 and 60305.

4.4. Post Insulators

Post insulator shall be in accordance with IEC 60168, IEC 60273 designation C.

Post insulators shall be brown glazed porcelain to match installation.

The porcelain shall be manufactured by the wet process and shall be of homogeneous structure free from laminations, cavities, or other flaws affecting its mechanical or dielectric

Post insulator shall be washable in service type.

The post insulators shall be completed with all necessary accessories for proper operation.

Top/bottom metal fittings shall be made of copper-bearing drop forged steel or heat treated malleable cast iron. They shall be free from cracks, shrinks, air holes, burns or rough edges.

Galvanized steel bolts cap screws shall be furnished for the assembly of all stacking units.

Top/bottom metal fittings and porcelain shell, shall be concentric and coaxial. The normal maximum values for the tolerance of parallelism, eccentricity and angular deviation shall be in accordance with IEC 60273.

All dimensions of the post insulator units and also top/bottom fitting of post insulator shall be in accordance with IEC 60273.

The insulators shall be designed to keep radio interference at a minimum level that has been indicated in data sheet. Result of radio interference test shall be submitted to the purchaser in accordance with IEC 60437.

Bonding material between porcelain and metal parts shall be Portland cement or aluminous.

Each insulator shall be marked with name or trademark of manufacturer and year of manufacture in accordance with IEC 60168. These marking shall be legible and inedible. In addition, each insulator shall be marked with specified mechanical failing load with conformity with IEC 60273.

4.5. Connectors

Parts of current - carrying connectors which are in direct contact with the conductor or equipment terminals shall be designed so that dangerous galvanic corrosion in the contact surface cannot occur.

Wherever a copper - aluminum connection is made, the contact of the copper shall be equipped with bimetal washers.

Connectors shall be designed to allow uniform current distribution in the conductor through the shortest current path.

Base material of the clamps shall be heat treated AL alloy and bolt shall be stainless steel.

Clamps shall be bolted type but fitting can be compressive type.

Contact surfaces shall be machine - finished with small tolerances and high accuracy and protected to prevent the buildup of non - conducting oxide.

Contact paste shall be used on all contact surfaces during installation of all kinds of connectors.

The contact paste shall not decay, evaporate, harden or crack under the service conditions.

Connectors shall be strong enough to carry electrical and mechanical loads, and to withstand the forces applied during transportation and installation, as well as those developed under extreme service conditions of short circuit, expansion and contraction, without suffering permanent deformation or breakage.

The design, manufacture and testing of connectors and hardware shall be in accordance with NEMA CC1.

Connector material shall be able to withstand environmental temperatures variations up to short circuit permissible temperature without becoming brittle or lose their mechanical or electrical properties.

The manufacturer shall submit connectors withstand torques and they shall be regarded by the contractor during installation.

5. Factory Tests and Inspections

Routine, sampling, acceptance tests shall be witnessed on all buswork equipment as specified in relevant standards.

Evidence shall be submitted that type test have been performed and passed successfully in an independent accredited laboratory. The said type test documents shall include full technical details and in general shall not be older than 5 years. All type tests shall be carried out at the manufacturers' expense.

The Engineer has the right to have representative(s) at the factory for determination of compliance of the buswork equipment with provisions of this standard.

All instruments and their calibration shall be to approved, and, if required by the purchaser, shall be calibrated by an approved body. All measuring, test equipment, and qualified personnel required to carry out the tests, shall be provided by the manufacturer.

The purchaser shall be notified 60 days in advance, whenever a type or routine test is going to be done, so that the test may be witnessed if required.

6. Submittals

The Contractor shall submit, in accordance with Section 3; drawings, calculations, test reports and literature pertaining to specified items of material to be supplied under this section.

7. Spare Parts

The Contractor shall be provided spare parts as per schedule of quantities and prices.

TECHNICAL SPECIFICATION

SECTION 13

CABLE SYSTEM

MONENCO – IRAN CONSULTING ENGINEERS COMPANY

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1. Description

1.1. Definition

Cable system shall be all cables, cable trays/ladders, cable sealing ends and cable accessories.

1.2. Works Included

Works of this section consists of:

- High voltage cable,
- Medium voltage cable,
- Low voltage cable,
- Control and communication cables,
- Signal and special purpose cables,
- Cable sealing ends,
- Cable accessories consist of cable lugs, ferrules glands, cable trays/Laddres and other required accessories.

1.3. Terminology

Technical terminology is to be as defined in the latest edition of International Electrotechnical Commission Standard IEC - No. 60050-461.

2. Standards

Work of this section shall comply with the requirements of the latest editions of IEC, BS or DIN standards.

IEC publications listed below form part of this specification to the extent specified in this section:

- IEC 60038 IEC standard voltages
- IEC 60050 International Electrotechnical Vocabulary
- IEC 60060 High voltage test techniques
- IEC 60230 Impulse tests on cables and their accessories
- IEC 60287 Calculation of the current rating
- IEC 60502 Power cables with extruded insulation and their accessories
- IEC 62067 Power cables with extruded insulation and their accessories for rated above 150 KV up to 500 KV
- IEC 60840 Power cables with extruded insulation and their accessories for rated above 30 KV up to 150 KV
- IEC 60811 Test methods for insulation and sheaths of electric cables and cords (elastomeric and thermoplastic compounds)
- IEC 60183 Guide for selection of the high voltage cables
- IEC 60228 Conductors of insulated cables

3. Design Summary

3.1. General requirements

The size and type of the cables shall be so selected that does not exceed the limiting temperature and current carrying capacity specified by IEC standards for site condition.

For selecting cables the following factors shall be considered:

- Continuous current carrying capacity by considering the feeder permissible over loads
- Short circuit capacity
- Voltage drop

Table 1 below states the maximum permissible continuous and transient conductor temperature for various types of cable insulation.

Table 1. Maximum permissible temperature for cable insulation

Type of cable Insulation	Maximum permissible continuous temperature (°C)	Maximum. permissible transient conductor temperature(°C)
XLPE	90	250
EPR	80	250
PVC	70	160

The Contractor is responsible for mutual compatibility and adequacy of all cable system and all other corresponding equipment, in any respect.

Cables shall be color coded as follows:

- For phase conductors : red, yellow and blue
- For AC neutrals and other connections : black
- For ground connections : yellow or green
- For DC circuits : gray

Cable cores belonging to different feeders or group wires may not be located in the same cable.

Cable segregation table shall be provided to be approved by the Engineer.

A common system of cable numbering shall be used throughout the plant. All cables shall have a unique number and the cores within that cable shall bear the same number such that they may be easily identified after the cables have been terminated.

All single phase power cables shall have 1 full sized conductors plus 1 earth continuity conductor which is ampere rated not less than 100% of the phase conductor.

All three phase power cables shall have 3 full size conductors plus 1 earth continuity conductor which is rated not less than 58% of the phase conductor.

The size of control cables shall not be less than the following:

- 1.5 mm^2 for panel wiring
- 2.5 mm^2 for other control cables
- 4.0 mm^2 for current transformer secondary circuits.
- 2.5 mm^2 for voltage transformer secondary circuits.

The size of AC, DC, CT and CVT Cables shall be finalized at design stage after CT and CVT Calculation.

3.2. Drop voltage

At each voltage level the size of conductors shall be such that the maximum voltage drop shall be:

A. AC System

- Not more than 5% when using full load current, between the Auxiliary transformer and the final equipment
- Not more than 2% when using full load current, between the Auxiliary transformer and the main panel/board
- Not more than 3% when using full load current, between the main panel/board and the final equipment
- Not more than 13% when using full starting current, between the main panel/board and each AC motors

- For PT & CVT secondary voltage measuring cable the allowable voltage drop is 0.5%.

B. DC System

- Not more than 5% when using full load current, between the Battery and the final equipment
- Not more than 2% when using full load current, between the Battery and the main panel/board
- Not more than 3% when using full load current, between the main panel/board and the final equipment
- Not more than 8% when using full load current, between the main panel/board and each CB trip/close coils
- Not more than 8% when using full starting current, between the main panel/board and each DC motors

3.3. Cable channels

All cables shall be installed on trays, ladders racks, in ducts, cleated to steelworks, laid in concrete trenches.

Cable trays shall not sag more than 0.5 cm at the midpoint between supports when the tray has been loaded with cables.

Cable trays where used shall be fabricated from hot dip galvanized steel.

Maximum intervals between cable trays supports shall be 2 meters.

Cables belonging to cubicle heaters or AC circuits may not be located in category of control cables.

MV & HV cables shall be installed in separate cable channel and not be located in LV cable channel.

When laying cables the radii should not be smaller than the given by the manufacturer or 15 times the cables diameter. Also minimum installation temperature recommended by the manufacturer shall be considered.

When laying cables by machine, particular attention must be paid to the permissible tensile forces submitted by manufacturer.

HV and MV cables which have high electromechanical forces shall be fastened on the cable ladders by appropriate accessories.

A spare loop shall be considered for MV and HV cables and in the cable channels appropriate area shall be considered for this purpose.

All power and control cable feeders shall be of a single length with no splicing jointing.

3.4. Cable Accessories

All cable boxes shall be of adequate proportions and designed in such a manner that they can be opened for inspection without disturbing the gland plate or incoming cable.

Cable glands shall be suitable for the type of cable to which they are fitted.

Cable glands shall be made of stainless steel.

All cables shall be identified with an approved plastic or Aluminum marker at each end of the cables. Cable cores shall be ferruled with the same number at each end.

All wirings shall be marked, except for conductors between terminals on a given item of equipment.

4. Fabrication and Manufacture

4.1 Conductor

The conductors shall be circular plain annealed stranded copper conforming to class 2 of IEC 60228.

4.2 Conductor Screen

The conductor screen shall be consist of extruded smie-conducting compound.

4.3 Insulation

All Low Voltage power and control cables shall be provided with fire retardant P.V.C. insulation.

All H.V. & M.V cables shall have XLPE insulation. There are different methods to XLPE curing such as Silane X-linking (curing or crosslinking the polymer by exposure to moisture), dry curing in Nitrogen gas which is at high pressure and high temperature. But only dry curing is acceptable.

Also it's recommended XLPE process line will be catenary dry cure or vertical dry cure type but not Horizontal steam type.

4.4 Insulation Screen

The conductor screen shall be consist of extruded smie-conducting compound.

4.5 Filler

In multi core cables, the interstics between the cores shall be filled with suitable material compatible with insulation and operaitng temperature of the cables.

4.6 Metallic Sheath

For HV, MV, signaling control and protection cables the metallic sheath shall be supplied. It may be copper wires or tape.

4.7 Bedding

The bedding under armor shall be extruded or lapped layer of PVC or synthetic tapes.

4.8 Water Blocking Layer

For HV cable longitudinal water blocking layer shall be considered.

4.9 Armor

For all cables armor shall be considered during the construction. For multi core cables the armor shall be galvanized round steel wire supplemented by a helix tape to keep the armor wire tight. But for single core cables the armor shall be made of non-magnetic material.

4.10 Overall Sheath

All cable jackets shall be self extinguishing and non-hydroscopic and suitably protected against oxidation and ultra violet rays.

5. Cable Sealing Ends

High voltage cable sealing ends shall be self supported, porcelain or silicon rubber type. They shall have sufficient mechanical and electromechanical withstand level.

Medium voltage Cable sealing ends shall be heat shrinkable type (polymeric type) and can be non self supporting type.

They shall feature high electrical insulation level, corona and tracking resistance.

Cable sealing ends shall be non-flammable, self extinguishing and heat resistance in accordance with cable final temperature after short circuit current.

Cable sealing ends shall be UV and ozone resistant.

Stress cones for controlling the electrical filed inside the cable sealing ends shall be considered.

Cable sealing ends shall be complete with all accessories necessary for proper installation.

6. Fiber Optic Cables

Fiber optic cables shall have an expected life span of 20 years.

Also cables shall be suitable for following applications:

a. Indoors in buildings

b. In underground conduits and ducts

Cables shall have rodent protection.

The cable jacket shall be a high molecular weight polyethylene (PE) with a thickness of 3 mm minimum.

Color of the jacket shall be orange or black with orange line mark.

The cable jacket shall have permanent surface printed sequentially numbered length markers at 1 m intervals.

The cable jacket shall have permanent surface printed marks at regular intervals consisting with: manufacturer, year of manufacture, number of fiber and manufacture code number.

The cable jacket shall be metal-free, consequently cables are immune to lightning and electromagnetic interference (EMC-Safe), spark free and require no earthing.

The cable jacket shall be designed for minimal fume emission and toxicity, with zero halogen material being applicable for accommodation modules. Test methods and results shall be provided.

The cable jacket shall be designed for minimal smoke emission. Test results for all cable types specified shall be provided.

Cables shall be heat, UV and oil resistant as far as practicable within the specified parameters.

Test methods and results for the following performance characteristics of all cable types specified are required to be provided:

- Limiting Oxygen Index
- Temperature Index
- Toxicity Index – Zero Halogen cables only
- Acid gas emission

The bend radius for fiber optic cable shall not be less than that recommended by the manufacturer. If no recommendation is provided, then the bend radius shall not be less than 10 times the cable outside diameter under no-load condition not less than 20 times the cable outside diameter when the cable is under a tensile load up to the rating of the cable, usually 2670 N.

Fiber optic cables shall be multi-mode type.

Cables shall be 4 cores and central loose tube (jelly filled) type

6.1 Fiber Specifications and Tests

Following tables shows the required characteristics of fiber optic cables:

Table 2

Item	Parameters		Unit	Value
1. OPTICAL CHARACTERISTICS				
1.1	Attenuation	@ 850 nm	dB/km	Max 0.5
		@ 1300 nm	dB/km	Max 0.35
1.2	Bandwidth	@850 nm	MHz-km	Min 160
		1300 nm@	MHz-km	Min 400
1.3	Point Discontinuity		dB	Max 0.1
1.4	Numerical Aperture		—	0.275 ±0.015
2. DIMENSIONAL SPECIFICATION				
2.1	Core Diameter		u.m	62.5 ± 3.0
2.2	Cladding Diameter		u.m	125.0 ±1.0

2.3	Coating Diameter	u.m	245 ± 10
2.4	Core Non-Circularity	%	Max 6
2.5	Cladding Non-Circularity	%	Max 1
2.6	Core/Cladding Eccentricity	u.m	Max 3
2.7	Coating/Cladding Eccentricity	u.m	Max 12.5

3. TEMPERATURE RATING			
3.1	Installation	°C	0 ~ +50
3.2	Operation	°C	-20 ~ +70
2.3	Storage	°C	-40 ~ +70

Also, following tests shall to be performed based on defined methods in this table.

Table 3

Test	Method	Conditions
Tensile	IEC 794-1-El	200 - 400 kgf according the acceptable pulling force of cable .
Repeated Bending	IEC 794-1 -E6	Mandrel dia = 10 times of cable dia 10 cycles 10 kg weight
Impact	IEC 794-1 -E4	4 kg weight / 1 m height and the 300 mm radius of middle part.
Torsion	IEC 794-1 -E7	Weight 10 kg Angle = ±180° 20 cycles
Kink	IEC 794-1-El0	No kink for specified dia.
Temperature Cycling	IEC 794-1 - Fl	10 cycles each cycle 24 hours Lowtemp = -40°C High temp = +85 °C
Compression	IEC 794-1- E	500 kg on 50 mm section of cable.
Water Penetration	IEC 794-1-F5	1 m height / 3m Length / 24 hours -no drop

6.2 Color Codin

For 4 fibers will be in accordance with the table here after. Meanwhile another color coding is acceptable:

Table4

Fiber No.	Color
1	White
2	Red
3	Green

4	Blue

6.3 Cable Drums

Cable shall be supplied in standard production lengths and drum types and sizes for the quantities of each type of cable required. All drum lengths shall be continuous. Cable jointing in any form is unacceptable.

Cable drums shall each be provided with two 200mm x 200mm identification labels made from stainless steel or similar durable material, securely affixed one per side and at the top and bottom of each drum.

Each label shall be engraved with the following information as a minimum:

- Supplier's name
- Supplier's drum number
- Cable type code
- Purchase order number/item number
- Drum length (meter)
- Net and gross weights (kg)
- Weight per meter (kg)
- Purchaser's quality control reference
- Date of manufacture

6.4 Pigtails

All the fiber optic cables part of the backbone network shall be terminated by splicing a single fiber pigtail cable to the entry cable in the protection cabinet installed in each switchgear. All pigtail cables shall be terminated to fiber distribution box (patch panel).

The pigtail cables will incorporate multi mode fiber classes, same manufacturer as main fiber optic backbone cables.

The pigtail shall be equipped with FC type connector on one end and open on the other end.

The length of pigtail cable shall be 2 meters.

6.5 Splicing

Splicing is used for joining fibers. Splicing plays a critical role in the system performance.

The object of the splicing is to precisely match the core of one optical fiber with that of another in order to produce a smooth junction through which light signals can continue without alteration or interruption.

Splicing of fiber optic cables and pigtails shall be done by arc fusion method using a latest model operation at the required single-mode operating wavelength.

Fusion splicing provides a fast, reliable, low loss, fiber-to-fiber connection by creating a homogenous joint between two fiber ends.

The average splice loss shall be 0.05 dB or less. No splice (individual) shall have a loss greater than 0.1 dB.

Fiber optic splice closure shall give protection for fiber optic connections.

It shall consist of cable ports and trays for fusion type splice.

Minimum protection degree of fiber splice closure: IP67

Losses of all fiber links shall be tested and recorded.

The fiber length test shall be made

from fiber distribution patch panel for each route. For this purpose an Optical Time

Domain Reflector (OTDR) shall be used.

The OTDR shall be suitable for multi-mode fiber optic type at wavelength 850/1300 nm.

The OTDR power supply shall be able to work with:

- AC Voltage: 100 to 240 Vrms, 50 Hz
- DC Voltage: 16 to 24 V

- Battery: 4 hours minimum discharging time

7. Factory Tests and Inspections

Sample tests shall be witnessed as specified in IEC standards.

Evidence shall be submitted that type test have been performed and passed successfully in an independent accredited laboratory. The said type test documents shall include full technical details and in general shall not be older than 5 years. All type tests shall be carried out at the manufacturers' expense.

The Engineer has the right to have representative(s) at the factory for determination of compliance of the equipment with provisions of this specification.

The Contractor shall submit complete procedure of tests and a copy of all test sheets.

All instruments and their calibration shall be to approved, and, if required by the purchaser, shall be calibrated by an approved body. All measuring, test equipment, and qualified personnel required to carry out the tests, shall be provided by the manufacturer.

The purchaser shall be notified 60 days in advance, whenever a type or routine test is going to be done, so that the test may be witnessed if required.

8. Submittals

The Contractor shall submit, in accordance with Section 3; drawings, calculations, test reports and literature pertaining to specified items of material to be supplied under this section.

9. Spare Parts

The Contractor shall be provided spare parts as per schedule of quantities and prices.

10. Packing and transportation

All cables shall be furnished on lagged reels of sufficiently large diameter to prevent modification of the physical properties of the cable.

The reels shall be of such design, construction and strength as to guarantee satisfactory delivery of the conductor to its destination without displacement, chafing or other damage, incurring during shipment of field handling.

The reels shall be capable of withstanding all stresses due to installation operations. Each end of the conductor shall be properly and securely sealed and fastened to the reel.

Each reel head shall be marked to show serial number, size and number of conductors, length of conductor, voltage and cable type and arrow showing the end of the conductors, and gross, tare and net weights.

Measurement marks shall be provided over the whole length of cable in suitable intervals.

If the transport condition differs from service conditions such as temperature, humidity and etc., manufacturer shall be guaranty that conditions and special precautions shall be considered for the protection on equipment during transport, storage and installation, and prior to energization.

All equipment shall be prepared for ocean or inland transport, as the case may govern, to prevent damage from handling, warehousing in open yard and during shipment.

Packages shall have sufficient strength to prevent damage during handling, warehousing and shipment.

Adequate shipping supports and packing inserts shall be provided in order to prevent internal damage during transport.

The equipment shall be thoroughly cleaned of slag, grit, dirt, moisture and other foreign matters before packing.

A packing list must be provided for each individual packing unit it enables the purchaser's personnel to identify the unit clearly at site.

TECHNICAL SPECIFICATION

SECTION 15

CAPACITOR BANK

MONENCO – IRAN CONSULTING ENGINEERS COMPANY

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1. Description

1.1. Definition

Capacitor banks shall mean assembled outdoor, "open rack type", shunt three phase's capacitor, 50 Hz by single phase capacitor units and their accessories such as reactor, load break switch, structure, fence, connections, fuses, surge arrester, current transformer, supporting base insulators of specified ratings and characteristics, for compensation of power factor at medium voltage level.

1.2. Work Included

Work of this section consists of design, manufacture, factory testing, transportation and supervision over erection and commissioning of capacitor banks and all their accessories necessary for proper operation as specified and supply of mandatory spare parts.

1.3. Terminology

Technical terminology is to be as defined in International Electrotechnical Commission standard IEC 60050.

2. Standards

Work of this section shall comply with the requirements of latest editions of International Electromechanically Commission (IEC) standards.

IEC publications listed below form part of this specification to the extent specified in this section:

IEC 60050	International Electromechanically Vocabulary
IEC 60060	High voltage test techniques
IEC 60071	Insulation co-ordination
IEC 60076-6	Power transformers - reactors
IEC 60099	Surge arresters
IEC 60137	Insulated bushings for alternating voltage above 1 kV
IEC 60273	Characteristics of indoor and outdoor post insulators for systems with nominal voltages greater than 1000 V
IEC 60296	Unused mineral insulating oils for transformers and switchgear
IEC 60529	Degrees of protection provided by enclosures
IEC 60549	High-voltage fuses for the external protection of shunt capacitors
IEC 60815	Selection and dimensioning of high-voltage insulators intended for use in polluted conditions
IEC 60871	Shunt capacitor for AC power systems having a rated voltage above 1kv
IEC 61869	Instrument transformers
IEC 62271	High voltage switchgear and control gear
IEEE C37.66	IEEE standard requirement for capacitor switches for AC systems
IEEE C37.99	IEEE Guide for the Protection of Capacitor Banks
IEEE 1036	IEEE Guide for application of shunt power capacitors

All of the equipment shall be manufactured according to corresponding Iranian Power Industry Standard in Capacitor Bank field.

3. Design Summary

The capacitors shall be the unit type mounted on the structure and suitable for outdoor installation.

They shall be connected in such a way that required size of three phase bank as specified in data sheet be provided.

The unit capacitance and bank capacitance tolerance shall be in accordance with IEC60871.

Unbalanced currents due to long term drift of the capacitor characteristics shall not cause the protection system to trip the circuit breaker without prior alarm being given.

Unit capacitors and capacitor bank shall be capable of withstanding without damage, or deterioration of internal or external short circuit on the terminals of the live unit capacitor or of the live capacitor bank up to specified duration.

Capacitors should be so placed that there is adequate dissipation by convection and radiation of the heat produced by the capacitor losses. The ventilation of any enclosure and the arrangement of the capacitor units shall provide good air circulation around each unit.

The temperature of capacitors subjected to radiation from the sun or from any high-temperature surface will be increased, if required some remedy shall be provided.

Capacitors which are liable to be subjected to high over voltages by lightning should be adequately protected. If surge arresters are used, they should be located as near as possible to the capacitors. Special arresters may be required to take care of the discharge current from the capacitor, especially from large banks.

When building up a capacitor bank from a random selection of units, care should be taken to control over voltages due to the difference in capacitance between the units or groups of units. In the case of star-connected banks with isolated neutral, capacitance differences between phases will lead to an increase of the voltage across the capacitors in the phase with the smallest capacitance.

All the materials for fencing, installation such as mounting racks, structures, supporting insulators, wiring and connection materials, nuts and bolts

necessary for installation and connecting the equipment to form a capacitor bank shall be included in scope supply all steel structures and nuts and bolts shall be hot dip galvanized.

3.1. Harmonic

Capacitor banks series reactors and their accessories shall be so designed to prevent exceeding harmonic levels from permissible levels in high voltage and medium voltage levels.

When the voltage rise at periods of light load is increased by capacitors, the saturation of transformer cores may be considerable. In this case, harmonics of abnormal magnitude are produced, one of which may be amplified by resonance between transformer and capacitor.

3.2. Discharging Units

Effective discharge devices, permanently connected to each unit capacitor shall normally be provided. These devices shall be designed to discharge the entire capacitor unit from the peak alternating voltage down to a voltage not exceeding 75 volts measured at the unit terminals within a time not exceeding 10 minutes.

Capacitor bank's fence door shall have necessary interlock to only be opened when the capacitor unit discharges to later level.

A discharge device is not a substitute for short circuiting the capacitor terminals together and ground before handling.

Means shall also be provided for the short - circuiting and earthing of each unit capacitor and for the earthling of all normally unearthed metalwork ; as far as practicable, these means shall be simultaneously operated from the outside the capacitor bank compound.

Interlocking shall be introduced to prevent access to the capacitors without these earths applied and the interlocking feature shall also be arranged to prevent the capacitor banks being energized whilst the earth's are applied for unit capacitors and metalwork not so earthed, reliance may be placed on devices supplied from within the compound but as far as practicable these should be applied simultaneously by a mechanical method.

Hand applied devices shall only be used at those points which are freely accessible from outside the unit capacitor racks.

4. Fabrication and Manufacture

4.1. Capacitor Units

Static compensators shall comply, as regards rating, temperature rises, over - voltages and overloads with the appropriate requirements of the latest edition of IEC 60871.

The increase in the continuous r.m.s current through the capacitor arising as a result of variation in supply voltage, supply frequency and the presence of harmonic voltages will be restricted to 130% of the normal current through the capacitor at rated sinusoidal voltage and normal frequency.

The contractors shall exercise a high degree of quality control during design and manufacturing to assure that all equipment and attachments will withstand earthquake forces as specified and also special attention should be given to the climatic conditions outlined in related chapter of the specification.

If needed and accordance with special service condition such as high altitude, high relative humidity, corrosive atmospheres, high pollution, earthquake area some provisions shall be considered.

Attention should be paid to the upper operating temperature of the capacitor, because this has a great influence on its life.

The internal element of capacitors shall be specified and shall be of the best quality and procedures. They shall be sealed hermitically in a case. The units shall be completely dehydrated under vacuum and temperature and dried, then impregnated with the insulating oil which had been completely refined not to leave any gas or impurities in the case, which may cause deterioration of the insulation. The changes in oil volume due to temperature change shall be possible without any contract with atmosphere.

All film units are preferred to paper film units because they have low probability of rupture.

The oil must be PCB free. The design of all materials and processes used in the construction of the capacitors shall be such as to reduce to a minimum the risk of the development of acidity in the impregnating fluid.

Every precaution shall be taken to ensure that the impregnating fluid is free from metallic particles and all other deleterious substances.

When capacitors are impregnated with material that must not be dispersed into the environment, precaution shall be taken.

The container for safety requirement and to enable the potential of the metal container to be fixed shall have provision for connection unit case to ground by means of a bolt or equivalent.

Lifting and pulling eyes shall be provided as appropriate on the various items.

In the case of any internal over pressure, only the punching container will be acceptable so there must not be seen any evidence of explosion.

Rating plate

Suitable wording shall be included on a suitable plate attached to each unit capacitor container to indicate whether the discharge devices are fitted internally or externally to the unit capacitor and the precautions to be taken before handling.

The rating plate and warning plate of each unit and capacitor bank shall be provided in accordance with IEC 60871.

4.2. Switching and Protective Devices and Connections

The switching and protective devices and the connections shall be designed to carry continuously a current of 1.43 times the current which would be obtained with a sinusoidal voltage of r.m.s value equal to the rated voltage at the rated frequency.

The switching and protective devices and the connections shall be capable of withstanding the electro - dynamic and thermal stresses which are caused by transient over - currents of high amplitude and frequency which may occur at switching on. Also they shall be capable of withstand short time symmetrical, asymmetrical currents.

When consideration of the electro-dynamic and thermal stresses would lead to excessive dimensions, special precautions should be taken.

In certain cases, for example, when the capacitors are automatically controlled, repeated switching operations may recur at relatively short intervals of time. The residual voltage on a capacitor prior to energization shall not exceed 10% of the rated voltage.

Switching devices especially suited for capacitor switching shall be used. These switching devices shall be suitable for opening capacitive currents at least class C2 (probability of restrike is very low) and suitable for closing capacitive currents especially for back to back capacitive making high frequency transient current.

Switching devices are not intended for use as fault current interrupting devices. But they shall have fault-making capability as the capacitor switch is closed in on a faulted capacitor bank.

Capacitor switches shall be capable of 100,000 operations at least and should have provision for manual tripping and closing.

Capacitor switches shall be provided with a position indicator that clearly indicates the closed or open position that visible while standing on the ground.

Capacitor bank and its control device shall be co-ordinate with the other parts of the offered medium voltage switchgear.

The protection against internal faults of a capacitor bank built up of a multiplicity of units is especially necessary. Suitable means should be provided to isolate automatically a faulted unit.

A capacitor switch having a metal housing shall have provision for the connection of a ground lead.

Capacitor switches for substation applications should have provision for manual tripping and closing.

A capacitor switch shall be provided with a position indicator that clearly indicates the closed or open position.

Any bad contacts in capacitor circuits may give rise to small sparks causing high-frequency oscillations which may over-heat and over-stress the capacitors.

Regular inspection of all contacts of the capacitor equipment is therefore recommended The contractor to furnish the details, places of inspection and periodicity of the inspection etc., for meeting the above criterion.

4.3. Fuses

Fuses may be provided internally for protection of individual capacitor elements of groups of elements, and/or externally for protection of complete capacitor units. These fuses shall minimize the probability of case rupture in the event of a capacitor unit failure but when energizing the capacitor bank and introducing inrush current fuses shall not be operated. Also these fuses shall not operate when a fault out of units is occurred and units outrush to fault.

Fuse rating current shall be at least 1.43 times the unit current. Fuses in particular should be chosen with adequate thermal capacity.

If fuses internal to the capacitor are provided they shall not blow when the capacitor is subjected to discharge test. External fuses may be allowed to blow when the capacitor is subjected to this test.

Outdoor Fuses with appropriate flag have better performance because of better visual inspection.

The contractor shall demonstrate or provide evidence to the satisfaction of the Engineer that the fuses are capable of breaking the fault current produced by the failure of a protected element and where the fuse is internal, that the contamination of the impregnate is not such as to affect the reliability of the remaining sound elements.

Fuses, whether internal or external shall be so constructed that when they operate due to a defective element, the blown fuse will withstand indefinitely the voltage imposed across working conditions.

External fuses shall be fitted with suitable means of indentifying a blown fuse from a safe distance whilst the capacitor is energized.

Where the capacitors are fitted with internal fuses, portable test equipment or other suitable means shall be provided to enable defective capacitors to be readily identified. The contractor shall demonstrate to the satisfaction of the Engineer the use and performance of the apparatus provided under this clause.

It is recommended that capacitors be protected against over - current by means of suitable over - current relays which are adjusted to operate the circuit breakers when the current exceeds the permissible limit specified in IEC 60871. Fuse protection generally is not acceptable for over-current protection.

The first stage of protection is the operation of unit fuse. The second stage is the relay protection of the bank (for example over current or unbalance protection). The third stage is the network or equipment protection.

4.4. Damping Reactors

Air core reactors shall be connected in series with each capacitors stage, to limit inrush current and over voltage to acceptable levels during energizing. These reactors shall be suitable for outdoor installation and shall be capable of operation continuously injurious heating at maximum rating.

The peak value of the over currents due to switching operations should be limited to both a maximum of 100 In (r.m.s. value) and switching devices maximum high frequency withstand currents.

The design and manufacture of reactors is to be such as to minimize noise and vibration. This is a matter of importance and attention shall be given by the contractor to ensure compliance with this requirement.

Material stresses which caused by vibration shall have approved safely factors, relative to material yield point strengths.

The coils and magnetic circuit shall be of robust design capable of withstanding any shocks to which they may be subjected during lifting, transport, installation and service including seismic shock.

4.5. Detuned Reactors

Detuned reactor is connected series with power factor correction capacitors. This equipment prevents harmonic amplification caused due to resonance and avoids overloading of the capacitors. Detuned reactors along with capacitors form a series resonant circuit with a certain tuning frequency at which the branch will offer a low impedance path at the fundamental frequency and a high impedance path at frequencies higher than its tuning point. As a result it can reduce high frequency voltage and current harmonics distortion in the network.

Connected in series, Detuned reactors shall be able to withstand losses resulting from both fundamental and other harmonic currents without exceeding the temperature limitation of their insulation materials under actual environmental conditions.

The measured loss of detuned reactors shall not exceed the guaranteed value by more than 10%. The measured quality factor of detuned reactors shall be within ±20 % of the value stated by the manufacturer in the tender.

Inductance accuracy must be within close tolerances, and sufficient core linearity must obtain to withstand switching of capacitor steps without causing saturation problems in networks of high harmonic distortion. For detuned reactors, the measured inductance at rated frequency shall be within ±2% of the specified value.

Other requirements, such as the capacity to withstand induced overvoltage, fault level and BIL, have to be considered. Moreover, since the detuned reactor causes increase of voltage on the resonance circuit capacitor, it is necessary to use capacitor at a higher voltage than the network rated voltage.

These reactors shall be suitable for outdoor installation and shall be capable of operation continuously injurious heating at maximum rating. It shall be equipped with appropriate protection devices to avoid its over-temperature and failures. A suitable ventilation system for enclosures (if any) shall be provided by the supplier of reactors and the calculation book shall be submitted for approval.

The arrangement of MV terminal connections of detuned reactor shall be finalized during detail design.

Detuned reactors shall be capable of being overloaded according to IEC 60871 and 60076 requirements.

Detuned reactors shall be provided with rollers to enable the movement in longitudinal and transversal directions. It shall be possible to remove the rollers and fix the reactor to the foundation. Necessary means shall be provided for lifting the reactor by chain or cable.

Detuned reactor core shall consist of individually insulated high permeability silicon steel laminations. The laminations shall be treated to avoid the ingress of moisture. The core shall be rigidly clamped and the windings shall be firmly braced to the core to ensure adequate mechanical strength and to reduce vibration under operating conditions.

One per phase, self-resetting thermal switches shall be provided for over temperature protection and indication of detuned reactor. The leads of contacts shall be wired to a terminal box attached to the reactor frame.

The design and manufacture of reactors is to be such as to minimize noise and vibration. This is a matter of importance and attention shall be given by the contractor to ensure compliance with this requirement.

Material stresses which caused by vibration shall have approved safely factors, relative to material yield point strengths.

The coils and magnetic circuit shall be of robust design capable of withstanding any shocks to which they may be subjected during lifting, transport, installation and service including seismic shock.

Each detuned reactor shall be provided with a rating plate securely fixed in a visible position. The rating plate shall be made of stainless steel.

4.6. Other Equipment

Other equipment required such as control and protection, Surge arresters, current transformer, Connections and insulators and Steel structure shall be provided in accordance with related.

4.7. Finish

The contractor shall recommend all instructions and supply all equipment that is necessary for safe and normal operation.

All external metal parts appropriate for painting shall be adequately cleaned and painted with one primer and two finish coats of oil and weather resistant paint.

All external metal parts appropriate for galvanizing shall be hot-dipped galvanized to minimum thickness of 80 µm.

Capacitors with mild steel cases shall be painted with primer and finish coats of paint in a manner so that damage to the surface will be self-healing and not support rusting or corrosion.

Capacitors with stainless steel cases may be painted or left unpainted at request of buyer.

All the consuming material for erection installation and complete operation of the capacitors shall be furnished.

4.8. Accessories

Accessories shall include but not limited to the following items:

- Capacitance measuring instrument for checking integrity of capacitors and fuses.
- Ground pad(s) with tapped holes at all locations requiring a ground connection.
- Terminal boxes and wiring.
- Tools-furnish all necessary special tools and equipment required for assembling and disassembling the equipment. Provide an itemized list of these tools.
- Compatibility with requirements of monitoring, measurement, operating conditions, alarms, annunciation

4.9. Shipment

The method of preparation for export shipment shall be adequate to protect each item against corrosion, dampness, breakage or vibration damage that might be encountered in transport and handling. Packaging shall be such as to prevent tampering or pilfering and to obtain approval and acceptability by transportation companies.

5. Factory Tests and Inspections

Routine tests shall be witnessed as specified in the latest edition of IEC Standard 60871 and other mentioned standards in this Technical Specification. Evidence shall be submitted that type tests and endurance test specified in latest edition of IEC 60871 and other mentioned standards in this Technical Specification have been performed and passed successfully in an independent accredited laboratory. The said type test documents shall include full technical details and in general shall not be older than 5 years. All type tests shall be carried out at the manufacturers' expense.

The engineer has the right to have representative at the factory for determination of compliance of the capacitor banks with provisions of the specification.

The manufacturer should provide curves or tables showing the capacitance, as well as losses under steady-state condition at rated, as a function of ambient temperature.

For all equipment for which factory testing is required, a comprehensive test program and time schedule shall be made by the contractor and submitted to the purchaser for approval. The program shall include such details as the sequence of the tests, blank test record sheets, test procedures, test circuits, details of the testing equipment to be used and calibration related information. No equipment shall be dispatched to the site without having been inspected and approved by the purchaser, and/or without his written consent.

All instruments and their calibration shall be to approved, and, if required by the purchaser, shall be calibrated by an approved body. All measuring, test equipment, and qualified personnel required to carry out the tests, shall be provided by the manufacturer.

Unless otherwise stated, type tests when called for shall be made on equipment, which has previously passed its routine tests. The arrangement of all tests and the method of computing the results shall be approved by the purchaser.

The purchaser shall be notified 60 days in advance, whenever a type or routine test is going to be done, so that the test may be witnessed if required.

6. Supervision over Installation and Commissioning

If requested, installation and commissioning of the capacitor banks shall be supervised by the Contractor, to ensure satisfactory and proper operation in every respect.

7. Submittals

The Contractor shall submit, in accordance with Section 3; drawings, calculations, test reports and literature pertaining to specified items of material to be supplied under this section. Submittals shall include but not limited to:

- Outline dimension drawings & Weights.
- Assembly, erection and termination drawings
- Control and protection schematics, wirings and circuit diagrams.
- Compartments drawing.
- Drawing and information sheets giving details of connection between capacitor banks and their accessories and other equipment in medium voltage switchgear.
- Type, endurance and routine tests reports.
- Instructions for maintenance and operation.
- All recommendations which are necessary for safe and normal operation.

8. Spare Parts

The Contractor shall be provided spare parts as per schedule of quantities and prices.

TECHNICAL SPECIFICATION

SECTION 17

LOW VOLTAGE AC SYSTEM

MONENCO – IRAN CONSULTING ENGINEERS COMPANY

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1. General

The scope of work of this section consists of design, manufacture, factory testing, transportation, erection and commissioning of 400/230V low voltage AC station service systems including main and distribution panels for both indoor and outdoor AC services, standby diesel generator unit (If required) and all their associated accessories necessary for proper operation in addition to supplying mandatory spare parts. The above mentioned includes:

- Main three phase, four wire, low voltage AC station service panels
- 3ph, 4wire low voltage AC lighting distribution panels for both indoor and outdoor use
- 3ph, 4wire low voltage distribution panels for both indoor and outdoor AC services
- Mandatory spare parts installed in each panels

The station service AC power supply shall be properly designed and sized to supply loads such as heaters, HVAC, oil filtering, lighting, outlets and other ancillaries and auxiliaries as required for substation operation. Load calculations, as well as calculations for short circuit on busbars and feeders, cable sizing and voltage drop shall be submitted by the contractor for the Engineer’s approval.

According to the technical specification, the minimum requirements are presented at the associated Data Sheet. Contents of the Data Sheet are strongly obligatory and any deviation from it, results in rejection of the bidders' proposal.

The tenderer must fill out the guarantee data completely and should provide a list of deviations from this Technical Specification and appended drawing which will be used in technical evaluations, otherwise it means that the tenderer has accepted all the requested requirements and has confirmed the correctness and suitability of this specification completely.

2. Codes and Standards

All processes and works classified under this section shall comply with the requirements of the latest editions of International Electrotechnical Commission (IEC) standards.

IEC publications listed below form part of this specification to the extent specified in this section:

IEC 60034 Rotating Electrical Machines

IEC 60059 IEC Standard current ratings second edition

IEC 60083 Plugs and Socket outlets for domestic and similar general use standardized in member countries of IEC third edition

IEC 60617 Graphical symbols for diagrams

IEC 60947 Low Voltage Switchgear and Control gear

IEC 60230 Impulse tests on cables and their accessories

IEC 60282 High Voltage fuses

IEC 60947 Low Voltage Switchgear and Control gear

IEC 60298 AC Metal Enclosed Switchgear and Control gear

IEC 60309 Socket Outlet and coupler for industrial purpose

IEC 60364 Electrical Installation of Building

IEC 60420 High Voltage AC switch-fuse combinations

IEC 60439 Low voltage switchgear and control gear assemblies

All the amendments and references listed with the above standards shall apply and other relevant IEC standard should be considered, by the Engineer Approval. In case of lacks in IEC, Other standards can be considered through the Engineer approval.

3. Design Requirements

The 400/230V AC auxiliary supplies shall be obtained from the LV side of the auxiliary transformers. It shall 400/230V, 3 phase and 4 wires with solidly earthed neutral at the main panel and consists of two busbars, essential and non-essential, connected to each other by a bus section CB. The LV system as per single line diagram shall have two air insulated single bus bar, three incoming breakers and one bus tie. The four circuit breakers shall be interlocked such that only two breakers can be closed at a time.

Under normal condition, only one auxiliary transformer will be feeding the entire load and the circuit breaker of the one incoming feeder (the essential or non-essential busbar) and bus section shall be closed. In the event of any voltage of incoming feeders falls below a predetermined, the other feeder circuit breaker shall be closed automatically. Also manual switching between feeders shall be made possible locally from the AC panel and remote from DCS workstation. No synchronizing between sources of supply is required and all breakers shall be breaking connection before make it. A local/remote selector switch shall be provided for AC system and mounted on main panel.

In special case, both auxiliary transformers may be fed the load and the circuit breaker of the both incoming feeder (the essential and non-essential busbar) shall be closed and bus section shall be opened. For this case, the priority selector switch is not required. In other special case, there is only one busbar and bus section is not required. Therefore, one of auxiliary transformers will be feeding the entire load and the circuit breaker of this incoming feeder shall be closed. In the event of any voltage of incoming feeders falls below a predetermined, the other feeder circuit breaker shall be closed automatically. The AC system shall be designed according to appended drawing anyway.

Contractor shall be provided an automatic/manual selector switch with all the necessary devices and interlocks for safe switching of the main circuit breakers with automatically and manually operation according to the principle described above.

None of the automatic and manual transfers shall take place if the respective incoming circuit breakers have tripped from their protections (i.e. due to bus fault and backup tripping and etc.).

All incoming connections, busbars and feeder connections shall be capable of the short time current rating specified and shall meet all required loads plus 25%. All outgoing groups for more than 25A from the station service AC supply

shall be protected by molded case circuit breaker. All final equipment ratings shall be determined by Contractor and submitted for review by the Engineer.

Contractor shall provide all necessary protective relays, instrument transformers, metering and indication equipment to ensure the safe operation and protection of the AC station service equipment. Contractor shall design and supply a protection system which will adequately protect against all types of faults and will provide discrimination and coordination in detecting and isolating faults.

It shall be the responsibility of Contractor to fully co-ordinate the over load and short circuit relays of circuit breakers with upstream devices and all downstream protections to provide satisfactory discrimination.

The essential busbar shall be fed from standby diesel generator source of AC supply. The standby diesel generator shall be designed for supply to the essential parts only according to appended drawing. When the diesel generator is connected, the non-essential parts are disconnected.

Lighting feeders shall be switch fuse contactor operated. The contactors shall be closed and opened manually and automatically by set of photo switches and/or preset timer having contact output which close when the natural light in the area of location of these photo sensitive devices is below the set value or the clock timer setting. Similarly, the light will be turned off in the morning. The design shall be allowing easy extensions of the boards with as small interruptions as possible for the existing system.

All equipment shall be of type satisfactorily tested by an approved short circuit testing authority for a busbar and main isolator through fault current according to datasheet values, for LVAC panel and switch fuse box. The peak asymmetrical fault withstands rating of the busbars and connections shall be equal to or greater than the making rating of the associated switchgear.

The enclosures shall be so designed that in the event of an arcing fault within a compartment, the effects are contained within the compartment for 3 seconds.

4. Fabrication and Manufacture

4.1. AC Main and Distribution Panels

The main AC distribution panel/boards shall be three phase and contain air circuit breakers and molded case circuit breakers to feed the switchyard lighting panel board, building lightings, heating and cooling panel boards, AC power supply to the battery chargers and relays and control panels in the control and switchgear buildings, and all other equipment requiring AC power.

The main panel/board shall contain breakers for the main incoming station service supplies and if applicable, an emergency diesel generator with suitable automatic changeover. The distribution board shall incorporate a bus section breaker interlocked with incoming breakers.

Panels shall be switchable for extension in either direction and designed with the requirements of specification and designed with the requirements of specification and fully type-tested as defined by IEC standards. They shall be designed in order to operate in the environmental conditions specified whether indoors or outdoors.

The boards and cubicles shall be dust, moisture and vermin proof and suitable for outdoor or indoor installation. Protection degree of indoor/outdoor switchboards and distribution boards shall be considered according to Data Sheet section and in accordance with IEC 60529 standard.

A minimum of 20% spare for outgoing breakers of each rating shall be provided. The minimum number and rating of the AC breakers shall be in accordance with the relevant drawings and finalized in design stage.

Photocell, contactor and necessary accessories for automatic control of the switchyard lighting should be provided.

Panels shall be front type with modular steel enclosures and lockable-hinged doors. All elements shall be arranged so that easy access is possible from the front for easy installation, maintenance and replacement. Removable steel plates shall cover openings which are not in use for breakers.

Internal separation of an assembly shall be provided by means of barriers or partitions made of steel sheet.

A ground bus of copper with suitable cross section shall be installed in the entire length of each panel. The ground bus shall be provided with clamp type terminals at each end for connection to the station's main ground grid.

Panels shall be suitable for terminating in an approved manner, for all necessary cablings whether of copper or aluminum conductor design.

It shall be possible to terminate any cable whilst adjacent circuits are energized and all cable entrances shall be through metal glands on gland plate.

All switches and circuit breakers supplying 3-phase loads shall include a neutral connection, with same current rating as the phases. Interlocked devices for earthing on both sides of incoming supply circuit breakers shall be included.

The overall height of each tier of cubicles shall be such that the operating handles of all equipment are within the reach of an average person standing at ground level.

A separate connection shall be made from the earth bar to the main earth system.

Circuit breakers shall be provided with a handle padlock attached to enable the breaker to be padlocked in the open or closed position.

Main circuit breaker shall be provided with a trip alarm contact for remote indication. All circuit breakers shall be provided with trip position indication to clearly indicate the breaker's trip position.

A mimic diagram similar to relevant drawing shall be provided on the panel's front door.

Space heater and thermostat to prevent condensation and lifting lugs for panels shall be provided.

Where required for protective relaying and metering, current transformers shall be provided and shall be indoor, wound or window, dry type, insulated for full voltage of the system, and conveniently located in the panels.

Isolating voltage transformers shall be provided for metering and control purposes and shall be mounted in suitable compartments in the switchgear cubicles.

4.2. Busbars and Earthing

The main/distribution panels shall be provided with 3 phase, neutral and earth busbars and shall have uniform cross section throughout the length of the switchgear. Busbars shall be made of copper and shall be PVC sleeved.

Busbar taps and joints shall be PVC shrouded.

Separate supports shall be provided for busbars of each polarity. If a common support is provided for the busbars, antitracking barriers shall be provided.

It shall be possible to earth all incoming supplies to the switchboard by means of a fully rated earthing device, either by using the circuit breaker with earthing attachments, a separate earthing truck, or a fixed fully rated earth switch.

Busbars and dead end feeders may be earthed by means of a voltage checking device and hand applied portable earths. These shall preferably be applied from the front of the switchboard, but application from the rear will be considered in case the former is proven impracticable. All non current carrying metal parts shall be connected to the earth bus.

Busbars shall be adequately supported and braced to withstand the stresses due to the specified short circuit currents for the associated switchgear. Bus bar supports shall be made of insulator materials or special molded plastic material with sufficient electrical and mechanical withstand.

Busbar joints shall be of the bolted type and busbars shall be thoroughly cleaned and galvanized at joint locations. Also suitable contact grease shall be applied just before making a joint.

4.3. Air Circuit Breakers (ACB)

4.3.1. General

The air circuit breakers shall be 4pole, metal-clad, mechanically operated, having anti-pumping feature, stored energy type, having internal current protection device, quick-make and quick-break air circuit breakers and shall be mounted individually.

Breakers shall be rated for 100 percent continuous duty, with frame and trip rating as shown on the drawings.

4.3.2. Closing and Tripping Operation

For automatic closing of the ACB, a universal motor fitted with limiting switches shall wind the spring mechanism. In addition, the spring mechanisms shall have manual charging facilities for emergency use.

Unless otherwise specified, trip coil of 110V DC type shall be fitted for local, remote or relay tripping. "Trip" push buttons shall be provided on the front plate of each ACB. These buttons shall be direct acting mechanically.

A push button shall also be mounted on the front plate of each ACB to enable local closing for normal operation.

Each breaker shall be equipped with four current transformers or sensors, three for phases and one for neutral, and a micro processor-based trip unit.

Circuit breaker operating mechanism shall provide the following requirements:

- The operating mechanism shall be of stored energy type. The storing of energy shall be possible both manually and electrically
- The manually operated mechanism shall be of the spring charging stored energy type
- The power operating mechanism shall be of the motor wound spring charged stored energy type
- The closing action of the circuit breaker shall charge the tripping spring and make it ready for tripping

- All stored energy mechanism shall be provided with mechanical indicators to show the charged and discharged conditions of the spring.

The design of the operating mechanism shall be such that:

- The circuit breaker does not close unless the spring is fully charged
- Shocks, vibrations or failure of spring does not cause the breaker to operate or to prevent an intended tripping.

Power operated mechanism shall be:

- Provided with a universal motor suitable for operation on 230V AC and 110V DC control supplies with voltage variation from 85% to 110% rated voltage.
- Designed to enable a continuous sequence of closing and opening operation as long as power is available and at least one opening operation on power supply failure.
- Provided with emergency manual charging facilities.
- Provided with facilities for remote closing and opening operations carried out on the CB for control and auto changeover schemes.

Power operating mechanism shall be provided with the following features:

- Closing of the circuit breaker shall automatically initiate recharging of the spring, and make it ready for next closing stroke
- The motor shall be mechanically decoupled as soon as emergency manual charging handle is coupled
- The circuit breaker mechanism shall make one complete closing operation once the control switch has been operated, even if the control switch is released before the closing operation is complete
- Closing controls shall be arranged so that only one closing operation of the circuit breaker results from each close initiating impulse.

4.3.3. Protection Units

Protection units shall be true RMS sensing, with trip ratings adjustable with removable rating plugs. The protection units shall be of magnitude and time adjustable, and shall include a local indication of the cause of a trip. The protection units shall be rated as shown on the related drawings.

The protection units shall allow adjustments without breaker trips and routine testings without removing the breakers from service.

The protection units shall be rated for 100 percent continuous duty.

4.3.4. Interlocking Facility

Suitable interlocking facilities shall be provided such that:

- The ACB cannot be plugged in or withdrawn when it has been closed.
- The ACB cannot be closed until it is fully engaged in either the CONNECTED or the TEST position.
- The ACB cannot be slowly closed except in TEST or ISOLATED position.
- It shall not be possible to initiate the closing action of the energy stored in spring mechanism until the spring has been fully charged.

Covers or doors giving access to live parts of the circuit breaker cannot be removed or opened unless circuit breaker is fully isolated.

4.3.5. Control and Monitoring Function

The control unit shall optimize the Protection of the equipment or the circuit conductors in the event of repeated over load or faults by using, thermal integration to memorize temperature rises.

A digital display with the ability to show real time current, voltage, power, power factor and frequency shall preferably be provided. A keyboard in the front side shall be available as interface.

The breakers shall be provided with green, red and amber indicating lamps for CB’s different statuses.

4.3.6. Auxiliary Contact

All contacts shall be self-aligning, provided with spring accelerated opening mechanisms.

Main contacts shall be fitted with detachable arc chutes for each pole.

Sufficient auxiliary contacts shall be provided for connection of secondary wiring. These auxiliary contacts shall remain engaged when the ACB is in the TEST or CONNECTED position and shall be disengaged when the ACB is in the ISOLATED position.

All ACBs shall be fitted with the maximum number of auxiliary contacts as in the manufacture's standard provision. In any case, not less than two pairs of normally closed auxiliary switches and two pairs of two normally open auxiliary switches shall be provided. All auxiliary contacts and switches shall be wired to an easily accessible terminal strip for external connection.

Terminals for secondary/auxiliary contacts of each ACB shall be separated from all other terminals by means of a spacer of 20mm width.

Breaker's position and all related conditions shall be provided with indications, such as CB in test position, CB in service position, CB tripped, CB open, CB close…

4.4. Molded Case Circuit Breaker (MCCB)

4.4.1. General

The operating mechanism of the MCCB shall be of the quick-make, quick-break type with fault tripping overriding manual operation or when breaker is held in the ON position. A toggle shall actuate it or handle that clearly indicates the three positions: ON, OFF and TRIPPED. The MCCBs shall comply with and be type tested according to IEC 60947-1 & IEC 60947-2.

When the MCCB is in the OFF position, isolation shall be provided by a double break on the main circuit. MCCBs shall be provided with a facility for pad locking in either the "ON" or "OFF" position.

MCCBs shall be equipped with a "push to trip" button in front to test operation and the opening of the poles.

4.4.2. Operating characteristics

MCCBs with built-in protection shall have thermal-magnetic or solid state electronic tripping device which features an adjustable, stable, inverse time current characteristic. The operating characteristics shall be calibrated at 45oC.

MCCBs with ratings of over 250A shall be equipped with electronic trip units. Electronic trip units shall comply with IEC 60947-2 Standard (measurement of RMS current values, Electromagnetic compatibility, etc) electronic trip unit characteristics shall include long time, short time and instantaneous protection and the protection's setting shall apply to all circuit breaker poles.

Where shunt trip release is specified, the MCCB shall operate correctly at values of supply voltage between 70% and 110% of the nominal supply voltage and under all operating conditions of the MCCB up to the rated short-circuit breaking capacity of the MCCB.

4.4.3. Performance Characteristics

MCCBs shall be certified according to IEC 60947-2 to have the following performance characteristics:

- Rated symmetrical short circuit breaking capacity not less than 25kA
- Rated operational voltage 690V AC
- Rated insulation voltage 750V AC

The maximum tripping time under short circuit conditions shall not exceed 25ms for inverse time and instantaneous tripping characteristics. For MCCBs of 100A and below instantaneous tripping at a fixed value of 800% to 1000% shall be provided.

4.4.4. Auxiliaries and Accessories

All MCCBs shall be compatible with motor mechanism for electrically controlled operation. Following tripping due to electrical faults (overload, short circuit, and earth faults), remote reset shall be inhibited.

The operating mechanism shall be of the stored energy type only.

Enough auxiliary contacts shall be provided for all MCCBs to allow remote indication of the position of the MCCB in addition to alarm contacts to indicate when the MCCB has tripped.

4.5. Miniature Circuit Breaker (MCB)

Where miniature circuit breakers are used for controlling and protecting AC power supply circuits, they shall be designed and tested according to BS 3871 or relevant IEC Standards.

Miniature circuit breakers in AC system circuits shall be of the single or three pole types.

Miniature circuit breakers shall be equipped with an auxiliary contact for alarm operation.

Miniature circuit breakers shall be designed and mounted in a way that inadvertent operation is prevented and checking circuit breaker's position is facilitated.

4.6. Fuse switches

Fuse switch units shall comply with the requirements of IEC 60947-3.

Each switch shall be rated to be able to interrupt circuit's rated load current and in case a motor circuit is being controlled it shall be capable of switching under locked rotor conditions.

Fuses shall be of the high breaking capacity type according to IEC 60269-3. Accessing the fuses shall only be possible when they are de-energized and are isolated from the source of supply.

Mechanisms shall be of the spring-loaded type such that the operation speed of the switch during opening and closing is independent of the operator and once initiated the operation is completed.

In case of spring failure, operation of the switch shall be possible but without danger to the operator.

ON or OFF Indication of the switch shall be clearly provided. It shall be possible to lock the operating handle in either of these positions.

The performance of the fuse switch unit shall match with the specified when the unit is mounted in its cubicle.

Isolating fuse switche units shall be of the air break type and shall have integral fuses. It shall be possible to safely replace the fuses with the busbars alive and the switch open.

4.7. Fuses

All fuses shall be of High Rupturing Capacity (HRC) plug in type.

Fuses shall be provided with visible indication to show that they have operated.

It shall be possible to replace fuses with the circuit being connected, without having electric shock hazard.

Current versus time characteristics of fuses shall be furnished with the tender.

Fuse ratings shall be suitable for the current rating of the circuit. Fuses for motor circuits shall take care of starting characteristic of the motor, thermal characteristics of cables, multi hot and cold start duty of motor etc.

4.8. Contactors

Contactors shall be of the electromagnetic air break type rated for uninterrupted duty. Each contactor shall be equipped with 4 normally closed and 4 normally open auxiliary contacts.

Suitable over voltage suppressors are to be provided on all contactor coils.

A suitable facility should be provided to test the operation of the contactor with the switch fuse isolator and the front door open.

Contactor shall be of the double break, non gravity electrically held in type, selector switches (auto-off-man), and red and green indicating lamps shall be provided on contactor units.

Contactors shall operate quite satisfactory for five (5) minutes duration when the supply voltage falls to 70% of the normal value periodically.

All motor feeders contactors shall be provided with a delayed release device arranged so that they will remain closed in case of interrupt on or reduction of

auxiliary supply voltage but not after operation of the protection relay for a period adjustable between (2 to 10) seconds.

4.9. Indicating Instruments and Meters

Indicating instruments shall be flush mounted on the panel with only flanges projecting.

Ammeters shall be connected through suitable current transformers. Ammeter selector switches shall be of the make-before-break type in order to prevent open circuiting of current transformer secondary when changing the position of the switch.

Voltmeters shall be protected with HRC fuses.

The voltage of essential and non-essential busbars, current of each incoming feeder and power (Measuring Center) of AC system should be provided for related AC panels and for controlling panel by transducers according to appended drawings.

4.10. Current Transformers

Current transformers shall be of dry type. The current transformer shall have a short time withstand rating equal to the short time withstand rating of the associated switchgear/distribution board.

Separate current transformers shall be provided for metering and protection.

It is the responsibility of the contractor to ensure that the current transformer's burden, saturation factor and etc. are adequate for the relays and meters connected. The accuracy class for metering shall be 1.0. The CT’s shall be as per IEC 60044.

Test facility shall be provided to the CT secondary to test the CT in service.

All current transformers shall be earthed through a separate earth link on their terminal block.

4.11. Automatic Transfer System

The main LVAC panel shall be provided with time delayed automatic transfer schemes through respective auto/manual selector switch.

The general principles shall be as follows:

1) Only one supply source shall be connected at one time. Measurements shall be taken for interlocking with the other sources of supply and the stand-by diesel generator set.

2) When loss of voltage is registered on the supply source1, the automatic switchover shall check for voltage availability on supply source 2. If voltage is available on source 2, source 1 shall be disconnected and source 2 connected. If there is no voltage on source 2 either, other sources shall be checked with the same sequence and in case that there is no voltage on other sources, all non-essential boards shall be disconnected and the diesel generator shall be started up and its breaker shall be closed automatically. Monitors shall be provided to indicate that the diesel generator set has acquired its full rated conditions (speed, voltage and frequency). Proper relaying scheme monitoring the speed, voltage and frequency shall then permit the operator to close the diesel generator's breaker manually.

3) Restoration of normal service (any one) shall be detected by monitoring the voltage on the auxiliary windings of Auxiliary Transformer.

4) In case of voltage return to power source 1, the switchover shall re-establish the normal conditions automatically. Any of the sources can be selected by the priority selector switch as the main source and the other as stand-by.

5) Manual changeover between sources shall be possible. The diesel generator set shall have facility for manual starting and stopping and connecting to the essential buses manually. Facilities shall be provided in other to connect the non-essential bus to the diesel generator supply, manually. If the load on the essential bus increases and the generator gets over-loaded, then the non-essential bus shall be tripped automatically.

For monitoring of incoming voltages, under voltage relays shall be supplied. The relays shall be of 3 phase type and the trip signal shall be sent after an adjustable time delay between 2-10 seconds to the respective incoming breakers.

Auxiliary relays and any other equipment required for achieving various interlocks shall be included in scope of work and also in the judgment of the Engineer as required in this specification.

These auxiliary relays shall preferably be located in the respective 400/230V panels.

If these auxiliary relays cannot be accommodated in main panels, Contractor shall supply separate panels incorporating these relays. These panels shall be located near respective AC panels.

Hand reset relays with adequate NO+NC contacts shall be used for each air circuit breaker to trip circuit breakers and block their closing unless being reset by hand.

The relays shall be suitable for specified supply and of flush mounted type. Other details shall be as required in the schemes.

The automatic transfer system shall be fed from the DC system.

5. Inspection and Tests

The contractor shall perform all inspections, routine and type tests stipulated in applicable standards to ensure that used materials and workmanship conform to the specification and drawings.

The contractor shall also provide access to the work for Client's representative in order to determine and assess the compliance of work with the provision of this specification or to witness the contractor's inspection or tests.

The contractor shall produce a compliance certificate for the equipment with the design, routine and type tests stipulated in the applicable standards.

All type, routine and special tests shall be performed in accordance with IEC standards. These tests are as follows:

5.1. Type Tests

- Temperature rise limit
- Dielectric properties
- Rated making and breaking capacities
- Rated short time withstand current
- Rated fused short circuit making capacity
- Mechanical endurance
- Electrical endurance.

5.2. Routine Tests

5.2.1. Mechanical Tests

- All contacts of all switches, relays and devices, including mounted equipment and devices furnished as un-mounted equipment in addition to spare parts, shall be tested for flawless contact operation

- Device markings, nameplate markings, conductor identifications, terminal block wire designations and the scales of meters and instruments shall all be checked against the approved shop drawings
- Each panel shall be checked for alignment of enclosure and devices, for rigidity of structures, and for adequacy of fastenings and supports.

5.2.2. Electrical Tests

- Point-to-point continuity and insulation resistance checks on all cubicle wiring
- Dielectric tests on all cubicles, in accordance with IEC standards
- Functional and operational checks on all circuit breakers, meters, control devices and circuits.

5.3. Site Tests

All switchgear and ancillary equipment shall be tested and shall include checking the completeness, correctness and condition of earth connections, labeling, painted surfaces, cables, wiring and all other auxiliary and ancillary items.

Loose items which are to be handed over to the Employer, i.e. tools, spares shall be checked to be in order or to be stored or handed over correctly.

Routine tests of switchgear's individual components i.e. circuit breaker, instrument transformers, relays, meters, etc.

- Insulation of control and power circuits
- Checks of fuses and circuit breakers
- Functional checks
- Checks of over current and other protective devices
- Checks of interlocks
- Checks of annunciations

- Calibration of indicating meters
- Checks on low voltage circuit breakers manual operation, electrical interlocks, tests on magnetic and thermal tripping devices, closing and tripping times, annunciations, auxiliary contacts
- Verification of effective grounding, earthing of armoring of cables, frame earthing, handle earth etc.
- Any other test recommended by the manufacturer.

Client's representative reserves the right to have a representative present during final workshop and functional tests. In order to give the client enough time for scheduling the survey, the contractor shall advise the date of test at least sixty (60) days in advance.

6. Supervision over Installation and Erection

The contractor shall perform visual inspections before installation to ensure that there is no damage resulting from shipment.

The contractor shall supervise installations, erection and commissioning of the station service equipment to ensure satisfactory and proper operation in every aspect.

This supervision covers the following where applicable, but is not limited to:

- Installing the equipment in accordance with the drawing and the manufacturer's instructions,
- Installing indoor and outdoor AC distribution panels,
- Installing diesel generator and its control cubicles, fuel tanks and accessories,
- Inspecting, making necessary adjustments, field-testing, and placing the equipment in commercial service.

Performing field tests and inspections including but not limited to the following:

- Visual inspection and checks, Hardware and mounting, Grounding connections, checking fuse and CB ratings, checking thermal relays and checking liquid level and density of the electrolyte in each cell,
- Alarm Tests, Loss of AC, AC output voltage low/high, Earth fault test,
- AC circuit breakers over current and thermal tests,
- Continuity test of all low voltage circuits,
- Measuring on all low voltage circuits,
- Check of the operation of all meters, relays, instruments, alarms and trips,
- Functional testing of all equipment,
- Starting up diesel generator, connecting the load and checking the circuits and functionalities.

7. Submittals

The Contractor shall submit, in accordance with Section 3; drawings, calculations, test reports and literature pertaining to specified items of material to be supplied under this section.

8. Spare Parts

The Contractor shall be provided spare parts as per schedule of quantities and prices.

TECHNICAL SPECIFICATION

SECTION 18

LOW VOLTAGE DC SYSTEM

MONENCO – IRAN CONSULTING ENGINEERS COMPANY

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1. General

The scope of work of this section consists of design, manufacture, factory testing and transportation during erection and commissioning of 125/110V DC and 48V DC station service Including battery chargers, battery and battery racks, DC main and distribution panels and all their associated accessories necessary for proper operation and supply of mandatory spare parts and shall include the following:

- Indoor and Outdoor DC main and distribution panels
- Battery chargers and battery equipment to supply control equipment, protection relays, PLC, RTU and emergency lighting at the substation
- Indoor and Outdoor DC emergency lighting panel
- Mandatory spare parts installed in each panel

The DC station service shall be properly designed and sized to supply loads such as control equipment, protection relays, motors, PLC, RTU, emergency lighting and other ancillary equipment as required for substation operation. Load calculations, as well as short circuit calculation for busbars and feeders, cable sizing and voltage drop shall be submitted by the contractor for the Engineer’s approval.

According to the technical specification, the minimum requirements are presented at the associated Data Sheet. Contents of the Data Sheet are strongly obligatory and any deviation from it, results in rejection of the bidders' proposal.

The tenderer must fill out the guarantee data completely and should provide a list of deviations from this Technical Specification and appended drawing which will be used in technical evaluations, otherwise it means that the tenderer has accepted all the requested requirements and has confirmed the correctness and suitability of this specification completely.

2. Codes and Standards

All work done in the scope of this section shall comply with the requirements of the latest editions of International Electrotechnical Commission (IEC) standards.

IEC publications listed below form a part of this specification to the extent specified in this section:

IEC 60050	International Electrotechnical Vocabulary
IEC 60269	Low voltage fuses with high breaking capacity for industrial and voltage contactors
IEC 60947-4-1	Clearances and Insulation level in air
IEC 60947-2	dielectric tests
IEC 60051	Direct-acting analogue electrical-measuring instruments and their accessories
IEC 60086	Primary batteries
IEC 60146	Semiconductor converters
IEC 60529	Degrees of protection provided by enclosures (IP Code)
IEC 60896	Stationary lead-acid batteries, general requirements and methods of test
IEC 60947	Low-voltage switchgear and control gear

All the amendments and references listed with the above standards shall apply and other relevant IEC standard should be considered, by the Engineer Approval. In case of lacks in IEC, Other standards can be considered through the Engineer approval.

3. Design Requirements

The LVDC supply shall consist of complete systems for protection, control signaling operation, alarms, emergency lighting, DC motors and Communication and Dispatching equipment such as PLC/RTU.

Main and Distribution DC systems (type of batteries, quantity of battery chargers, batteries, busbars, CBs and etc.) shall be generally as shown in DC Single Line Diagram (LVDC SLD) appended drawings. Generally, the station service DC supply shall consist of two busbars, SUB1 and SUB2, which are connected to each other through a bus section CB. Each section shall be fed from one of the main sources of DC supply.

DC voltage is normally supplied from the battery chargers, but if the AC supply is lost, the batteries should take over the power supply without causing any interruption in substation operation and protective functions as well as in substation emergency lighting for 10 hours until the AC station service is reinstated or until the stored charge in the battery cells is depleted. Under normal operating conditions, the chargers operate in parallel to supply the specified DC load and float charge of the related battery at the same time.

Each battery charger shall be sized to provide 100% of station's complete DC load current plus any additional current required in order to maintain the battery banks in a fully charged condition (float charge). Also, each battery bank shall be capable of feeding station's complete DC load through the distribution boards.

Each of the above mentioned DC supply systems shall comprise a stationary battery, battery charger, fuse box, main/distribution panel with all their required accessories.

Each battery shall comprise sufficient number of cells to provide the specified rating. The battery charger shall be capable of float battery charging, from the specified AC supply voltage. A system shall be provided for equalizing battery cells charges of the battery cells as well.

As part of this Work, Contractor shall also supply the following equipment and services:

- Duty cycle and short-circuit fault analysis for the DC system which will be used for equipment selection and rating and protection coordination

- Preparation of complete DC station service's load lists, identifying and quantifying all loads, which will be used for load allocation and equipment and cable selection and rating
- Preparation of connection wiring diagrams and cable lists for all DC station service system cables throughout the substation
- Any other item not specifically identified but necessary to complete the design, manufacture, assembly or testing of the Work

The 48V DC distribution shall be independent and supplied by separate main distribution panel(s) adjacent to the battery (ies) for the SCADA and communication equipment. Sub-circuit protection shall be in the particular panels, using MCBs. Any change-over and transfer facilities shall be located at these panels. Multiple grounding or earth return system is not permissible.

According to National Standard, the battery capacity shall then be optimized to the minimum obtainable temperature of 10°C inside the powerhouse. Final battery capacity shall include a minimum 15% design margin in the calculated value to allow for aging and temperature effects on the battery. Aging factor shall be considered 25%.

If more than one system is specified, manual or automatic transfer facilities which will be fully interlocked to prevent loss of output voltage shall be provided. Manual or automatic transfer system shall be considered of make-before-break type.

To the automatic operations, the following requirements shall also be met with the selector switch in the `Auto' position:

- On an automatic transfer, the breakers shall operate in such a way to prevent an interruption of power to the loads being transferred. Paralleling of supply systems will occur momentarily during this transfer. It shall not be possible to parallel the supply systems under any other circumstances.
- Individual control of each one of the supply and bus section breakers by means of their local control switches shall be blocked.

- The under voltage transfer control shall be blocked if any of the supply or bus section breakers are withdrawn from their `connected' position.
- The automatic under voltage transfer control shall be blocked if either of the supply breakers are tripped due to an over current condition, or if there is a complete AC failure to both battery chargers.

In the manual mode, it shall not be possible to parallel supply systems. The following requirement shall also be met with the selector switch in the `Man' position:

- Individual control of each of the supply and bus section breakers shall be possible by means of their local manual control switches. This shall apply whether the breakers are in the `connected' or 'test' positions - The automatic under voltage transfer control shall be blocked.

The system shall continue its normal operation in case of a fault on one feeder or section of the system without affecting the DC supply to other section. The system is required to continue its normal operation with a single ground fault but an alarm shall be initiated. The system will interrupt DC supply if ground fault current increases to a predetermined level or there are two ground faults.

4. Fabrication and Manufacture

4.1. DC Main and Distribution Panels

Panels shall be front type, floor mounted with modular steel enclosures and lockable-hinged doors. All elements shall be arranged so that they are accessible from front side for easy installation, maintenance and replacement. Removable steel plates shall cover openings not used for breakers.

Each outdoor distribution panel/board shall have silver-plated copper busbars, and shall be complete with a main incoming load breaker switch and outgoing MCBs, equipped with trip indicating auxiliary contacts.

The DC distribution panel assemblies shall be located in the control room adjacent to the battery room. The main DC distribution panels/boards shall be two phase and contain molded case circuit breakers and miniature circuit breakers to feed the emergency lighting panel, DC power supply to the control equipment, protection relays, motor of circuit breakers and disconnectors and all other equipment requiring DC power.

The distribution panel shall be fed from relevant battery charger / batteries combination via a 2-pole, electrically operated, withdraw-able type circuit breaker having DC shunt trips. The electric operator shall be suitable for operation on a DC supplies. Each circuit breaker shall be complete with 4NO plus 4NC auxiliary contacts for interlocking and remote position indication, and a trip alarm contact.

Panels shall be switchable for extension in either direction and designed with the requirements of specification and fully type-tested as defined by IEC standards. They shall be designed for operating in the specified environmental conditions whether indoors or outdoors.

Suitable arrangements shall be made for glanding and terminating of all cables entering and leaving the distribution panel in a manner that allows the addition of future cables as required.

Panel's main circuit breaker shall be provided with a trip alarm contact for remote indication. All circuit breakers shall be provided with trip position indication to clearly indicate the breaker's trip position.

The distribution panel assembly shall be complete with protective relaying and instrumentation including local and remote metering, alarms, indication and control switches.

A mimic diagram similar to relevant drawing shall be provided on the front door.

A removable card shall be provided in a holder fastened to the rear side of each door for use in identifying each outgoing branch circuit.

DC panels should be equipped with the following items:

- indicating signal for earth leakage (earth fault relay),
- indicating signal for increasing and decreasing of the DC voltage (i.e. under voltage and over voltage),
- indicating signal for loss of DC supply,
- fluorescent lamp for each panel with suitable lighting intensity controlled by ON/OFF switch and all other auxiliary materials,
- Space heater and thermostat near the lower part of the panel,
- Solderless clamp type terminals,
- Ground lugs for grounding the panels,
- A minimum of 20% spare DC circuit breakers, terminals, racks and etc,
- Nameplates on the front of the panel approximately 15 mm x 80 mm,
- Nameplates identifying each distribution circuit,
- Four lifting lugs shall be provided,
- Auto-transfer alarm,
- Auto-transfer blocked,
- Supply breaker over current trip,
- Feeder breaker over current trip.

The DC busbars shall be fully insulated and silver-plated at all joints. Connections shall be provided for the incoming single-conductor copper cables from the batteries and chargers. The buses shall be connected by a 2-pole electrically operated, withdraw able type, bus tie, circuit breaker having DC shunt trips. No over current devices shall be fitted to the bus-tie circuit breakers.

The distribution panel shall be fitted with a suitably rated DC voltmeter and ammeter with shunt and transducers, for remote indication of all DC voltages and currents at the powerhouse control room computerized equipment.

A DC over current relay, adjustable type, definite time, shall be fitted to each bus supply feeder for tripping the supply circuit breaker.

Ground fault relays shall be fitted to each bus in distribution panel to provide an alarm should a ground fault occurs on either the positive or negative bus, and to trip the incoming circuit breaker on occurrence of a second ground fault on either of the two buses, and block closing of the tie breaker.

DC under voltage relays shall be connected to each incoming battery supply feeder to provide alarms and under voltage transfer.

The supply breakers and the feeder circuit breakers shall be coordinated so that an overload or fault on any outgoing branch circuit shall be cleared by the associated circuit breaker, without tripping the supply breaker.

An overload or fault on a bus in distribution panel shall be cleared by the associated supply breaker. After tripping, the supply breaker shall lock out and require manual resetting.

Each panel shall have silver-plated copper busbars, complete with a main incoming molded case switch, and feeder circuits with molded case circuit breakers, equipped with trip indicating auxiliary contacts.

A copper ground bus shall extend the full length of the distribution boards at the lower rear of the panel, and shall be equipped with two pressure type clamps for connecting the ground bus to the station's ground grid.

Contractor shall determine circuit breaker quantities and their sizes based on load requirements. Trip settings and interrupting ratings of all circuit breakers shall be based on calculated short-circuit currents available from the DC station service system.

4.2. Batteries

The discharge capacity of the power supplier battery shall be sufficient to supply the following loads during a period of specified duration mentioned in the Data Sheet.

- Operation of all switching devices (circuit breakers, isolators etc.) within their respective operating voltage limits shall be provided.
- Supply the normal standing load for the full discharge period.
- Supply the emergency lighting load for a period of ten hours.

The battery shall be suitable for operation on equalizing and floating charge system and capable of providing the guaranteed output throughout the specified range of ambient conditions.

The batteries shall consist of lead acid or nickel cadmium in sealed type units, and in leakage proof containers. Covers shall be fitted with spray - proof vent plugs.

Inter-cell connectors shall be of PVC insulated solid copper. Special care for inter-cell connectors shall be considered to ensure high current carrying capacity for high discharge current rate cells.

The connector wires from battery to loads running through terminals in the wall shall be of PVC insulated copper and supported on insulators. All necessary fixing arrangements shall be provided.

Each battery shall be provided with acid separation plugs, level indicators, and all necessary equipment for maintenance as follows:

- Two syringe hydrometers for each lead acid battery,
- One plastic filler bottle for distilled water,
- One instruction card,
- One set of emergency eye-washing and neutralizing apparatus.

The cells shall be numbered and mounted on stages of wood or plastic covered steel, but more than two stages are not permitted. If the batteries are located

together in two rows, there shall be enough space for maintenance access along the two long sides.

In case the racks are made of steel, racks shall be painted with two layers of acid-resistant paint conforming to IEC standards, rack rails shall be insulated by applying suitable insulating material. Wooden racks shall be painted with a suitable, nonconductive, wood preservative.

Each battery shall be supplied with complete intercell connectors, terminal lugs, mounting rack and all necessary material for operating in conjunction with the charger and distribution equipment.

All battery stands shall be suitably protected against corrosion and exposure to the battery electrolyte. Inter-cell connections shall be of low resistance, in a clean condition when bolted and protected against corrosion.

When selecting rack dimensions and configurations, full consideration shall be given to the general layout arrangement and space available in the battery rooms to ensure sufficient clearance for equipment installation, testing and maintenance.

The racks shall be designed to secure the battery cells under the specified seismic accelerations.

Elements shall be suspended either from ledges molded in the jar-walls or from the covers. Sufficient space shall be provided for sediment so the batteries will not require cleaning during normal operation life cycle.

Cell terminal posts shall be equipped with connector bolts having acid-resisting nuts.

The power supply system (125/110 volt battery) will operate with battery terminals free of earth whilst that for communication equipment (48 volt battery) will operate with the positive pole permanently earthed.

Main battery and charger protection shall be mounted as close to the battery terminals as possible. Battery and charger cables shall be separately protected and linked.

Battery connection cables shall run overhead through insulated barriers into the battery room while all other circuits shall be connected from underneath.

Containers shall be made of materials satisfying the following properties:

- Fire retardant
- Stress crack-resistant
- High strength
- Impact-resistant.

Name Plates shall be provided and approved by the Engineer.

4.3. Battery Charger

4.3.1. General

The chargers shall have 400/230V AC, three phase and 50 Hz input line adjusting transformer taps plus or minus 10% with an auto/manual changeover switch and the facility for manual control and voltage adjustment. The output DC load voltage shall be maintained at nominal DC voltage range in floating charge mode according to Data Sheet value.

The battery chargers shall be housed in robust, floor-standing, sheet metal and fully ventilated enclosures. All components shall be impregnated with humidity resistant varnish.

On the AC input side, there shall be one ammeter and one voltmeter. A DC ammeter with shunt and a voltmeter with fuses shall be installed on the bus side of the DC output breaker.

The chargers shall have two stages, i.e., float charge and high-rate charge with both manual switching to high-rate charge mode and automatic/manual switching from high rate to float mode, regardless of whether switching to high rate was automatic or manual. There shall be potentiometers for adjusting the float voltage and the high rate voltage. The chargers shall have a high rate charge timer which shall reset the charger to float charge mode after fully charging the battery, following a preset time (adjustable from 0 to 24 hours).

Each charger shall be equipped with an automatic switch to transfer from the floating voltage to the equalizing voltage under the following conditions:

- When the voltage of the connected battery reaches the minimum prescribed value for a time longer than a minute.

- Every thirty days in both cases, an adjustable timer (8-12 hours) shall be used to determine the length of time the equalizing voltage is to be applied.

The equalizing and float voltage levels shall be adjustable and suitable for the range of operating conditions recommended by the battery manufacturer.

The chargers shall have a current limiting feature to limit the output current at 120% of rated value and shall be maintained to short circuit.

The chargers shall incorporate diode isolation in the output circuit to eliminate voltage feedback from the battery plant and thus permit proper operation of an output voltage detector circuit.

The thyristor-controlled rectifiers shall be protected against transient over voltages on both input and output, and suitable means shall be provided inside charger cubicles to dissipate heat.

A reverse current limiting device shall be provided to protect the battery in case of AC supply failure shall be provided. Each charger shall automatically return to service on restoration of AC supply after an interruption.

The capacity of each charger shall be equal to supply the constant continuous DC load of the station and float charging of batteries or restoring the batteries from the fully discharged condition to the fully charged condition within 10 hours, after a 4 hours duty cycle (as described before), capacity of either of these two supplies which is larger.

Name-plates approved by the Engineer shall be provided.

Series diodes for reducing DC voltage shall be connected automatically at equalizing mode.

4.3.2. Boost Charger

A charge conditioning facility shall be provided which shall be located in the battery room and capable of boost charging a single cell's at cell terminal voltage, with normal load being connected to the battery during this period.

4.3.3. Output Voltage Adjustment

The float and equalize voltage shall be adjustable at least to plus or minus 10%.Float and equalize charge adjustments shall be independent of each other and without interaction. The voltage shall be filtered to less than 1% rms ripple with battery disconnected.

4.3.4. Terminal Blocks

Terminal blocks shall be of unit construction, grouped and labeled according to their duty by strips securely attached to each terminal block. They shall be mounted to give easy access to terminations and to enable ferrule numbers and labels to be read without difficulty.

The terminal blocks shall have insulating barriers between points.

4.3.5. Alarms

The chargers shall be equipped with the following indicating alarms with local alarm indicator lamps and free output contacts provided (wired to a terminal strip) for annunciator display:

- High resistance ground detector alarm
- DC Charger failure alarm
- DC output voltage low/high
- Occurrence of equalization voltage on the operating charge
- AC power supply failure
- Earth fault supervision (DC system ground fault)
- Float charge on (white)
- High rate charge on (amber).
- DC breaker trip
- Charger failure

These alarm relays shall be automatically reset.

Each charger shall be equipped with the following self-reset type alarm relays and local alarm indicator lamps. Relays shall have `C' type alarm contacts for remote annunciation of:

4.4. Circuit Breakers

The incoming circuit breakers shall be 250 volts DC, double break, draw-out type, and molded case type suitable for DC ungrounded systems and having rated symmetrical short circuit breaking capacity according to appended DC Data Sheet. The minimum number and rating of DC circuit breakers shall be in accordance with the relevant drawings.

The short-time rating of these molded case circuit breakers shall be calculated from the internal resistance of the battery bank and the highest system voltage. All molded case circuit breakers shall be equipped with thermal magnetic trips, auxiliary switches and adjustable magnetic trip for coordination with the fuses in the local distribution panels.

In the OFF position, isolation shall be provided by a double break on the main circuit. MCCB shall be provided with a facility for pad locking in either the "ON" or "OFF" position.

MCCB shall be equipped with a "push to trip" button in its front side to provide the ability to test its operation and the opening of the poles.

Where shunt trip release is specified, MCCB shall be able to operate correctly at all values of supply voltage ranging from 70% to 110% of the nominal supply voltage under all operating currents up to MCCB's rated short-circuit breaking capacity.

Circuit breakers shall be provided with a handle padlock attachment to enable the breaker to be padlocked in the open or closed position.

Panel's main circuit breaker shall be provided with a trip alarm contact for remote indications. All circuit breakers shall be provided with trip position indication to clearly indicate the breaker trip position.

It shall be possible to equip the molded-case circuit breakers with a motor mechanism for electrically controlled operation via automatic changeover scheme. Following tripping due to electrical faults (overload, short circuit, and earth faults), remote reset shall be inhibited.

The operating mechanism shall be of the stored energy type only.

Enough auxiliary contacts shall be provided in all MCCBs to allow remote indication of the MCCB's contact position in addition to alarm contacts in order to indicate when the MCCB has tripped.

Sufficient number of circuit breakers should be provided to supply DC power to feed panel boards, relay and control panels in control and switchgear building, emergency lighting, and all other equipment requiring DC power.

For extension substations, the facilities of the existing DC panels shall be used to supply power to new panels and equipment covered under this contract.

The above mentioned facilities shall comprise of spare MCBs, fuses, disconnectors, or blank space to accommodate new circuit breakers, fuses, etc.

A minimum of 20% spare DC breakers shall be provided.

4.5. Miniature Circuit Breakers

Where miniature circuit breakers are provided for the control and protection of DC power supply circuits, they shall be designed and tested according to BS 3871.

Miniature circuit breakers in single-phase circuits shall be of single pole type and they shall be of the double pole type in DC circuits.

Miniature circuit breakers shall be provided with an auxiliary contact for alarm operation.

Miniature circuit breakers shall be designed and mounted so that inadvertent operation is prevented and circuit breaker position checking is facilitated.

4.6. Fuse switches

Fuse switch units shall comply with the requirements of IEC 60947-3.

Each switch shall be rated to be able to interrupt circuit's rated load current and in case a motor circuit is being controlled it shall be capable of switching under locked rotor conditions.

Fuses shall be of the high breaking capacity type according to IEC 60269-3. Accessing the fuses shall only be possible when they are de-energized and are isolated from the source of supply.

Mechanisms shall be of the spring-loaded type such that the operation speed of the switch during opening and closing is independent of the operator and once initiated the operation is completed.

In case of spring failure, operation of the switch shall be possible but without danger to the operator.

ON or OFF Indication of the switch shall be clearly provided. It shall be possible to lock the operating handle in either of these positions.

The performance of the fuse switch unit shall match with the specified when the unit is mounted in its cubicle.

Isolating fuse switche units shall be of the air break type and shall have integral fuses. It shall be possible to safely replace the fuses with the busbars alive and the switch open.

4.7. Fuses

All fuses shall be of High Rupturing Capacity (HRC) plug in type and the high rupture capacity rated for nominal DC with visible indication to show that they have operated.

It shall be possible to replace fuses with the circuit being connected, without having electric shock hazard.

Current versus time characteristics of fuses shall be furnished with the tender.

Fuse ratings shall be suitable for the current rating of the circuit. Fuses for motor circuits shall take care of starting characteristic of the motor, thermal characteristics of cables, multi hot and cold start duty of motor etc.

4.8. Load breaker Switches

Load breaker switches shall be air-break, manually operated, 2 pole and suitable for nominal DC operation.

5. Inspection and Tests

The contractor shall perform all inspections, routine and type tests stipulated in applicable standards to ensure that used materials and workmanship conform to the specification and drawings.

The contractor shall also provide access to the work for Client's representative in order to determine and assess the compliance of work with the provision of this specification or to witness the contractor's inspection or tests.

The contractor shall produce a compliance certificate for the equipment with the design, routine and type tests stipulated in the applicable standards.

In addition, the contractor shall submit satisfactory evidence of the equipment having successfully undergone at least the following tests, before delivery to site:

- Operation of all meters and relays using single phase or three phase supply as required, including operation of relay contacts.
- Energizing of all low voltage control circuits using the appropriate voltage supply, and testing the operation and sequence of operation; polarity tests where required.
- Di-electric strength test at 1500 volts AC on all wirings
- Continuity of all low voltage circuits

Client's representative reserves the right to have a representative present during final workshop and functional tests. In order to give the client enough time for scheduling the survey, the contractor shall advise the date of test at least sixty (60) days in advance.

5.1. General

All DC station service equipment, batteries, battery chargers, switchgear and distribution panels are subjected to inspection and testing, by and at the expense of Contractor, in the factory and on Site, in the presence of the Client and Engineer.

The DC station service equipment shall be manufactured and assembled in the factory to the maximum extent possible. The assemblies shall be complete to facilitate dimensional checks, inspections and testings.

5.2. Shop Tests

The equipment are subjected to shop tests in accordance with the latest issue of the applicable standards.

Specifically, Contractor's shop test program for the dc station service equipment shall include the following.

5.2.1. Mechanical Tests

- All contacts of all switches, relays and devices, including mounted equipment and devices furnished as un-mounted equipment and spare parts, shall be tested for proper contact operation.
- Device markings, nameplate markings, conductor identifications, terminal block wire designations and the scales of meters and instruments shall all be checked against the approved shop drawings.
- Each panel shall be checked for alignment of enclosure and devices, for rigidity of structures, and for adequacy of fastenings and supports.
- Each battery rack shall be checked for alignment and rigidity.

5.2.2. Electrical Tests - Battery Chargers

- Temperature test as detailed in applicable IEC standards. The test shall be performed with the charger supplying full rated current with the battery at the highest recommended equalizing voltage.
- Functional tests on the automatic reverse current protection.

5.2.3. Electrical Tests - DC Switchgear

- Standard insulation withstand tests on the complete switchgear units, between the buses and ground, and between the positive and negative buses.
- Standard insulation withstand tests on the relays and devices and on all small wiring at the dc or ac equivalent voltage specified above.
- Continuity and polarity tests on all coils and circuits.
- Functional tests on all equipment.
- Resistance measurement of the operating coils of each electrically operated circuit breaker.
- Verification of the minimum control voltage at which each electrically operated circuit breaker operates.
- Control current with minimum and normal control voltage impressed on the circuit breaker operating coils.

5.3. Site Inspections and Performance Tests

Contractor shall carry out site inspections and performance tests generally in accordance with the latest version of the applicable standards. The following specific site inspections and performance tests shall also be performed.

5.3.1. Site Inspections and Tests

Contractor's site inspection and test program for the dc station service equipment shall include the following:

- Test to check the continuity of all buses, control and auxiliary circuit wiring and cables
- Testing of all current-carrying and ground connections to all conductors and terminal pads, to determine that full clamping pressure is applied to all contact surfaces and all bolted connections are tightly secured with lock

washers; testing of all flexible connections to ensure that sufficient slack is available for expansion

- General inspection of the equipment, including checking of all connections/wires on component terminals, and labels on terminal boards
- Operational test under simulated service conditions to ensure operability of all components, proper mechanical functioning of all parts, and correct mutual functioning of interrelated components
- Insulation resistance tests on secondary and control wiring and auxiliary circuits
- Individual inspection and operation of all auxiliary devices to determine their condition.

5.3.2. Tests on Completion

As the final stage of site inspections and performance tests, Contractor shall carry out Tests on Completion. The tests to be carried out on all components of the dc station service equipment shall include

A) Batteries

- Discharge test on all battery banks to an end voltage as determined by the number and type of cells
- Electrolyte and cell voltage test on each cell and identification of pilot cells

B) Battery Chargers

- Mechanical operation of the components to ensure that all parts operate correctly.
- Standard insulation withstand tests on all circuit breakers, switches, relays and other devices and on all wirings.
- Continuity and polarity tests on all circuits.

- Functional and operational checks of all equipment and all control, metering and protection circuits.
- Ground fault test.

C) DC Switchgear

- Final check on interchangeability of removable elements and verification of bus polarities
- Mechanical operation of circuit breakers, draw-out mechanisms, control and auxiliary switches, interlocks, etc
- Standard insulation withstand tests on the complete switchgear units, between the buses and ground, and between the positive and negative buses
- Standard insulation withstand tests on the relays and devices and on all small wirings at the dc or ac equivalent voltage as specified above
- Continuity and polarity tests on all coils and circuits
- Operational tests of all main and auxiliary systems and equipment, simulated transfer conditions, etc
- Verification of all indication and alarm functions

D) Distribution Panels and Circuit Breakers

- Mechanical operation of all circuit breakers to ensure that they operate correctly
- Verification of bus polarities
- Standard insulation withstand tests on all circuit breakers and on all wirings and buses
- Verification of the operation of all circuit breakers trip and alarm contacts

E) Plant Connected to the Station Service System

- Inspection and testing of all equipment grounding, external cabling and terminations to be carried out as necessary.
- Actual functional tests/checks on Plant to verify proper operation.

6. Supervision over Installation and Erection

The contractor shall perform visual inspections before installation to ensure that there is no damage resulting from shipment.

The contractor shall supervise installations, erection and commissioning of the station service equipment to ensure satisfactory and proper operation in every aspect.

This supervision shall cover but not be limited to the following where applicable:

- Installing the equipment in accordance with the drawing and the manufacturer's instructions.
- Assembling and erecting battery racks.
- Cleaning and setting the cells on the racks.
- Installing inter-cell links and cables.
- Filling battery cells links and cables.
- Installing battery chargers.
- Installing indoor and outdoor DC distribution panels.
- Interconnecting equipment.
- Inspecting, making necessary adjustments, field-testing, and placing the equipment in commercial service.
- Notifying Client's representative in written later as soon as installation of the equipment is completed.

Performing field tests and inspections including but not limited to the following:

- Visual inspection and checks, Hardware and mounting, Grounding connections, Check of fuse and CB ratings, Check of thermal relays and Check of level and specific gravity of the electrolyte in each cell.
- Charger output voltages, Polarity check, Normal output voltage, Raised output voltage, adjusted current (in position of boost charge), and Boost voltage.
- Alarm Tests, Loss of DC, Loss of DC output voltage low/high, Earth fault test.
- Insulation resistance of battery connections.
- Charging the batteries and providing charging chart according to charging instructions.
- Operational capacity test (discharging batteries according to instructions)
- DC circuit breakers over current and thermal tests.
- Continuity test of all low voltage circuits.
- Measuring on all low voltage circuits.
- Check of the operation of all meters, relays, instruments, alarms and trips.
- Functional testing of all equipment.

7. Submittals

The Contractor shall submit, in accordance with Section 3; drawings, calculations, test reports and literature pertaining to specified items of material to be supplied under this section.

8. Spare Parts

The Contractor shall be provided spare parts as per schedule of quantities and prices.

TECHNICAL SPECIFICATION

SECTION 19

PROTECTION, CONTROL AND METERING SYSTEM

MONENCO – IRAN CONSULTING ENGINEERS COMOANY

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1. General

This section specifies the functional performance requirements for the design, manufacturing, transportation, supervision over erection, commissioning and factory testing of switchyard and switchgear protection, control, metering, alarm, indication systems and panels. Protection, control and metering system shall be offered in accordance with following appended drawings:

- Overall single line diagram,
- Overall layout diagram,
- Protection and metering single line diagram, and
- DCS overview (If any).

The tenderer shall fill out the guarantee data completely and shall provide a list of deviations from this technical specification and appended drawing which will be used in technical evaluations, otherwise it means that the tenderer has accepted all the requested requirements and has confirmed the correctness and suitability of this specification completely.

The functional requirements of this specification relating to relay protections shall apply to all equipment on which the protection function is dependent. They shall thus also apply to parts which are not directly related to the relay protection such as functions in the auxiliary power distribution, interface cubicles, remote end feeders protection etc. included in the relay protection function.

Where existing substations have to be extended, the Contractor shall investigate the facilities and arrangement of the existing part and has to provide a suitable incorporation of the new bays and equipment in the existing schemes and systems (e.g. busbar protection, voltage selection, synchronizing system, DCS software and hardware, RTU/PLC, fault recording, voltage regulation etc.). If existing systems are required to be modified/extended for any reason, (e.g. in order to operate with newly installed equipment), the Contractor shall supply all the necessary modules, relays, boards, wiring terminals, wiring, MCB's etc in order to ensure satisfactory performance. The Contractor shall also modify/improve the corresponding drawings, erect all necessary equipment and perform the commissioning. All necessary hardware and software adaptation work (additional I/O modules, modification of the application screens at the HMI in DCS project etc.) is included in this contract.

2. Codes and Standards

The protection equipment shall be designed, manufactured and tested in accordance with the latest edition of the following standards:

1. List of type test for General protection relays according to IEC 60255-1:

Functional requirements:

- IEC 60255-100 Series Clause: 6.5, 6.7	Steady state requirements
- IEC 60255-100 Series Clause: 6.8	Dynamic simulation

Product safety requirements:

- IEC 60255-1,Clause: 6.4 - IEC 60255-27,Clause: 10.5.2.2	Verification or measurement of clearance and creepage distance (Power frequency Dielectric strength test)
- IEC 60255-1,Clause: 6.3 - IEC 60255-27,Clause: 10.5.2.3 - IEC 60529	IP rating
- IEC 60255-1,Clause: 6.4 - IEC 60255-27,Clause: 10.5.3.1	Impulse voltage
- IEC 60255-1,Clause: 6.4 - IEC 60255-27,Clause: 10.5.3.3	Verification of insulation resistance (after environmental tests)
- IEC 60255-1,Clause: 6.4 - IEC 60255-27,Clause: 10.5.3.4.1	Protective bonding resistance
- IEC 60255-1,Clause: 6.4 - IEC 60255-27,Clause: 10.5.4.2	Flammability of insulating materials components and fire enclosures
- IEC 60255-1,Clause: 6.4 - IEC 60255-27,Clause: 10.5.4.5	Single fault condition

Electrical environmental tests:

- IEC 60255-1,Clause:6.4 - IEC 60255-27,Clause:10.5.4.1	Maximum temperature of parts and materials

- IEC 60255-1,Clause:6.4 - IEC 60255-27,Clause:10.5.4.3	Thermal short time
- IEC 60255-1,Clause:6.4 - IEC 60255-27,Clause:10.5.4.4	Output relay, make and carry

Energizing quantities:

- IEC 60255-1,Clause:6.10.1	Burden for Voltage transformers
- IEC 60255-1,Clause:6.10.2	Burden for Current transformers
- IEC 60255-1,Clause:6.10.3.1	Burden for AC power supply-Quiescent state
- IEC 60255-1,Clause:6.10.3.2	Burden for AC power supply-Maximum load
- IEC 60255-1,Clause:6.10.3.3	Burden for AC power supply-Inrush Current& power up duration
- IEC 60255-1,Clause:6.10.4.1	Burden for DC power supply-Quiescent state
- IEC 60255-1,Clause:6.10.4.2	Burden for DC power supply-Maximum load
- IEC 60255-1,Clause:6.10.4.3	Burden for DC power supply-Inrush Current & power up duration
- IEC 60255-1,Clause:6.10.5	Burden for Binary Input
- IEC 60255-1,Clause:5.2.2.3	Operating range of auxiliary energizing quantity
- IEC 60255-1,Clause:6.9 - IEC 60255-11	Change of auxiliary energizing quantity-Interruption to and alternating component in dc auxiliary energizing quantity
- IEC 60255-11	Interruptions to and alternating component(ripple) in d.c. auxiliary energizing quantity of measuring relays

Climatic environmental requirements:

- IEC 60255-27,Clause10.5.1.1 - IEC 60255-1,Clause 6.12.3.1 - IEC 60068-2-2	Dry heat test +Verification of function (16H)
- IEC 60255-27,Clause10.5.1.2 - IEC 60255-1,Clause 6.12.3.2 - IEC 60068-2-1	Cold test +Verification of function (16H)

- IEC 60255-27,Clause10.5.1.3 - IEC 60255-1,Clause 6.12.3.3 - IEC 60068-2-2	Dry heat test at maximum storage temperature +Verification of function (16H)
- IEC 60255-27,Clause10.5.1.4 - IEC 60255-1,Clause 6.12.3.4 - IEC 60068-2-1	Cold test at minimum storage temperature +Verification of function (16H)
- IEC 60255-27,Clause10.5.1.5 - IEC 60255-1,Clause 6.12.3.5 - IEC 60068-2-14	Change of temperature test (cyclic) +Verification of function
- IEC 60255-27,Clause10.5.1.5 - IEC 60255-1,Clause 6.12.3.6 - IEC 60068-2-78	Damp heat steady state test +Verification of function & dielectric (10 days)
- IEC 60255-27,Clause10.5.1.6 - IEC 60255-1,Clause 6.12.3.7 - IEC 60068-2-30	Cyclic temperature with humidity test +Verification of function

Mechanical requirements:

- IEC 60255-21-1 - IEC 60255-1,Clause 6.13.1	Vibration response and endurance (Sinusoidal) +Verification of function
- IEC 60255-21-2 - IEC 60255-1,Clause 6.13.2	Shock response , Shock withstand +Verification of function
- IEC 60255-21-2 - IEC 60255-1,Clause 6.13.2	Bump +Verification of function
- IEC 60255-21-3 - IEC 60255-1,Clause 6.13.3	Seismic +Verification of function

EMC requirements-emission tests:

- IEC 60255-26 - IEC 60255-1, Clause:6.15 - IEC 60255-25	Radiated emission
- IEC 60255-26 - IEC 60255-1, Clause:6.15 - IEC 60255-25	Conducted emission

EMC requirements-immunity tests:

- IEC 60255-1, Clause:6.15 - IEC 61000-4-3 - IEC 60255-26 - IEC 60255-22-3	Radiated radio frequency electromagnetic field +Verification of function
- IEC 60255-1, Clause:6.15 - IEC 61000-4-2 - IEC 60255-26 - IEC 60255-22-2	Electrostatic discharge (ESD) 1 +Verification of function
- IEC 60255-1, Clause:6.15 - IEC 61000-4-8 - IEC 60255-26	Power frequency magnetic field +Verification of function
- IEC 60255-1, Clause:6.15 - IEC 61000-4-6 - IEC 60255-26 - IEC 60255-22-6	Conducted disturbance induced by radio frequency fields +Verification of function
- IEC 60255-1, Clause:6.15 - IEC 61000-4-4 - IEC 60255-26 - IEC 60255-22-4	Electrical fast transient/burst immunity (EFT) +Verification of function
- IEC 60255-1, Clause:6.15 - IEC 60255-26 - IEC 61000-4-18 - IEC 60255-22-1	1MHz burst immunity tests -damp oscillatory waves +Verification of function
- IEC 60255-1, Clause:6.15 - IEC 61000-4-5 - IEC 60255-26 - IEC 60255-22-5	Surge immunity tests +Verification of function
- IEC 60255-1, Clause:6.15 - IEC 61000-4-16 - IEC 60255-26 - IEC 60255-22-7	Power frequency immunity (BI only)1 +Verification of function
Contact performance:	
- IEC 60255-23 - IEC 60255-1, Clause:6.11 - IEC 61810-1	Specification state verification
- IEC 60255-23 - IEC 60255-1, Clause:6.11 - IEC 61810-1	Contact circuit resistance measurement

- IEC 60255-1, Clause:6.11 - IEC 61810-1, Clause:4.1.2.3	Open Contact insulation test (AC Dielectric strength)

Other:

- IEC 60255-1,Clause 6.6	Communication requirements
- IEC 60297-3-101 - IEC 60255-1,Clause: 6.1, 6.2	Dimension and structure and visual inspection
- IEC 61850	Communication networks and systems in substations All Parts
- IEEE Std C37.94	IEEE Standard for N Times 64 Kilobit Per Second Optical Fiber Interfaces Between Teleprotection and Multiplexer Equipment
- IEEE C37.111	Standard Common Format for Transient Data Exchange (COMTRADE) for Power Systems
- IGMC	Technical Instruction of Purchasing and Technical Specification of Transmission Protection Relays based on Microprocessor Technology and Relative Software (Last edition)

2. List of type test for Specific protection relays according to IEC 60255-100:

- IEC 60255-121	Functional requirements for distance protection (revision of IEC 60255-16)
- IEC 60255-124	Functional requirements for volts per hertz protection
- IEC 60255-125	Functional requirements for synchronizing or synchronism-check
- IEC 60255-127	Functional requirements for over/under voltage protection (revision of IEC 60255-3) (including the phase, neutral, residual and negative sequence)
- IEC 60255-132	Functional requirements for over/under power protection (revision of IEC 60255-12)(including the real reactive and power factor)

- IEC 60255-140	Functional requirements for loss of excitation protection
- IEC 60255-149	Functional requirements for thermal protection (revision of IEC 60255-8)
- IEC 60255-151	Functional requirements for over/under current protection (revision of IEC 60255-3) (including the phase, ground, residual and negative sequence)
- IEC 60255-160	Functional requirements for voltage or current unbalance protection
- IEC 60255-167	Functional requirements for directional current protection
- IEC 60255-178	Functional requirements for power swing/out-of-step protection
- IEC 60255-179	Functional requirements for reclosing
- IEC 60255-181	Functional requirements for frequency relay (including over/under, rate of change)
- IEC 60255-185	Functional requirements for teleprotection function
- IEC 60255-187	Functional requirements for differential protection (revision of IEC 60255-13) (including generator, transformer, busbar, line and restricted earth fault)
- IEC 60255-195	Functional requirements for synchro phasor measurement

The control and metering equipment shall be designed, manufactured and tested in accordance with the latest edition of the following standards:

1. List of type test for energy meters and measuring centers:

- IEC 62052-11	General requirements, tests and test conditions Part 11:Metering equipment
- IEC 62053-21	Electricity metering equipment(AC) Particular requirements Part 21: Static meters for active energy (Classes 1 and 2)

- IEC 62053-22	Electricity metering equipment (AC) Particular requirements Part 22:Static meters for active energy (classes 0,2 S and 0,5 S)
- IEC 62054	Electricity metering (AC) Tariff and load control
- IEC 62053-23	Electricity metering equipment (AC) Particular requirements Part 23:Static meters for reactive energy (Classes 2 and 3)
- IEC 62056	Electricity metering Data exchange for meter reading, tariff and local control

2. List of type test for Control Equipment:

- IEC 60947 - IEC 61439	Low voltage Switchgear and Controlgear
- IEC 60051	Direct acting indicating and analogue electrical measuring instruments and their accessories
- IEC 60258	Direct acting recording electrical measuring instruments and their accessories
- IEC 60715	Dimensions of Low-Voltage Switchgear and Controlgear Standardized Mounting on Rails for Mechanical Support of Electrical Devices
- IEC 60269-1	Low-voltage fuses
- IEC 60898	Electrical Accessories - Circuit-Breakers for Over current Protection for Household and Similar Installations Second Edition
- IEC 60073	Basic and safety principles for man-machine interface, marking and identification –Coding principles for indicators and actuators
- IEC 60359	Electrical and Electronic Measurement Equipment -Expression of Performance
- IEC 60688	Electrical Measuring Transducers for Converting AC Electrical Quantities to Analogue or Digital Signals
- IEC 60387	Symbols For Alternating- Current Electricity Meters

3. List of type test for fault and event recording:

- EN 61000-6-2	Electromagnetic compatibility (EMC) Part 6-2: Generic standards - Immunity for industrial environments
- EN 61000-6-4	Electromagnetic compatibility (EMC) Part 6-4: Generic standards - Emission standard for industrial environments
- EN61010-1	Safety requirement for electrical equipment for measurement, control and laboratory use Part 1: General requirements
- EN 61000-4-30	Electromagnetic compatibility (EMC) Part 4-30: Testing and measurement techniques - Power quality measurement methods (IEC 61000-4-30:2008)
- IEC 61000-4-2	Electromagnetic compatibility (EMC) Part 4-2: Testing and measurement techniques – Electrostatic discharge immunity test
- IEC 61000-4-4	Electromagnetic compatibility (EMC) Part 4-4: Testing and measurement techniques – Electrical fast transient/burst immunity test
- IEC 61000-4-5	Electromagnetic compatibility (EMC) Part 4-5: Testing and measurement techniques – Surge immunity test
- IEC 61000-4-8	Electromagnetic compatibility (EMC) Part 4-8: Testing and measurement techniques – Power frequency magnetic field immunity test
- IEC 61000-4-11	Electromagnetic compatibility (EMC) Part 4-11: Testing and measurement techniques – Voltage Dip, short interruptions and variations immunity tests
- CISPR11	EMI conducted measurement
- IEC 60068-2-1	Environmental testing Part 2-1: Tests – Test A: Cold

- IEC 60068-2-30	Environmental testing Part 2-30: Tests – Test Db: Damp heat, cyclic (12 h + 12 h cycle)
- IEC 60529	Degrees of protection provided by enclosures (IP Code)
- IEC 61557-12	Electrical safety in low voltage distribution systems up to 1000 V a.c. and 1500 V d.c.– Equipment for testing, measuring or monitoring of protective measures –Part 12: Performance measuring and monitoring devices (PMD)
- IEC 61326-1	Electrical equipment for measurement, control and laboratory use – EMC requirements – Part 1: General requirements
- IEEE C37.118 standard	IEEE Standard for Synchro phasors for Power Systems Applicable as Phasor Measurement Unit
- IEEE Std C37.111	Common Format for Transient Data Exchange (COMTRADE) for Power Systems

All the amendments and references listed with the above standards shall apply and other relevant IEC standard shall be considered, by the Engineer approval. In case of lacks in IEC, Other standards can be considered through the Engineer approval.

In addition, the protection equipment shall comply, where necessary, with standards of other related equipment in fault clearing equipment, e.g. CB, CT, CVT, etc.

According to latest revision of relevant IEC standards or other acceptable standards type tests shall be done in well-known accredited laboratories according to ISO-IEC 17025.Relevant documents and routine test report, as required by IEC or equivalent standards shall be submitted.

3. Protection, control and metering panel

3.1. General

All panels, boards, boxes, … (indoor/ outdoor) shall be metal enclosed and shall be self supporting, free standing, floor mounting and shall comprise rigid welded structural frames enclosed with cold sheet steel for protection, control and metering panels.

Dimension of panels shall be 2200mm (H) * 800mm (W) * 800mm (D). In special cases, that the number of equipment is less or more than usual, depth of panel shall be varied until 600mm and the width of panel shall be varied until 1000mm.The 20cm plinth shall be considered bottom of the panels. Also 10cm above the panel shall be considered for installing labels.

The height of equipment that installed in front of panels shall be considered so that access of equipment and reading data shall be done easily.

All panels shall be dust, moisture and vermin proof. Panels shall be provided with at least 2 louvers, it is also essential that the ventilation be natural circulation, except when panel contains sensitive electrical devices, and then with special permission of the engineer, fan and its relative devices can be considered. It is preferably that 1 louver is placed in front (bottom) of panel and another one is placed rear (top) of the panels. If it's not possible to installed louvers in this manner, louvers shall be placed rear (bottom) of panel and ceiling of the panel. If these 2 ways not possible, louvers shall be placed rear of the panel (top and bottom). Position of louvers shall be submitted to consulting engineering for approval.

Ventilating louvers shall have screens and filters to prevent the entrance of insects and rodents. The screen shall be of fine wire mesh of brass, galvanized steel wire meshes are not acceptable. All doors and removable covers shall have gasket all around with neoprene gaskets.

The degree of protection shall be considered according to Data Sheet.

All panels shall have hinged doors with at least 3 appropriate hinges. Indoor panels shall be equipped with rotary handles for locking. Outdoor panels shall be equipped with lock switch which can be opened with relative key (can’t be opened with screwdriver). Also panels shall be equipped with lockable proper stoppers to be made of rigid cyanide plating not to be damaged by sudden shocks. Doors can readily be opened and closed and the wiring will be allocated sufficient spare to be clearly and neatly arranged. Angle between open door and panel's body shall be 120°.All panels shall have eye bolt for lifting. Eye bolts shall be installed on structure of panels. Detail of stopper,

hinges, lockable switch and etc. as a document shall be submitted for consulting engineers for approval as well as panel accessories.

Color of panels shall be in accordance with datasheet. Thickness of color shall be between 80 and 120 micron.

The arrangement of equipment in the panel or in the front side of it shall be submitted to the engineer for approval.

The end panels shall be designed and arranged to permit their removal and to allow future extension to each end. Panels shall be bolted together and to the floor, they shall not be welded.

All panels shall be fitted with an interior fluorescent or LED light which is turned on by a door switch. Also panels shall be equipped with single phase socket, heater with thermostat and hydrostat (to prevent formation of condensation), MCBs and etc. it's noted that heater and thermostat shall not be installed in one side of panels.

The protection panels, energy meter, fault/event recorders shall be swing type and shall be equipped with front tempered glass door. These panels shall be provided with racks of 19" standard modular system. Racks are constructed and arranged on a hinged frame. Equipment shall be flush mounted in this type of panels.

The control panel shall not be rack mounted and swing type in any case, except for DCS or special cases where submitted by designer to engineers for approval. These panels shall be fix type. All equipment on the front side of fixed panel shall be mounted flush or semi flush. In case of semi flush mounting only flange or bezel shall be visible from the front side.

All control, indication, alarm and measuring circuits which are required for remote control and supervision shall be connected to separate SCADA panel (for conventional substations). These panels shall be equipped with terminal block, rack, DIN rails, duct and etc. SCADA panel as well as all wiring between the substation and SCADA panel shall be provided by the contractor. All terminal blocks shall be provided with test links and isolation facilities for using during commissioning and testing. Also CT secondary circuit shall be provided with short circuiting and earthing facilities. Terminal blocks of the SCADA panel shall be grouped separately according to the functional requirement. SCADA panels shall be fixed and front access.

The outdoor panels shall be provided with slopping roof. Foundation height for marshalling panels shall be at least 40cm. All necessary provisions shall be considered for marshalling panels that at least 60% of gland plate will be used

(such as 2 side marshalling panel).Marshalling panels shall be equipped with double door, If the width of the panel exceeds 80cm.

All conditions of site shall be considered for painting. Therefore, type of paint and painting procedure shall be approved by engineers. Paint quality shall be capable of withstanding impact and shall be non-reflecting.

Inside of all panels a place for catalog, electrical diagrams and drawings shall be considered.

3.2. Mimic

To make changes to the operating conditions of equipment and supervise them, we need control panel and mimic diagram. The mimic diagram shall be same as layout of substation space and all equipment for possible extensions in the switchyard shall be considered in mimic diagram and control panel, in order to prevent drilling on panel when extension needed.

Type, color and material of mimic shall be submitted to an engineer for approval. Color for various voltages in mimic diagram shall be as follows in accordance with National Standard.

Voltage level	Color	Related RAL
> 400kV	Brown	RAL 8023
400 kV	Violet	RAL 4005
230kV	Red	RAL 3000
132 kV	Light green	RAL 6017
63/66 kV	Blue	RAL 5010
33 kV	Orange	RAL 2008
11/20 kV	Yellow	RAL 1018
400 V	Black	RAL 9005

3.3. Terminal block, wiring and cabling

Terminal blocks shall be provided to accommodate all circuits entering or leaving the panels. Terminal blocks shall be through-type plug in type and shall be completed with washers, nuts and lock nuts. Terminals shall be grouped and labeled according to their duty by strips securely attached to each terminal block.

Terminals shall have insulating barriers between points. Marking on the terminal strips shall correspond to wire numbers on the wiring diagrams.

For circuits greater than 100 volts potential, terminals shall be segregated from other terminals and fitted with non-inflammable transparent plastic- covers to prevent contact with any live parts and to be separated from DC circuit. They shall have warning labels mounted on them in there on in conspicuous position.

Terminal blocks shall not be as junction points for cables which are not used in panel.

The markings related to terminals and wirings, shall be clearly visible and terminal blocks shall be arranged vertically and mounted at sides of cubicle. Multi level terminal block (Double/Triple) is not acceptable. Terminal blocks for CT and VT's secondary leads shall be provided with special test links and isolating facilities without disturbing any wire connections. Also CT secondary leads shall be provided with short circuiting and earth facilities by the use of CT short circuiting switching.

At least 20% spare terminals shall be provided on each strip for spare or future circuits.

Copper earthing busbars shall be rectangular cross section. Earthing busbar shall be 2 sections located in 2 side of panel (right and left) or be 1 section located along and back of the panel. Clamp type connectors shall be provided for directly connecting, earthing buses of adjacent panels and cable shields together. Buses shall be arranged so that they do not interfere with removal parts of panel.

Cables shall enter to the panels from the bottom of the panel. For indoor panels appropriate plate shall be used at the bottom of the panels with thickness of at least 3mm and proper strength. This plate shall be rail type and galvanized. Appropriate fastener shall be used for fixing cable. Flexible and appropriate sponge shall be provided for filling the holes. For marshalling panels, appropriate gland plate shall be used with thickness of at least 3mm and proper strength. Glands shall be used for fixing cables in marshalling panels.

Details of fixing cables shall be submitted by the contractor for the engineer's permission.

Cable end cubicles shall be marked by means of designation labels made of aluminum plates with engraved markings. Provisions shall be made for tightly fastening of the labels on the cable sheath.

The labels shall be readily visible and both the remote end address and the cable designation shall be indicated.

All wires within the panel, between terminal blocks and equipment or between equipment themselves, shall be laid in PVC ducts and shall also be marked.

The markings shall describe designation strip, terminal number, phase position, etc.

To any terminal or plug-in connector, a maximum of two wires of the same type and size may be connected to one terminal. All wire ends, even those not in uses, shall be terminated. In cases in which due to lacks of space, additional terminals cannot be employed for connection of unused wire ends, they can be suitably isolated.

Flame- proof plastic wiring ducts shall be provided at sides and bottom of the panels to carry wiring to terminal blocks or from terminals to equipment or between equipment themselves.

Ducts shall be provided with detachable cover and no more than 70% of their space usage is allowed.

The panel wiring shall be carried out with 1000/600v grade, single core with flame, vermin and rodent proof PVC insulation.

Conductors in panels shall consist of extra multi strand single copper conductor with following minimum cross sectional areas:

- Current circuits $2.5mm^2$
- DC supply (all ranges) $1.5mm^2$
- AC supply $1.5mm^2$
- DC signal $1.5mm^2$
- VT secondary circuit $1.5mm^2$

LVAC/LVDC supplies that enter to the panels shall be connected through MCB independently and isolated from other panels.

All cubicle and control wiring shall conform to the following color codes:

- AC phase. Connections — Red, yellow, blue
- AC neutrals — Black
- Ground connections (except grounded Phase conductors) — Green/Yellow
- DC circuit — Grey

All wire numberings shall be ring type and shall be approved by the engineer. Current transformer secondary circuits shall be terminated on test links. The current leads shall be short circuited when test links are open.

3.4. Control panel equipment

3.4.1. Discrepancy switch

Control switches used for remote control of circuit breakers, motorized disconnector switches and earthing switches shall be discrepancy control type. Discrepancy switches shall be arranged so that two discrete movements are required to affect operation. Therefore for close and trip command, the switch shall be pushed to permit rotation to the operate positions (Turn-push-turn).

Discrepancy switches when released from the operate position shall return automatically to the associated position. Each switch shall be equipped with a label plate engraved to show the switch position.

Discrepancy switches shall be incorporated in the mimic diagram to represent the relevant circuit breakers, motorized disconnector switches and earthing switches. Discrepancy switch related to CB shall be differed from DS/ES discrepancy switch in appearance. The discrepancy switches shall be provided with a built-in lamp.

A strong restoring spring is to be provided to return the switch mechanism automatically from the momentary contact position to the maintained contact position. This spring shall be strong enough to prevent any inadvertent operation due to touch and shall not be used as current carrying parts. The rating of the switch contacts shall be suitable for the current imposed by the circuit breaker, disconnector switch, earthing switches closing mechanism and shall conform to the recommendations to be given by the related manufacturers.

3.4.2. Selector switch

Selector switches shall be provided rotary type, rear terminal connections and maintained (stay-put) type with escutcheon plates clearly marked to show operating positions. All Selector Switches shall be mounted flush type.

The contact assembly at the back of the selector switches shall be enclosed in dust tight removable covers. The access to the contacts shall be from the back by the removal of the cover.

Contacts of the selector switches shall be spring assisted and contact faces shall be silver plated. Spring shall not be used as current carrying parts. The contacts of all switches shall preferably open and close with snap action to minimize arcing.

The contact quantity and rating and number of positions shall be finalized after detailed design stage. Each position shall have at least 20% spare contacts.

Voltmeter Selector Switch shall be seven position type (6 position& off) with 3 phase to phase and 3 phase to neutral position marked clearly on 48x48mm aluminum plate with black handle.

Ammeter selector switches shall have make before break type contacts so as to prevent open circuiting of CT secondary when changing the position of the switch. If three ammeters are provided, this is to be omitted.

Interlocking bypass switch (ON/OFF position) shall be stay put type with key. The lock shall be fitted on the operating handle and shall be removable only in the OFF position. When locked it shall not be possible to move Interlocking bypass switch to the ON position.

The restoring springs shall be strong and robust enough to prevent any inadvertent operation due to touch.

3.4.3. Push button

Push buttons shall be of momentary contact type with rear terminal connections. They shall be suitably shrouded to prevent inadvertent operation. All push buttons shall have 2 NO and 2 NC contacts. If it's needed illuminated type push buttons shall be used.

3.4.4. Indication lamp

Indicating lamps shall have rear terminal connections. Lamps shall be provided with series connected resistors of adequate thermal capacity, preferably built in the lamp assembly to prevent short circuiting of the control supply on filament fusing. Lamps shall have translucent covers to diffuse lights and shall be colored red, green, orange, clear white and blue as specified below:

- Red: energized or situation which requires immediate action.
- Green: Un-energized or indication of safe situation.
- Orange: Caution on abnormal condition.
- White: Any specific meaning not covered in Red, Green and Orange.
- Blue: Any meaning, may be used whenever doubt exists.

Lamps and covers shall be interchangeable and easily replaceable from the front side of the panel.

3.4.5. Position indication

Position indicators of “Semaphore” type shall be provided on panels in order to indicate the position of non-motorized disconnector switches and earthing

switches. Indicators shall be suitable for semi-flush mounting with only the front disc projecting out and with terminal connections from rear.

When the indicator's supply fails, the pointer shall take up an intermediate position to indicate the supply failure. Semaphore indicators shall be mounted in the mimic in a manner that Non-motorized DS's and ES's closed position completes the continuity of the mimic.

3.4.6. Auxiliary relay

The auxiliary relays for achieving various interlocks, control and protection scheme, alarms, recordings and remote signaling (SCADA), etc. as required in this specification and also for transmitting the status information from switching devices(circuit breakers, disconnector switches, earth switches,…) in the switchgear, to the control equipment shall be included in scope of work.

These auxiliary relays shall be located in the respective follower interface panels, control and protection panels.

The auxiliary relays shall be self reset type and consist of sufficient N.C., N.O. and changeover fast enough contact with DC voltage coil, parallel quenching diode, and resetting ratio of more than 90 and sufficient contact rating.

The position of switchgear equipment such as circuit breaker, disconnector switch, earthing switch, etc., and related repeater relays shall be supervised continuously. The switchgear equipment position shall be repeated by auxiliary relays and with using two auxiliary relays (for open and close position repeating), shall give ambivalent signals. An alarm shall be initiated if these position indications are inconsistent or if the time required for operating mechanism to change position exceeds a predefined limit.

3.5. Label

Labels shall be provided to indentify each panel plus all ANSI device function numbers. Labels material shall be approved by the engineer.

Labels shall be mounted above relay cases, indicating lights, control switches, push buttons, auxiliary relays and other auxiliary equipment on or inside the panels.

4. Control and metering system

4.1. General

The main duty criterion of the control system involves supervision and control of the various primary items of the substation from control panels, and to indicate and record the status/events which exists/occurs. For abnormal condition and intentional changes in operating conditions, the control equipment shall secure the network as a whole.

The control equipment comprises equipment for measurement, indication, registration, signaling, protection functions and apparatuses for manual and automatic control and regulation. Also all cables, connection boxes, auxiliary equipment and supervision relays for auxiliary power supply are included in the control equipment.

Various parts of the control system shall be accessible during testing and maintenance work, without requiring unnecessary blocking of functions which are not affected by the work.

It shall be possible to perform future modifications and extensions to the control equipment with the minimum interruption of other parts.

The suitable operation, measurement, indication and acknowledgement system shall be provided for all circuit breakers, disconnecting switches and earthing switches in substation.

The control priority shall be submitted for all equipment which can be controlled from different levels. Local control level (control mechanism cubicle), remote control level (control panels/HMI for DCS substations), SCADA control level (from dispatching center) are traditional in substations which the priority order of control levels are determined by the distance to the controllable equipment. The shortest distance shall have the highest priority.

For control of substation from SCADA, a Sub/SCADA selector switch shall be considered for each voltage level that shall mounted on synchronizing panel.

4.2. Operating system

Suitable discrepancy switches shall be considered separately for each circuit breaker and motorized disconnector switches and earthing switches. They shall be mounted at the proper location in the mimic diagram of control panels.

If the status of the discrepancy switch is not in accordance with the actual position of the related equipment, the discrepancy switch shall show a flashing light. The flashing signal shall be supplied from flasher relays. The flashing

cycle shall be adjustable between 80 to 120 per minute and the duration of lighting shall be about 50 percent the flashing cycle. At least, two flasher relays shall be supplied per each station.

When the indication of the discrepancy switch is in accordance with the actual position of the related equipment, the switch lamp shall be extinguished. Operation in progress of CB and DS/ES shall be indicated by a steady light in the discrepancy switch.

Non-motorized DS’s and ES's shall only be operated locally by hand in the switchgear. Suitable position indicator shall be installed on the mimic instead of discrepancy switch.

4.3. Interlocking

Substation shall be provided with a full interlocking scheme to ensure that all disconnectors, earthing switches (or other interlocked earthing devices) and circuit breakers, are operated in the correct sequence.

The interlocking shall be designed considering personnel safety. Interlocks shall prevent any unsafe operation of the switchgear and shall ensure that the operator follows safe and logical sequences of switching device operations.

Interlocking schemes shall, if reasonably practicable, provide the maximum operational flexibility and shall not unnecessarily impose fixed operating sequences.

The interlocking of switching sequences involving manually operated switchgear may be by electrical or mechanical means (Mechanical Interlocking between disconnectors and adjacent earthing switches shall be provided In addition to electrical interlocking). The interlocking shall be designed such that the correct interlocking status shall be confirmed immediately before an operation.

Mechanical and hard-wired electrical interlocking schemes shall operate satisfactorily under the full range of environmental conditions specified for the associated primary equipment.

Interlocking schemes shall cover the following conditions:

- Interlocking between circuit breakers and disconnectors to ensure disconnectors do not make or break load currents
- Interlocking between disconnectors and earthing switches to ensure that earthing switches cannot be closed on to an energized circuit and circuit cannot be energized, when ES closed, by operation of disconnectors.

- To ensure that each circuit breaker is only closed remotely with its associated disconnectors open or closed
- To ensure that each circuit breaker is only open or closed locally with its associated disconnectors both open.

Closing and opening of circuit breakers from CB cubicle in switchgear shall only be possible when CB cubicle is in the local position and its associated disconnectors on both sides are open.

Earthing switches at the line terminals shall have interlocking not only with open position of adjacent line disconnectors but also with the dead line condition. Dead line condition shall be obtained from under voltage relay of the line protection.

In order to close the circuit breaker remotely, disconnectors in series with it shall be open or close (in end position) and for opening or closing of disconnectors, circuit breakers shall be open.

Electrical magnet shall be made for disconnectors and adjacent earthing switches which are not equipped with electrical motor provision so that the operation condition has been fulfilled.

Where an interlocking scheme is being supplied for an extension to an existing substation at the same operating voltage, the interlocking scheme should be match the existing design. Necessary modification shall be implemented in existing interlock logic according to extension.

Interlocking for a future extension of substation shall be fully interfaced with the existing interlocking scheme to achieve the functional requirements specified in this document.

4.4. Synchronizing system

The voltage, frequency and phase angle conditions shall be checked by synchronizing system before the closing signal is supplied to the circuit breaker.

The synchronizing equipment shall be provided for manual and automatic closing of the circuit breaker. A manual/automatic/off selector switch shall be considered on the control panel to select the related mode of operation.

In auto mode, the circuit breaker closure from control panel or remote SCADA shall be executed automatically via the synch-check relay while the circuit breaker is called (by CB call push button).

In manual mode, closing of circuit breaker shall be executed when operator visually check synchronizing bracket and closing command is sent via discrepancy switch.

In off mode, the closing of CB shall not be executed anyway.

For closing of circuit breaker, separate synchronizing panel completely with all its accessories along with synchronizing brackets shall be provided for substation.

All necessary circuit for synchronizing (such as repeaters circuit and etc.) shall be considered in related control panel.

For automatic closing action of the circuit breaker via Synchro-check relay, this equipment shall be provided in order to permit circuit breakers to be closed on live line/dead bus, dead line/live bus, live line/live bus and dead line/dead bus conditions. The relay shall recognize live condition for voltages above or equal to 80% of rated voltage (UN) and dead conditions for voltages adjustable between 5% - 80% of rated voltage.

Check synchronizing relay shall be provided with the following setting range:

- Phase difference angle adjustable between 5 to 45 electrical degree having steps at least equal to 1º degree.
- Voltage difference adjustable between 5% to 40% having steps at least equal to 1%
- Frequency difference adjustable from 3 mHz up to 0.5 Hz having steps at least equal to 0.01Hz.

The synchronizing facilities and relative circuits in substation shall be used for close command to circuit breaker from local (substation) and remote (SCADA).

The source voltage for synchronizing equipment shall be supervised so that the equipment is blocked if fuse fails (VT MCB failed or fuse failure relay operated) for the secondary winding of voltage transformer.

The synchronizing system shall have the following features:

- Voltage selection circuit shall be prepared for each circuit breaker: when a circuit breaker is chosen to be closed, the correct voltages on both sides of the circuit breaker shall be select from secondary windings of determined voltage transformers and transmit to synchronizing equipment. The status of related circuit breakers and disconnector switch shall be considered in logic circuit of voltage selection.
- Calling circuit shall be provided for each circuit breaker: The calling circuit with calling push button shall be designed to choose a circuit breaker for

closing. In this circuit a timer shall be considered for calling expiration and the calling cancellation equipment shall also be prepared in order to cancel circuit breakers calling. The circuit shall be designed in a way that only one circuit breaker can be synchronized at a time. Synchronizing of the circuit breakers shall be called from the related control panel and remote SCADA.

- synchronizing OK Indication
- Breaker closing circuit
- Automatic synchronizing equipment

Measured voltages shall be connected across follower relays controlled from auxiliary contacts of circuit breakers and disconnector switch. Follower relays shall be supervised, and synchronizing equipment shall be blocked in cases of discrepancy.

In several scheme if needed, the guard relay shall also be provided in manual mode. It allows the circuit breaker to be closed only after first synchronizing check relay has been closed. The guard relay shall allow the CB to close only after check synchronizing relay's closure, an indication and a closure impulse will be given later, thereby providing a firm guarantee that both machine and human give closing impulse together and not human or machine alone.

Swinging synchronizing brackets containing analog indicating instruments shall be provided for synchronizing panel. This synchronizing panel shall be mounted on side/center of the control panels. Synchronizing bracket shall be provided with 144×144 mm dimension for each instrument and swinging facility to enable reading from any control panel in substation's control room.

Each bracket shall consist of following instrument:

- One analog rotary synchro-scope
- One analog double read voltmeter
- One analog double read frequency meter
- Two synchronizing lamps
- All auxiliary CVTs and other devices

4.5. Alarm annunciation

Alarm annunciation system shall be provided in each control panel by means of visual and audible alarm in order to draw the attention of the operator to the abnormal operating conditions or the operation of some protection equipment.

The details of inscriptions for the window block for different panels shall be intimated at the time of approval of drawings.

The annunciation system shall be provided with acknowledge, lamp reset, and lamp test push buttons on relevant control panel, and one horn off push button on the synchronizing panel. The alarm points shall be divided in critical and non-critical alarms. Critical alarms require immediate action and shall be detected with suitable different colors (white for non-critical and red for critical alarm). Two different audible alarms with DC supply (klaxon and buzzer) shall be considered for distinction between critical and non-critical alarms in the control room. A separate audible alarm with DC supply (klaxon) shall be supplied for any alarm in the outdoor switchgear.

An audible alarm test push button shall be provided on synchronizing panel to test all audible alarm. Audible alarm shall be de-energized upon release of the test push button.

Annunciator windows shall be engraved (with understandable description of the alarm nature), with 24 mm x 36 mm Dimensions for each window. Number of alarm points shall be sufficient designing in order to identify and locate the trouble.

In visible alarms, All alarm points (such as illuminating tile or window) shall be divided according to feeder type (such as lines, transformers etc.) and common alarms (including AC, DC, general etc.) and shall suitably be arranged on the relevant control panels. Each tile or window shall consist of at least two LEDs. Lamps shall be replaced from front side of the panel.

Alarm unit shall be programmable so that alarms shall be triggered by downward or upward pulses.

20% of the annunciator windows shall be prepared as spares and maximum similarity to existing alarm system shall be considered for extension feeders unless otherwise mentioned.

Classification of critical / non-critical alarms and Alarm signal list shall be submitted at design stage for approval by the engineer.

The supply voltage to the audible and visual alarm shall be the DC voltage available at the substation. In case of DC supply failure, another audible alarm (horn) shall be considered having AC supply.

Annunciator shall be of electronic type and on operation of contacts of a remote alarm sensing device. The annunciator system shall provide the alarms even if the contact operation is only momentary.

The operation procedure of annunciator shall be in accordance with ISA-2C standard and shall be as follow:

- When a fault or an event is occurred, the relevant annunciator window shall be lit in flashing mode and audible alarm shall be activated.
- Audible alarm shall be silence using horn off push button.
- Flashing alarm lamps shall be cancelled using acknowledge push button and cause the annunciator window to show a steady light. If second alarm is going to be initiated on the same annunciator, the new alarm shall be lit in flashing mode whereas last alarms remain on steady light.
- The annunciator window shall be reset to normal state using reset push button. If the alarm window does not change to normal state, it means that the alarm signal is still active.
- A lamp test push button shall be provided on control panels to test all lamps on the panel. Lamps shall be de-energized upon release of the test push button.

4.6. Automatic and manual voltage control

The on-load tap changing equipment shall be operated in manual/automatic mode, and automatic voltage control relays (AVR) shall be provided. The relay shall be responsive to variations in the measured voltage and shall cause the necessary tap change action in order to restore the voltage to the desired level within predetermined limits. Automatic voltage regulation equipment shall be supplied for each power transformer.

If transformers have their LV windings connected in parallel, the related AVR shall be able to control transformer with relation to other AVR. The voltage control equipment shall be suitable for controlling up to a specified maximum number of transformers (according to single line diagram drawings) in parallel. Initially it may be required to control less than the maximum transformers, but it shall be possible to extend the facilities to cover up to the maximum transformers in future extension programs of substation.

The AVR relay shall be provided with the following features:

- Over current blocking
- Low voltage blocking
- High voltage blocking
- Blocking due to transformer disconnection
- Line drop compensation
- On-off type of regulation method

- Adjustable dead-band
- Preselectable constant time delay or inverted time delay in order to limit the number of switching operation
- The remote tap position indication through activation with BCD signal input, analog signal (4-20 mA) input and potentiometer input
- Sufficient programmable binary input/output
- Parallel operation management via communication links between AVR relays
- Master/follower and minimum circulating current operation mode
- Appropriate alarm when minimum circulating current is exceeds the permissible limit.

The voltage regulation shall also be possible manually from remote SCADA, tap changer mechanism, AVR relay and control and selector switches on AVR panels. AVR panels shall be prepared with all accessories such as control switches, pushbuttons, tap-position indicator, alarms, indications, necessary interposing and auxiliary relays for voltage control.

Also oil and HV winding temperature shall be monitored by appropriate analogue indicators on AVR panel.

Emergency stop push button shall be provided on AVR panel for tap changer of transformer. This push button shall be mushroom type.

These switches shall be provided for transformer:

- Automatic/manual selector switch
- Parallel/individual selector switch
- Master/follower selector switch
- Raise/lower control switch
- SUB/SCADA selector switch

Failure of the AVR shall keep the tap-changer in position and give an alarm.

AVR relays equipped to accept electrical signals to control the actual set point, shall be capable of set point adjustments in steps not exceeding 1 percent. The relay sensitivity band relative to the voltage setting shall be adjustable from not more than 1.5 times to not less than 2.5 times the percentage equivalent of one tap changer's step.

4.7. Metering and Indication Instrument

4.7.1. General

Each bay in the substation shall be provided with metering devices and functions as listed below:

- **Line feeder**
  - A measuring center with related technical specifications for each line or cable feeders
  - One energy meter with related technical specifications for each line or cable feeder (for electricity market)
  - Three analog ammeters (one for each phase) (for conventional substations)
  - One voltmeter with selector switch to indicate phase to phase and phase to ground voltages (for conventional substations).
- **Busbar**
  - If three phase CVT available for busbars, one voltmeter with selector switch to indicate phase to phase and phase to ground voltages for each busbars.
  - If one phase CVT available for busbars, one voltmeter for each busbars.
- **Power transformer**
  - Three analog ammeters (one for each phase) for HV side.
  - Voltmeter to indicate phase to ground voltage for HV side of transformer (if CVT in HV side is available)
  - A measuring center with related technical specifications for LV side.
  - Three analog ammeters (one for each phase) for LV side (for conventional substations).
  - One voltmeter with selector switch to indicate phase to phase and phase to ground voltages for LV side (for conventional substations).
  - One energy meter with related technical specifications for LV side.
  - One position indicator for tap changer with its transducer shall be provided on the AVR panel.

- **Reactor feeder**
  - Three analog ammeters (one for each phase) (for conventional substations),
  - A measuring center with related technical specifications.
- **Capacitor feeder**
  - Three analog ammeters (one for each phase) or,
  - A measuring center with related technical specifications.
- **Synchronizing system**
  - One double voltmeter, scaled as preset percentage of nominal voltage.
  - One double frequency meter.
  - One synch scope, of pointer type.
- **AC/DC system**
  - The quantity and the location of indicating instruments necessary for AC/DC panels shall be specified at relevant chapters.

Measuring and indicating instruments for each bay shall be located on the relevant control panel. MV line/cable feeder instruments shall be mounted on the LV compartment front side plate (door) of the relevant MV cubicle (and on the MV control panel if existed).Energy meters shall be mounted on dedicated metering panel.

In order to connect the measuring centers, energy meters and analog indications to CT and CVT's cores/windings refer to the appended drawings.

4.7.2. Indicating instrument

The indicating instruments consisting ammeters, voltmeters, WATT meters, VAR meters, frequency meters, power factor and synch scope shall be used for line feeders, transformer feeders, bus bars, low voltage AC/DC, AVR and synchronizing panels.

Indicating instruments shall be of the flush mounted, long scale 240° and switchboard type with red point. The dimension shall be 96 x 96 mm generally (for special cases such as synchronizing 144x144 mm shall be considered), with scale length of not less than 15 cm, unless otherwise stated. They shall be provided with white dial, black marking and pointer, and have shadow proof cover and glare proof glass. Protective form of the cases shall be IP52 or better. The accuracy class of all indicating instruments shall be 1.5.

Zero adjustment of the pointer shall be possible without removing covers. When multi ratio current transformers have been employed, the different scale plates, corresponding to each tap of CT shall be supplied.

All indicating instruments shall be provided with overload capacity of 2In, 1.2Un continuously and 10In, 2Un for the time duration of 5 sec.

Calibration of scale plates for all indicating instruments shall be submitted by the contractor for the Engineer’s approval.

4.7.3. Measuring center

Measuring center shall be installed on 3 phases and 3 or 4 wires electrical systems by instrument transformers (Voltage and current transformers) for measuring of electrical parameter's of the relevant system.

Measuring center shall be able to measure the following parameters and quantities:

- Three phase and neutral true RMS currents,
- Phase to phase and phase to earth true RMS voltages,
- Incoming or outgoing active, reactive and apparent power,
- Maximum demand,
- Power factor,
- Phasor angles,
- Frequency,
- Analyze harmonic contents of currents and voltages up to at least 23’rd harmonic and calculate percent of Total Harmonic Distortion (THD), and
- Etc.

Accuracy class shall be at least 0.5 for current, voltage, power, frequency, power factor and etc.

It shall be possible to set voltage and current ratio so that in case of using voltage and current transformers real value of voltage, current and power of system displayed or read with no extra calculation.

Measuring centers shall be installed on related control panels according to attached protection and metering single line diagram. These metering shall be flush mounted and shall have separate current and voltage test blocks.

The measuring center shall have the following features and functions:

- The meters shall be programmable logic, digital type power meters, and shall include features for power analysis, data logging, alarms, communication controls, etc.
- It shall be possible to get information and put settings via RS232 port. It is preferred that the measuring center have RS485 port for connection to RTU via appropriate protocols.
- Liquid Crystal Display (LCD) shall be able to show data with at least 12 digits and measured parameters shall be indicated in units of kilo with 2 decimal digits. When the measured parameter is high, display unit shall change from kilo to mega automatically.
- Parameters on LCD shall be indicated large enough.
- Measuring center shall have enough capacity and flexibility for reading data. Measuring center shall have enough memory for saving measured data (at least 2 GB).

Relevant software shall be able to read all measured and calculated quantities and data, put settings on measuring center with capability to show the read data in table and graphic form (curve and chart). The software shall be windows compatible with ability to save data and settings data in table and graphic in form of files. It shall be possible to retrieve and show the saved data, or to use the saved settings in measuring center.

For avoiding loss of functionality and recorded data, it shall include internal backup batteries, super capacitors, etc. or non-volatile memories shall be used whenever it is possible. Alarms for ending life cycle of internal batteries and supper capacitors shall be provided at least 1 month before the device's complete failure for operator's maintenance duties. Loss of supply shall not cause loss of data.

Measuring centers shall be able to withstand the following situations without any damage:

- 3 times rated current continuously and 30 times rated current for 1s.
- 1.2 times rated voltage continuously and 2 times rated voltage for 10 s.

Enough hardware and software security means such as passwords and locks shall be provided to avoid any changes in settings or wire connections by unauthorized personnel.

Measuring centers shall include extensive automatic self-checking facilities to supervise and monitor the individual condition, measuring elements, DC supply, etc. At least one potential free contact shall be provided for alarm indication

purposes in the event of MC being faulty. In addition, a LED shall be provided on the front of MC to indicate both healthy and faulty with green and red colors, respectively.

4.7.4. Energy meter

The energy meter shall be microprocessor based, multi tariff, three phase and 3 or 4 wires electrical systems. The energy meters shall be suitable for operation from the secondary of CT's and VT's. Separate test blocks for the testing of the meters shall be provided.

The energy meters shall be able to measure, record and display following values:

- Import and export active energy (kWh/MWh),
- Import and export reactive energy (kVARh/MVARh), and
- Import and export apparent energy (kVAh/MVAh).

Accuracy class shall be at least 0.2 for active energy meter and 1 for reactive energy meter according to IEC standard. The energy meters shall be conformed the requirements stipulated in TAVANIR[1].

It shall be possible to set voltage and current ratio so that in case of using voltage and current transformers real value of energy of system displayed or read with no extra calculation.

The energy meters shall be installed on metering panels according to attached protection and metering single line diagram. These metering shall be flush mounted and shall have separate current and voltage test blocks.

The energy meters shall have the following features and functions:

- The meters shall be programmable logic, digital type and shall include features for data logging, alarms, communication controls, etc.
- It shall be possible to define starting and ending date for reporting of metered energy.
- Phase sequence shall not have any impact on correct energy measurement and registration.
- Energy meters shall be supported DLMS/COSEM protocol according to IEC62056 standard.
- Communication baud rate shall be 1200 up to at least 19200 Selectable.

[1] Iran Power Generation, Transmission and Distribution Management Co.(TAVANIR)

- It shall be possible to get information and put settings via RS232 port.
- The energy meter shall have RS485 port for connection to remote control center via appropriate Protocols. Communication shall be possible through electrical port using any necessary equipment such as converters, standard modems and etc.
- Liquid Crystal Display (LCD) shall be able to show data with at least 12 digits and measured parameters shall be indicated in units of kilo with 2 decimal digits. When the measured parameter is high, display unit shall change from kilo to mega automatically.
- Parameters on LCD shall be indicated large enough.
- Meters shall have enough capacity and flexibility for reading data. Meters shall have enough memory for saving measured data (at least 2 GB).
- The metering pulses shall be available for output to the SCADA (At least four output scalable pulse)
- It shall be possible to modify date of daylight saving change in time and it shall be possible to enable or disable this option.

Relevant software shall be able to read all measured and calculated quantities and data, put settings on meters with capability to show the read data in table and graphic form. The software shall be windows compatible with ability to save data and settings in form of files. It shall be possible to retrieve and show the saved data, or to use the saved settings in meters.

For avoiding loss of functionality and recorded data, it shall include internal backup batteries, super capacitors, etc. or non-volatile memories shall be used whenever it is possible. Alarms for ending life cycle of internal batteries and supper capacitors shall be provided at least 1 month before the device's complete failure for operator's maintenance duties. Loss of supply shall not cause loss of data.

The energy meters shall be able to withstand the following situations without any damage:

- 3 times rated current continuously and 30 times rated current for 1s.
- 1.2 times rated voltage continuously and 2 times rated voltage for 10 s.

Enough hardware and software security means such as passwords and locks shall be provided to avoid any changes in settings or wire connections by unauthorized personnel.

The energy meters shall include extensive automatic self-checking facilities to supervise and monitor the individual condition, measuring elements, DC supply,

etc. At least one potential free contact shall be provided for alarm indication purposes in the event of meters being faulty. In addition, a LED shall be provided on the front of meters to indicate both healthy and faulty with green and red colors, respectively.

The energy meter shall have a built-in clock and calendar of an accuracy that allows a maximum time error of not more than 1 minute per month without assistance of external time synchronizing pulse. The clock shall be synchronized by GPS time synchronizing equipment.

4.7.5. Transducer

The transducer shall be made by the latest state of the art microprocessor technology. No adjustment to settings shall be accessed externally. The transducers shall be protected against surge voltages between all terminals and between terminals and ground.

Transducers shall be provided to convert the analog values of AC/DC system, position of the tap changer, analog values of oil and each winding's temperature to proportional standard milli-ampere signals for input into the distributed control system and for transmission to the control panel.

Transducers shall have an external power source. The power supply circuits shall operate from an 110V DC and 230V AC source.

All transducers shall have the following ratings:

- Accuracy class: 0.2
- The output signal: 4 to 20 mA
- Repeatability 0.1% of rated output
- Response time not exceeding 0.3 seconds to 99% of final value
- Surge withstand to IEC standards

Each transducer carries an externally visible label which shows the information listed here bellow:

- Manufacturer’s name
- Manufacturer’s type designation
- Serial number and manufacture date
- Accuracy class
- Measured quantity nature and circuits quantity
- Lowest and highest values of measured quantity

- Current and voltage transformer ratios (when applicable),
- Output current and load resistor ranges for which the specified operation is obtained
- Measurement scale limits
- Dielectric test-voltage
- Auxiliary supply voltage (rating and range)

When text and symbols are located on an easily removable part of the transducer, for instance on its cover, the serial number will also be engraved on the transducer's main body.

4.8. Event recording and data logging

The event recorder shall be considered for sequential recording of events occurring on each feeder's circuits individually with good resolution and sufficient time accuracy. It shall be located in a separate panel in the control room. The recorder shall be of advanced design, comprising microprocessor based monitoring system to acquire, store and record high-speed data.

The design of the recorder shall be such that it is able to both print the recorded data directly onto a high-quality graphics printer and include provision of a display mode to display the fault data selectively through the use of a graphic monitor.

Resolution of events shall be better than 5ms.Time and date (month, day, hour and minute) shall be automatically recorded and possibility of external synchronization. The storing, recording and presenting of operational data as it occurs shall not be over-written by further events.

All external and internal faults in the recorder such as power supply fail, processor/memory fail etc shall be monitored. At least one potential free contact shall be provided for alarm indication purposes in the event of recorder being faulty. In addition, a LED shall be provided on the front of fault recorder to indicate both healthy and faulty of fault recorder with green and red colors, respectively.

In acquisition stage, the recorder shall not malfunction due to any interference such as relay contact bouncing, etc. However the total filtering time shall not be more than 15 m sec.

The event recorder shall be suitable for operating from an 110V nominal DC power supply. The relative computer, monitor, printer and etc units shall be

suitable for operating from a 230V, 50Hz supply. Computer and relative equipment shall be industrial type.

The contents of sequential buffer memory shall be kept for a reasonable duration. Events text characters limits, Specifications of hardware and software, number of events that can be recorded shall be specified. The software shall be capable to run under win XP, 9x and NT.

Event recorder shall not hang in fault condition and shall have capability for recording data in fault condition.

At least the following quantity of events shall be recorded:

- 30 points for each: Transmission lines
- 20 points for each: Sub-transmission lines
- 15 points for each: Distribution lines
- 30 points for each: auto-transformers
- 25 points for each: 2 winding power transformers
- 30 points for each: power plant feeders
- 10 points for each: busbars
- 30 points for each: reactors
- 20 points for each: Transmission CBs
- 15 points for each: Sub-transmission CBs
- 10 points for each: Distribution CBs
- 2 points for each: disconnectors
- 80 points for general/common alarms per each station

4.9. Fault and disturbance recording

The fault recorders shall be microprocessor based and shall be used to record the graphic form of instantaneous values of voltage and current in all three phases, open delta voltage and neutral current, open or closed position of relay and breakers contacts during system faults.

The fault recorder shall be distributed type. It shall consist of individual acquisition units, one for each feeder and an evaluation unit which is common for the entire substation. Evaluation unit shall cover all substation feeders including extension feeders. Necessary hardware and software shall also be supplied for on line transfer of data from all acquisition units to evaluation unit. Data transferring shall be with appropriate speed. Acquisition units shall have sufficient analogue and digital input channels for acquisition of fault data and events. These units shall be suitable for inputs from current transformers with 1A rated secondary and capacitive voltage transformers with 63.5V (phase to neutral voltage) rated secondary.

The evaluation unit shall consist of an industrial computer (including VGA screen, printer, mouse and key board). Technical specification of computer (CPU, RAM, HARD and etc.) shall be submitted to consulting engineer for approval.

The acquisition unit shall acquire fault data and instantaneously transfer data to the evaluation unit for storage in solid state non-volatile memory.

Fault recorder evaluation software shall be provided for the analysis and evaluation of the record data in the industrial computer under WINDOWS environment. The software features shall include:

- Showing of analog waveform, analog measure trend, spectrum analysis, analog measure (RMS, 50Hz RMS, THD, Sequences, Frequency), statistic distribution of the analog measure, phasors, Vectorial values, digital inputs status, and etc.
- Powerful analysis tools
- Selection and amplification of time and amplitude scales of each analogue and digital channel
- Calculation of MAX/MIN frequency and phase difference values.
- Recording of MAX/MIN values etc. of analogue channels
- Grouping of signals to be drawn on the same axis etc.,
- Listing and numbering of all analogue and digital channels and current, voltage, frequency and phase difference values at the time of fault/tripping.
- Carrying out Fourier /Harmonic analysis of the current and voltage wave forms.
- Filtering fault based on time, equipment, and etc.
- Zoom in/out on X-axis, Y-Axis, window, zoom area between cursors, find zero crossing on rising and falling transition and etc.
- Transient analog and measure recording configuration.
- Compare two measures.
- Waveform management tools (copy, paste, move and delete)
- Export waveform in Excel, pdf, image
- Etc.

The fault records shall also be available in COMTRADE format (.cfg file).

The acquisition units shall be located in the protection or control panels of the respective feeders and the evaluation unit along with relative equipment shall be located suitably within the separated panels.

Time and date (month, date, hour and minute shall be automatically recorded.

The fault recorder system shall have non-volatile memory of the last ten faults.

The fault and disturbance recorder shall be programmable for Pre-fault sampling rate, immediate post fault sampling rate, long-term sampling rate, duration of each record, analog scaling factors and analog and event triggering.

The operation of the equipment shall be based on programme stored in non-volatile solid state memory. The programme shall be stable and no inadvertent change of programme shall occur.

Large scale integrated circuits shall be used as far as possible to reduce the number of components and interconnections and the amount of wiring. The components used shall be subjected to strict quality control which shall include screening of components by heat soaking and testing their functioning prior to assembly.

The number and type of modules employed shall be minimized. The modules shall be easily accessible for maintenance and repair wherever required.

The equipment shall be designed to operate satisfactorily even when subject to the effects of severely hostile electrical environment such as interference signals.

Fault recorder equipment shall be suitable for operation from 110V DC supplies. The industrial computer and related equipment shall be suitable for operating from a 230VAC, 50Hz supply.

All external and internal faults in the fault recorder equipment such as power supply fail, processor/memory fail etc shall be monitored. At least one potential free contact shall be provided for alarm indication purposes in the event of recorder being faulty. In addition, a LED shall be provided on the front of fault recorder to indicate both healthy and faulty of fault recorder with green and red colors, respectively.

The acquisition unit shall have a scan rate of 6400 Hz/channel or better in normal and fault condition continuously.

The equipment shall have internal starting sensors based on over voltage, rate of change of current and rate of change of frequency. When starting sensors are picked up, fault data shall be recorded during the period of system fault

including pre-fault and post fault time. In addition, fault recorder shall be triggered for recording fault data by binary input.

Faults which trigger the recorder shall operate and produce immediate information on the following points:

- Pre-fault and post-fault voltage and current curve with pre-fault time that not be less than 300 ms and the post fault time adjustable at a minimum of two seconds and a maximum of at least five seconds. If another system fault occurs during one post-fault time, the recorder shall also be able to record the second fault.
- Fault duration.
- Identification of faulted phase.
- Magnitude of voltage.
- Magnitude of phase and neutral currents.
- Operational times for all main trip outputs.
- The phase on which single-pole reclose equipment operated.
- Stages within the reclosing cycle.
- Monitor the protection signaling signals.

Amplitude resolution shall not be less than eight bit. Event resolution shall be 2ms or better.

Fault recorder shall have capability to synchronize by GPS. Faults shall be time tagged in acquisition units.

Time synchronizing shall be performed through time tagging method. Time tagging to fault shall be executed in acquisition units.

Fault recorder shall not affected by harmonics, switching transients.

4.10. Shunt capacitor bank control

Control scheme of capacitor bank feeders shall be prepared in automatic and manual mode and an automatic/manual/off selector switch shall be considered for this purpose on capacitor's control panel.

In automatic operation mode, one capacitor bank control relay with power factor control (PFC) and reactive power control (VCR) functions shall be provided for automatic controlling of each shunt capacitor bank feeder on each busbar, to prevent occurrence of hunting. The relay shall be connected to current and voltage transformers of related incoming feeder. Capacitor control relay shall be provided with separate setting stages, output contacts according to the number

of capacitor bank stages that are considered in the relevant switchgear of substation. In other words, each relay shall control all capacitor banks.

In manual operation mode, controlling load breaker switches (LBSs) and relevant circuit breaker shall be available from capacitor control panel.

Load breaker switches are used after CB in order to divide the capacitor bank into separate parts which will be controlled by different stages of capacitor control relay (automatic mode) or by operator manually (manual mode).

A separate panel with all its complete accessories along with the capacitor control relay (VCR/PFC relay) shall be provided. Mimic diagram, indications, selector switches (local/remote, auto/manual/off, sub/scada and etc), discrepancy switch, semaphore and other accessories shall be provided on the panel to control each LBS and relevant CB of capacitor feeders manually. It is required for voltage information to be supervised and for the relay to be blocked in case of fuse failure.

The controlling of all LBSs and CBs of capacitor feeders shall be possible in local position from switchgear cubicle, remote position from control panel and remote SCADA.

Adequate time delay shall be considered between AVR equipment and capacitor control relay operation. For this purpose enough time delay relay shall be prepared.

Re-energizing of the capacitors shall be delayed adequately (minimum 5 minutes time delay).

Electrical interlock between capacitor bank's door lock and the relevant earth switch in the switchgear shall be considered in a way that prevents entrance after energizing and prevents energizing when the door is open. Enough time delay shall be considered for unlocking the door after de-energizing the capacitor bank or closing the related earth switch.

5. Protection system

5.1. Protection design criteria

The functional requirements of this specification relating to protection relaying shall be applied to all equipment used for any protection functions.

Strict demands shall be made on selectivity in fault isolation. To improve security, the protection systems shall be designed to isolate only the faulty portion of the network. For faults external to the protection zone, the protection system shall remain stable or operate selectively in conjunction with other protection systems, including breaker failure.

Protection relays shall be connected to current and voltage transformers in accordance with appended drawings. Respective protection relays shall actuate circuit breakers adjacent to the measurement zone, for complete isolation of the fault. In some cases, breakers in other voltage levels may also have to be tripped remotely. For isolation of a fault, all breakers around the fault shall be tripped.

Every fault condition shall be detected by at least two protection relays. The protection shall be arranged into overlapping protection zones. For each fault case, there shall be a fast primary protection having a limited protection zone, normally supported by a slower or less sensitive backup protection preferably based on a different measuring principle and often with a more extended protection zone. Main and Backup (SUB1 and SUB2) protection systems, including their auxiliary supply, shall be separated to allow maintenance on one protection without affecting the function of the other, and to avoid common mode failures.

To improve dependability, the two protection systems shall be divided into separated parts by means of:

- Separated DC power supply
- Separate current transformer cores
- Separate voltage circuits
- Separated tripping devices
- Separated cables
- Separated relay protection channels (only for lines)

When one set of relaying in a circuit is taken out of service for repair, maintenance or testing, the circuit shall be adequately protected by the other sets of relays.

All protection relays shall be numerical and of microprocessor controlled type.

When the protection relay is being tested then the testing signal shall be transferred to the event recorder. At the end of testing process the normal operation mode signal shall be transferred to event recorder.

Some relay data shall be visible from relay such as:

- Order code
- Serial number
- Rated current and/or voltage of the relay
- Auxiliary supply voltage

5.1.1. Dependability

The relay system shall be highly dependable. The relay system shall produce a trip output for all faults within the zone of protection and shall not operate for any external faults.

The relay shall not commit maloperation in any of the following conditions:

- Any kind of external faults beyond the protected sections,
- System's transient disturbances,
- Current surges due to sudden changes in line charging capacity in the case of one phase to ground fault, line switching on external faults, etc,
- DC components of short circuit currents and CT saturation,
- Magnetic fields from other relays.

5.1.2. Tripping circuit

The trip circuits of the main and backup (SUB1 and SUB2) protections shall be completely independent. This implies that they shall not include common switching devices, connectors, terminal blocks, cables, auxiliary relays, etc.

No time delay for the tripping contacts is accepted. Master trip relays shall have a maximum tripping time equal to 8 ms or less.

The tripping contacts of protection relays shall reset automatically when no further fault conditions are present.

The Contractor shall also quote the maximum breaking capability of the trip relay (in Amps) when associated with an inductive burden having a time constant of not less than 40 ms at a rated voltage of 110 volts DC and at other voltages as may be specified for a particular installation.

Both high functional security and speed are necessary in the tripping circuit, so the system design shall be such that a minimum of series-coupled elements are required.

5.1.3. Current circuit

The protection relay shall be designed for a rated current, which corresponds to the secondary rated current of the current transformers. The contractor shall select current transformers to match the protection relays and measuring instruments. Separate current transformer cores shall be used for main and backup protections.

All current secondary circuits shall be earthed only once at the related marshaling panel.

In the each panel in the substation, provisions shall be made for short circuiting the secondary current circuit by means of terminal blocks with short circuiting contacts.

All CT requirements shall be specified separately for each protection relays and measuring instruments and respective calculation shall be sent to the Engineer for approval according to following facts:

- High source side fault levels,
- High X/R ratio,
- All CT ratios,
- Single shot auto-re-closures requirements with circuit breaker duty cycle as O - 0.3 Sec. - CO-3 Min. -CO,
- Summation of interconnected burden to CT secondary and cable between CT and control room, and
- All other technically required features.

5.1.4. Voltage circuit

The protection relay shall be designed for a rated voltage, which corresponds to the secondary rated voltage of the capacitive voltage transformers. The contractor shall select voltage transformers to match the protection relays and measuring instruments. Separate voltage transformer windings shall be used for main and backup protections.

The secondary windings of the voltage transformers in the various phases shall be interconnected and earthed in the nearest marshaling panel to voltage transformers.

The voltage circuit shall be divided into separate groups for each protection relay or other equipment to be connected. Various groups shall be individually protected against short circuits with miniature circuit breakers in the marshaling panel. The miniature circuit breaker shall be provided with electromagnetic and thermal protection elements and shall have potential free contacts for blocking purpose and signaling.

Failure of fuses and MCB's shall be monitored by very high speed fuse failure relays. This relay shall operate in the event of open circuits in one, two or three phases of the secondary but not in the event of primary loss of voltage. Sufficient free potential contacts shall be provided in the relay for initiation of alarm system and blocking of control and protection equipment if necessary.

5.1.5. DC voltage supply

Power supply requirements of the protection system shall match the DC supply system specification specified in the relevant chapters of the technical specifications.

All feeders protected by more than one protection equipment or relay (main and backup) shall have a separately protected DC power supply for the control and tripping of each one of these relays. CB control circuits shall be fed by separately protected DC circuits in any case.

All numerical relays shall be equipped with a self monitoring alarm system, especially for DC supply and abnormal levels of stabilized DC voltages but not necessarily limited to only these two.

Separate circuits from main DC distribution board shall be considered per each object (Line, Trans, etc) for the following purposes according to LVDC drawings:

- The protection relays,
- CB and D.S motor,
- Trip and close circuits,
- Meters,
- Alarm,
- Synchronizing,
- Control and Interlocking, and
- etc.

The DC circuit used to actuate the tripping relays shall be separated from the DC circuit for the tripping coils.

DC auxiliary supplies relevant to each protection relay, measuring center or other purpose shall be protected individually by means of their own miniature circuit breakers. All MCB's shall be supervised with alarm.

All DC control circuits shall include a circuit supervision relay which initiates an alarm (after a time delay) in the event of loss of the DC supply. To the extent that it is practical, the supervision relay shall be wired at the end of the DC supply loop so that it also monitors the continuity of the DC supply wiring. In addition, the DC supply of equipment shall be monitored by means of an auxiliary contact of the related MCB which shall be provided with an alarm in case of loss of supply.

5.1.6. Test blocks

In general, the components of the protection relays shall be designed for easy maintenance and testing at the front of each protection equipment panel. All protection relays shall be capable of being tested individually, even during substation normal operation, with adequate safety of the test personnel and without the risk of spurious tripping. The testing action shall not affect other protection relays.

The sufficient test blocks shall be provided for each relay for following purposes:

- Isolate all DC circuits,
- short circuit on the CT side,
- Isolate the associated CT circuits,
- Isolate voltage circuits,
- Isolate both sides of all protection relay trip outputs,
- Isolate both sides of all protection relay outputs for initiation of other protections (such as CBF, A/R and etc), and
- Provide possibility to connect portable test equipment.

When testing the protection, it is not acceptable that the protection functions in the other sub system are blocked or activated.

Test block shall be designed, manufactured and tested in accordance with the IEC 60255 standards. The test blocks shall have sufficient circuits. Each circuit shall be comprised of a pair of internal contacts which are normally sprung together to complete the circuit link through the test block when the associated protection equipment is in normal service. Each contact shall be spring loaded,

flexible, resistant, minimum current withstand 20A continuous, 150A for 10s and 500A for 1s, and working voltage 300V AC rms or DC.

Test block are separated from other contact by insulated barriers of test plug. The contacts of test block shall loosen automatically when the test plug is removed.

Separate test block shall be provided for metering equipment for isolating voltage and current inputs of this equipment. Test equipment shall be connected without open circuiting the normal current circuit. Voltage and current shall be injected into the metering equipment from portable test equipment without removing the metering equipment from the panel.

The sufficient test plugs for testing protection relays and the sufficient current & voltage test plugs for testing metering equipment shall be provided.

Sample test of each type of test block and test plug shall be executed in the presence of client and consultant engineers.

5.1.7. Direct Transfer Trip (DTT)

The direct transfer tripping scheme shall generally be provided for necessary remote tripping for transmission and sub transmission lines, but the contractor shall provide other unforeseen conditions depending upon particular scheme after proper approvals of the Engineer.

The direct transfer tripping shall be achieved by using a dual channel transfer trip scheme using PLC or fiber optical or other suitable communication system according to communication technical specification.

Direct transfer tripping shall comprise of following protection functions:

- Line Over voltage protection trip,
- Line circuit breaker failure protection in stage.2 trip,
- Short zone protection trip, and
- Protection trips of Transformer or reactor feeders installed on line without CB.

The direct transfer tripping scheme shall provide reliable and secure high speed remote tripping of Line Terminals. Normally the trip and output contacts of both two receivers are connected in series to provide maximum security.

In the event of failure of a channel an alarm signal shall be activated. When one of these two channels fails and the tripping signal is received through the other healthy channel, tripping shall be resulted after a preset time delay. Also in the situation of one faulty channel, zone2 tripping of distance relay in series with

tripping signal received by one healthy channel shall be considered as a tripping signal and result in tripping the corresponding line feeder.

5.2. Numerical protection relay's requirements

Relays shall be of approved makes and types, fully numerical microprocessor based, shall have approved characteristics and be flush mounted type, dust proof and shall be high speed operating. The construction of the relays shall be sturdy and shall be such that all parts are readily accessible for easy adjustment.

Each relay shall have a display of adequate size for indicating the events, online voltages and currents, settings, software version, fault counter and alarms. In case of an event, numerical protection relays shall always display the latest event automatically.

Each relay shall have all necessary software such as configuration and setting software, data recorded access software, evaluation software for fault data and event recording, software for relay diagnostics and communication facility for remote and local access. A numerical protection without the appropriate software shall not be accepted.

A copy of relay firmware which used in the relay shall be provided, so that in case of difficulty in operation of relay, recovery of the relay and necessary modifications shall be possible by the client in the substation (without necessity of sending relay to manufacture).

Baud rate of each communication port of relay shall be at least 9600 bit/sec.

Relays shall have equipped with fault and event recorder. Relay shall have capability to monitor and record fault and event data in a non-volatile buffer. Information shall be maintained during DC supply failing or relay impairing.

Each fault or any other occurrence recognized by the relay shall be tagged with the actual time and time stamp shall be with an accuracy of at least 1ms.

Fault recorder of relay shall have following features.

- Pre fault and post fault time setting shall be adjustable and the total time duration of recording data shall be at least 5sec.
- Mode of starting to record shall be programmable (This feature shall offer the possibility to trigger fault recordings by a remote signal connected to the relay or thresholds of analog signals to be set during setting of the relay).

- The fault recording function shall record at least all three phase currents and voltages, earth current, neutral voltage, synchronizing voltage, trip signal and frequency (related to protection function). So sufficient analogue and binary input (related to relay) shall be provided.
- Fault recorder shall be capable to record at least latest 8 faults.

Recorded data of fault recorder shall be displayed as time, polar, impedance and harmonic curves. Voltage and current sampling rate shall be at least 16 samples in each cycle. Recorded data shall be available in COMTRADE format.

Event recorder of relay shall have capability to record at least 100 events.

Numerical protection shall be designed in such a way that in case of DC auxiliary infeed failure, full information and fault data is maintained. After a recovery of the DC auxiliary infeed, the last information and alarms shall be displayed and the alarm of the DC auxiliary infeed shall be released.

Protection relay designs shall include extensive automatic self-checking facilities to supervise and monitor the individual relay's condition, measuring elements, DC supply, etc. Defects that may cause relay's maloperation shall inhibit operation of that particular relay or element of a relay system. At least one potential free contact (watch dog) shall be provided for alarm indication purposes in the event of protection relay being faulty. In addition, a LED shall be provided on the front of relay to indicate both healthy and faulty of relay with green and red colors, respectively.

The protection units shall also be equipped with Human Machine Interface (HMI) for local control of the terminals. This local HMI shall be front mounted and based on a user friendly menu structured program.

All of trips and alarms shall be programmable and able to be related to output contacts of the numerical relays.

The number of output contacts and binary inputs of all protection relays must satisfy requirements of the related scheme. Also, at least 20% of output contacts and binary inputs shall be provided on each protection relay for spare or future scheme.

Relays shall have time synchronizing port (such as IRIG-B, DCF) for external synchronizing with GPS.

It shall be possible to access the protection parameter settings from HMI terminals of relay, laptop connected to relay and eventually the remote control center for DCS substation. In this regard, relays shall be equipped with appropriate communication interfaces.

The setting of parameters or activation of parameter sets shall be restricted by password to the protection engineer.

Relay shall have appropriate catalogue and information CD such as:

- Configuration and setting manual
- Commissioning manual
- Maintenance manual
- Operation manual
- Application manual
- Technical manual

Contractor shall provide a laptop for substation with latest technology which is equipped with appropriate ports for connecting to relays and metering instruments. Technical specification of laptop shall be submitted for consulting engineers for approval.

All other necessary accessories for relay shall be provided.

5.3. Common circuit breaker protection

5.3.1. Circuit Breaker Failure protection (CBF)

Circuit breaker failure protection shall be provided to clear faults which have been correctly detected by the appropriate protection but for which the associated circuit breaker has failed to open.

Separate circuit breaker failure protections shall be provided for each circuit breaker according to the respective protection single line diagram.

The breaker failure protection on circuit breakers shall be initiated by all other protection devices including main and backup, which normally initiate the tripping of that breaker, except second stage of adjacent circuit breakers failure protection and the under voltage protection.

Meanwhile manual opening command shall not start the breaker failure protection.

If a trip command fails to open the circuit breaker, after a time delay (adjustable between 0 to 5s in steps 10 ms) the circuit breaker failure relay shall send a "first stage" tripping command to both trip coils of the respective circuit breaker. The re-trip can be a three pole trip or single pole trip according to tripping mode of protection function.

If the circuit breaker is not able to open the circuit after operation of CBF relay's "first stage", the CBF relay shall send a different tripping command, after a second time delay (adjustable between 0 to 5s in steps 10 ms) to all circuit breakers around the one for which the trip initiation failed, in order to interrupt fault current.

Sufficient separated binary input and output shall be provided. These output shall not used for logic programming and just used for relay command functions.

The circuit breaker failure protection shall consist of a current detecting element and CB auxiliary contacts detecting to determine whether the interruption of fault current has been carried out satisfactorily or not. Relay shall have capability to configure such that just current detecting element checking, or just CB auxiliary contact checking, or both current and contact element checking is executed for recognizing circuit breaker failing. In the situation of both current and contact element is checked, relay shall have capability to recognize CB fail if both current and contact element detect CB fail or one of them detect CB fail (one of them is checked with high priority)

The current detector element of relay shall provide an acceptable safety against spurious taking into account CT saturation. The settings range of the current detecting elements shall be 5% to 100% of related CT's secondary nominal current (with steps 5%).

This protection shall be effective during single pole tripping cycles and shall not operate during the single pole open conditions prior to single pole reclosing.

Sufficient binary inputs shall be considered for circuit breaker failure, so that it shall be possible to initiate CBF relay from different protection functions in single and three phase tripping mode. Input and output of relay shall be isolated by opt-coupler.

The circuit breaker failure relay in second stage shall incorporate provision for initiating direct transfer tripping of any remote infeeds, and the circuit breaker of the other side of power transformer.

Binary input for relay blocking shall be provided.

5.3.2. Short Zone protection (SH.Z)

The short zone fault (end zone) is a short circuit occurred between the circuit breaker and the participant current transformer in a feeder. This relay shall be provided for each circuit breaker according to the respective protection single line diagram and shall be initiated from different protection functions when CB is in open position.

This protection function shall send a trip signal to all CT side circuit breakers that feed the fault current after an adjustable time delay (between 50 to 500 ms continuously or in steps smaller than 10 ms). It shall also incorporate provision for initiating direct transfer tripping of any remote infeeds, and the circuit breaker of the other side of power transformer.

The short zone protection scheme shall be finalized during design stage by the consulting engineer.

5.3.3. Pole Discordance protection (PD)

The pole discordance protection shall be applied to supervise the coordinated operation of 3 poles in single pole operated circuit breaker. Separate pole discordance protection shall be provided for each single pole operated circuit breakers.

The pole discordance protection shall use the auxiliary contacts of associated circuit breaker and the current in different phases (current setting shall be adjustable between 0.05 and 1 times of rated current with step 0.01), so that an alarm shall be initiated with an adjustable time delay in both closing and opening operation of the circuit breaker (time delay setting shall be adjustable between 0 and 10 sec with step 0.05sec). The time delay shall be sufficient to avoid spurious function due to normal differences in operating time of different poles.

During single phase auto reclosing, the pole discordance protection shall be blocked. The pole discordance protection shall activate the trip relay of the circuit breaker and shall initiate the breaker failure protection relay of the same circuit breaker. Also at the same time an alarm is initiated.

5.3.4. Lockout relay (86)

The lockout relay shall be considered for each circuit breaker to lock closing circuit after fault and to prevent malapropos closing operation. This relay shall be of mechanically latched type with manual and electrical resets from all possible remote controls. The relay shall have at least one Flag or LED for operation indication.

This relay shall have two coils in order to perform the set and reset operations of the relay. This relay shall be initiated by all other protections except under voltage relay protection and first stage of CBF protection. Also if auto-recloser relay is activated, the first zone of distance protection and directional earth fault protection shall not initiate lockout relay.

Circuit breakers closing circuit shall be interrupted if lockout relay is operated.

5.3.5. Trip Circuit Supervision (TCS) / Close Circuit Supervision (CCS)

The trip circuit supervision scheme shall involve passing an ignorable current through the trip circuit, the trip coil of circuit breaker and all other related connections to supervise trip circuits of the circuit breaker.

Separate Trip circuit supervision relays shall be provided for continuously monitoring of each trip circuit of each circuit breaker in either the closed or the open position. The supervision shall include the DC supply, tripping coil, outputs of trip relays and all connections in tripping circuit.

This relay shall open the closing circuit of relevant circuit breakers and initiate an alarm. Latched output contacts of trip circuit supervision relay is not accepted.

The closing circuit of each circuit breaker shall be supervised in both states when the breaker is open and closed, (where applicable in accordance with attached drawing). Design of close circuit supervision (CCS) shall be similar to TCS relay scheme.

5.3.6. Switching control relay

Switching control relay shall be applied to control switching of high voltage circuit breakers for elimination of harmful electrical transients upon planned switching of mainly capacitor banks, shunt reactors, power transformers and transmission lines.

For more detail of this relay refer to related high voltage circuit breaker technical specification.

5.4. Transmission line protection

The transmission line protection (more than 200kV) shall be divided in sub1 and sub2 categories comprising of the following protection relays. The protection shall be connected to measure current and voltage transformers' values as shown in appended drawings.

5.4.1. Transmission line protection (SUB1)

Sub1 line protection shall consist of the following Relays/Functions:

A) Distance protection (21/21N)

The distance relay shall be of numerical type, "non switched full scheme" design. The relay shall selectively operate for all types of phase and earth faults with high degree of security against spurious tripping due to any type of power system transients. Separate phase and earth fault distance measuring elements shall be provided for each zone. The type of measuring characteristic shall be convenient in case of over head line or cable feeders. Phase selection and sequential measurement are not acceptable. Phase and earth fault compensation features shall be incorporated to ensure accurate distance measurement for all types of faults.

For both SUB1 and SUB2, the distance relay shall have MHO characteristics as well as quadrilateral characteristics for phase and earth faults and for each zone.

Distance protection relay shall provide at least three forward and one reverse zone of protection. Tele-protection channels over Power Line Carrier and other communications media will be used in conjunction with the distance relays to form protection schemes such as permissive under reaching transfer tripping scheme, permissive over reaching transfer tripping scheme, blocking scheme, unblocking scheme and zone extension scheme.

Also distance relay shall have weak infeed function.

The reach of each measuring zone and starting relay shall be individually adjustable. The setting ranges of the relay shall be continuously adjustable according to current and voltage transformers ratios. The characteristic angle shall be adjustable between approximately 30 and 90 degrees in step 1 degree. Zone 2 and zone 3 shall have time delay setting ranges of 0-1.5 seconds and 0-3 seconds respectively. Each zone shall have separate settings for phase faults and ground faults.

All zones shall be provided for zero sequence impedance and mutual impedance compensations. Compensation factor shall be adjustable. The effect

of mutual coupling between the double circuit lines on the protection shall be described together with any measures considered necessary to overcome this effect.

The minimum operating current shall be less than10% of the rated current.

Distance protection relays shall have facilities for independently tripping duplicate single pole operated circuit breakers and initiating auto-reclosing, circuit breaker failure protection, protection signaling, inter tripping, alarms, fault locators, fault and event recorders etc. the relay shall be suitable for single pole and three pole tripping.

The distance relays shall incorporate indicators to show the zone in which the relay tripped and the faulted phase or phases, whether the relay's operation was due to aided trip, switch onto fault, power swing blocking, VT fuse fail or directional earth fault if appropriate. Indication shall not be lost in the event of a supply failure.

Distance relay shall have capability to recognizing and monitoring negative sequence, capability to defining Load Blinder characteristic and voltage memory for recognizing close up faults.

Distance protection shall include a fault locator for identifying the location of fault on the lines. The fault locator shall provide visual information to the operator by means of a LCD location of the fault in km or percent length of line length. The fault locator function shall have an accuracy class of better than 2%. The fault location assessment shall be independent of fault resistance, load current or the supply of a data from different sources.

5tele-protection systems shall be provided for each transmission line. Distance SUB1,DEF SUB1,Distance SUB2, DEF SUB2, Direct transfer trip.6 communication channels shall be provided for this purpose, 1 channel for Distance SUB1, 1 channel for DEF SUB1, 1 channel for Distance SUB2, 1 channel for DEF SUB2, and 2 channels for direct transfer trip. All necessary provision (such as appropriate media and etc.) shall be considered according to communication technical specification.

Distance protection relay shall have at least 3 setting group.

Distance protection relay shall have following internal functions:

- **Switch On To Fault protection (SOTF)**

Switch on to fault feature shall be incorporated to ensure instantaneous tripping in events that the circuit breaker is closed onto a fault on a previously de-energized line.

- **Fuse failure supervision (97)**

The distance protection shall include a voltage transformer supervision unit to prevent the possible unwanted operation of the distance relay comparators in the event of a failure of one, two or three phases of voltage caused by open or short circuit faults in the voltage transformer's secondary circuits or due to removal of VT fuses. In the event of loss of one, two or three phases the distance relay shall be blocked and a time delayed alarm shall be initiated. The VT supervision unit shall be faster than the distance relay's measuring units under all circumstances.

- **Stub protection (50-STUB)**

To protect the stub connection in one and half circuit breaker or ring arrangements the stub protection shall be considered. This protection consists of three instantaneous over current relays with a setting range of 0.1 to 10 times of CT secondary rated current and is only activated when the line disconnector switch is open and no adequate fault voltage is fed to the distance protection. The stub protection shall be stable for through faults owing to current transformer saturation or characteristic mismatching etc.

- **Power Swing Detection (PSD)**

The distance relays shall incorporate appropriate power swing detecting elements to prevent undesired operation or tripping of the relay during stable power swing conditions. Facilities shall be provided to block one or more zones of the distance relay as required and an alarm signal to be initiated. Blocking the logic shall be derived by determining the time taken for the apparent impedance of the power swing locus to pass from the characteristic of the power swing element to the distance relay's starter characteristic.

Also relay shall have capability to set such that blocking shall not tack place in special cases.

Where applicable, power swing blocking shall be inhibited during the single pole dead time of an auto reclose cycle so that if a power swing is developed during this period the distance protection can give an immediate three phase trip.

B) Directional Earth Fault protection (67N)

This function shall be internal function of distance protection (part 5.4.1.A).

To achieve fully discriminative clearance of high resistance earth faults at any point on the protected line, distance protection relay shall incorporate a directional earth fault (DEF) element operating in conjunction with tele-

protection channels. The DEF protection shall be matched with DEF protection at the remote ends of the line.

The DEF function shall consist of inverse (IDMT) and definite time (DMT) relay. Time Multiplier Setting (TMS) shall be adjustable between 0.05 and 1.2for inverse characteristic.

The DEF function shall be polarized by residual voltage that calculated inside the relay by programming software. The VT supervision unit associated with the distance protection shall also inhibit the DEF function in the event of VT fuse failure. The DEF function shall have Non-directional, Reverse and Forward options.

Maximum Torque Angle (MTA) shall be adjustable between 0 and -85 degree with steps maximum 1 degree.

The DEF function operation shall be blocked during single phase tripping of distance relay and dead time of auto reclosing.

Single pole tripping and single pole auto-reclosing from the DEF scheme shall be considered.

Tele-protection channels over Power Line Carrier and other communications media will be used in conjunction with the distance relays to form DEF protection schemes such as permissive and blocking scheme.

C) Under and Over Voltage protection (27/59)

The over voltage protection shall generally consist of inverse and definite time over voltage relay and have a voltage setting from 90% to 150% of rated voltage in steps 1% and adjustable time delay (for definite time) of 0to 60 sec in steps 0.05s. This protection shall send direct transfer tripping to other side of the line. Pick up to drop off ratio shall be high enough (between 95% and 99%).

The under voltage protection shall consist of inverse and definite time under voltage. The under voltage protection shall only operate for low voltages in all three phases with a setting voltage range of 50% to 100% of the rated voltage, adjustable in steps of 1%. Adjustable time delay shall be provided between0.01 and60sec in steps 0.05s.Pick up to drop off ratio shall be between 1.01 and 1.05.The function is necessary to avoid spurious tripping due to removal of fuses in the measured voltage circuit.

After the relay's operation, the tripping signal of under voltage shall be interrupted after about 2s. The operation of the under voltage relay shall be blocked automatically when the series disconnectors of the line are opened, so that spurious tripping is prevented when the line is isolated.

D) Fuse failure device (97)

Failure of fuses and MCB's shall be monitored by very high speed fuse failure (CVT supervision) relays separately. This relay shall operate in the event of open circuits in one, two or three phases of the secondary but not in the event of primary loss of voltage. Sufficient free potential contacts shall be provided in the relay for initiation of alarm system and blocking of protection equipment where necessary.

The VT supervision unit shall be faster than the voltage protection relay measuring units under all circumstances.

5.4.2. Transmission line protection (SUB2)

Sub2 line protection shall consist of following Relays/Functions:

A) Distance Protection (21/21N)

All technical specifications of sub2 distance protection and related functions shall be considered similar to sub1 distance protection (5.4.1.A item).

It's noted that backup distance relay shall differ from main distance relay in design, technology and logic.

B) Directional Earth Fault Protection (67N)

All technical specifications of sub2 directional earth fault protection shall be considered similar to sub1 directional earth fault protection (5.4.1.B item).

C) Single and three phase auto reclosing with synchro check relay (79/25)

Single and three pole multi shot (at least 2 shot) high speed and delayed auto reclosing relay shall be provided for each the overhead line circuit breakers. Different settings shall be chosen in operation of single or three pole auto-reclosing.

The auto reclosing relay shall act in conjunction with built-in check synchronizing relay.

Auto recloser relay shall have adequate binary input for initiate from other protection according to design requirement. It shall have inputs for blocking and disabling. Also relay shall have sufficient binary output according to design requirement. Also relay shall provide with phase-phase and phase-ground voltage input.

The auto reclose relay shall have the following functions:

- A three pole auto reclosing scheme being capable of giving high speed reclosing without synchro-check facilities.
- A voltage check facilities to enable dead line/dead bus (with adjustable voltage setting between 1 and 0.5 times of nominal voltage with steps 1% for determining dead line/dead bus and adjustable voltage setting between 0.5 and 1.2 times of nominal voltage with steps 1% for determining live line/live bus) and synchronism check for live line reclosing.
- In normal operation, all single pole trip outputs initiate single pole reclosing following the tripping of the appropriate phase.
- Any further faults in other phases at any stage during any reclosing operation are caused to immediate tripping of any closed phases and achieve three phase trip.

A selector switch for each circuit breaker shall be provided on the related control panel with 2 positions: ON/OFF.

An operation counter to record the number of operations for single pole and three pole trips separately can be provided. It can be used to lock out the reclosing operation after a pre-defined number of reclosing acts optionally.

Relays shall offer the adjustable dead time between 0.1 and 60s with steps 0.05s for each shot.

The reclaim time of relay shall be adjustable between 1 and 250sec with step 1s for each shot. (The reclaim time commences at the instant the reclose command is given to the circuit breaker and therefore, includes the circuit breaker closing time).

The duration of the closing command shall be limited to 2 seconds, after which the reclosing relay shall be automatically reset without resetting the reclaim timer. The reclosing relay shall also reset if synchronism check conditions are not satisfied within predetermined time of the check relays being energized.

Adjustable time setting for holding reclosing command shall be provided for ensures CB is closed.

When a voltage is present on both sides of a circuit breaker, the synchronism check relay shall monitor the magnitudes of the two voltages across the open circuit breaker and the phase angle and slip frequency between these voltages. Closing shall only be permitted when these are within prescribed limits. Synchronism check relay shall be provided with the following setting range:

- Phase difference angle adjustable between 5 to 40 electrical degree with steps 1 electrical degree.
- Voltage difference adjustable between 5% to 30% of nominal voltage with steps 0.5%.

- Frequency difference adjustable from 30mHz up to 0.5 HZ with steps 0.01Hz.

Also reclosing shall have capability by bypassing synch check relay (without voltage synch check).

There shall be no reclosing on power transformers and underground cable lines.

5.5. Sub-Transmission line protection

The sub-transmission line protection (between 63kV and 132kV) shall be divided in main and backup categories comprising of the following protection relays. The protection shall be connected to measuring transformers as shown in appended drawings.

5.5.1. Sub-Transmission line protection (Main)

Main line protection shall consist of the following Relays/Functions:

A) Distance protection (21+21N)

All technical specifications of distance protection and related functions shall be considered similar to sub1 distance protection of transmission line protection (5.4.1.A item).

The quantity of channels in sub-transmission lines shall be considered 4 channels, such as distance Main (channel 1), DEF Main (channel 2), and direct transfer trip (channel 3, 4).

B) Directional Earth Fault protection (67N)

All technical specifications of directional earth fault protection shall be considered similar to sub1 directional earth fault protection (5.4.1.B item).

C) Under and Over Voltage protection (27/59)

All technical specifications of under and over voltage protection shall be considered similar to sub1 under and over voltage protection (5.4.1.C item).

5.5.2. Sub-Transmission line protection (Back up)

The backup Line protection shall consist of the following Relays/Functions:

A) Directional Over Current and Directional Earth Fault protection(67/67N)

Directional over current and directional earth fault relay shall be of the inverse definite minimum type (IDMT) with instantaneous high set elements and shall have multi characteristics as inverse, very inverse, extremely inverse and definite time.

Directional over current and earth fault protection shall have a pick up current range from 0.1 to 2 times of the nominal current in steps of 1% for inverse characteristic, a current range from 0.5 to 20 times of the nominal current for definite characteristic and a time setting adjustable from 0 to 60s in steps of 50ms for definite characteristic. Time Multiplier Setting (TMS) shall be adjustable between 0.05 and 1.2 with steps 0.01 for inverse characteristic. The characteristic of over current protection shall define independently from earth fault protection.

Directional elements shall be voltage polarized. The angle of the base voltage shall adjustable between -180 degree and 180 degree with steps 1 degree.

Relay shall have voltage memory for recognizing 3phase close up faults, binary input for blocking and at least 2 setting group with automatic switching.

B) Three phase auto reclosing with synchro check relay (79/25)

All technical specifications of above protection and related functions shall be considered similar to sub2line protection of transmission line protection (5.4.2.C item), except following items:

- In sub transmission feeders, just three phase auto reclosing shall be executed. So all features related to single pole auto reclosing that describe in part 5.4.2.C shall be omitted.
- A two position On/Off selector switch shall be provided for each feeder.

C) Fuse failure device (97)

All technical specification of fuse failure protection and related functions shall be considered similar to sub1 line protection of transmission line protection (5.4.1.D item).

The VT supervision unit shall be faster than the directional over current and directional earth fault protection relay's measuring units under all circumstances.

5.6. Power transformer protection

The power transformer protection shall be divided into Electrical and Mechanical protections. The Electrical protections of power transformer shall be divided into Main and Backup categories comprising of the following protection relays.

5.6.1. Power transformer protection (Main)

The main protection of power transformers for different voltage levels shall consist of the following Relays/Functions:

A) Differential Protection (87T)

The differential protection relay used for the transformer shall be of percentage differential type having three sections bias characteristic. The differential relay shall have restraining and operating circuits in each phase.

The differential protection relay shall have fast clearance of heavy internal transformer faults with high set differential element. Current setting of high set differential element shall be adjustable between 0.5 and 30 times of rated current in steps of 0.1 of rated current.

The pickup current range of percentage characteristic of differential relay shall be adjustable between 0.1and 1 times of rated current in steps 0.01. The first slope of the characteristic is adjustable between 0.1 and 0.5 in steps 0.05 and the second slope of characteristic is adjustable between 0.25 and 0.95 in steps 0.05.

Relay shall have two or three separate input current for calculating operating and restraint currents for protecting two or three winding power transformers against winding short-circuit, inter-turn fault, earth fault and short circuit.

The relay shall be of high speed type and its total operating time shall not exceed 35ms.

The differential protection relay shall have the following functions:

- The relay shall be stabilized to prevent unwanted operations for faults occurring outside the protected area.
- 2^{nd}harmonic restraint for prevention of unwanted relay operations at transformer inrush (setting adjustable between 10% and 80%).
- $3^{rd}$and 5^{th}harmonic restraints for prevention of unwanted relay operations at transformer over excitation (setting adjustable between 10% and 80%).

- Relay shall have capability to trip in duration of transformer energizing if a fault exists in protection zone.
- Insensitive to DC components and CT saturation and transient phenomena.
- No interposing CTs are needed for the protection of transformers in order to match the vector groups of HV, MV and LV sides.
- The differential relay shall be capable of accurate measuring the amplitudes of phase currents and differential currents, phase angles between phase currents and phase differences of HV and MV/LV side phase currents. The measured amplitudes and phase angles are presented on the relay's display.
- Necessary quantity of binary input/outputs and programmable LEDs shall be provided in order to handle control, communication, monitoring and tripping functions. Also binary input for relay blocking shall be provided.
- The differential relay shall not need any necessary setting changes whenever the transformer's taps are changed from one extreme to the other extreme.
- A negative-sequence protection may be defined for sensitive over current protection in the event of asymmetrical faults in the transformer.
- Differential protection relay shall have at least 4 setting group.

The main transformer's differential protection shall always include the auxiliary/earthing transformer inside its zone of protection.

The three phase thermal overload function protects the insulation against thermal stress. The thermal protection is provided with two independently set levels for alarm and tripping. This protection shall be internal function of differential protection.

Wherever the transformer's tertiary is used for any feeder loading etc, the zero sequence compensation for stabilizing the main differential protection shall be provided. This function is required to provide stabilizing effect to the differential relaying under heavy transient through fault conditions.

B) Over flux protection (24)

The over flux protection shall protect the power transformer against excessive excitation. This relay shall have inverse and definite time characteristics with adjustable setting range between U_n/f_n and $1.4U_n/f_n$ with steps 0.01.The

protection shall continuously monitor the over flux by measuring the voltage to frequency ratio.

The over flux protection relay, shall initiate the lockout relays when tripping the circuit breaker.

Over flux protection shall not be applied on that side of power transformer which has an OLTC installed.

This relay shall have a drop off to pickup ratio greater than 95%.

C) High impedance Restricted Earth Fault Protection (87N)

High impedance restricted earth fault protection schemes are required for each neutrally earthed voltage levels winding.

Restricted earth fault protection relays shall have maximum sensitivity and minimum operating times consistent with stability for faults occurring outside the protected zone and on magnetizing inrush surges.

All necessary equipment such as stabilizing resistors of adequate ratings and nonlinear overvoltage protection resistors (metrosil) shall be provided. The rated stability limit shall not be less than the maximum current available for an external fault. Contractor shall calculate technical specification of stabilizer and metrosil resistors and submit for consulting engineers for approval as well as CT calculation.

Current setting of REF protection shall be adjustable between 0.05 and 1 times of rated current.

The related CT's shall have equal ratios, identical magnetizing characteristics and identical secondary resistances.

The relay shall not be affected by harmonics, DC components and CT saturation, transient phenomena, and etc.

D) Under and Over Voltage protection (27/59)

The over voltage protection shall generally consist of inverse and definite time over voltage relay and have a voltage setting from 90% to 150% of rated voltage in steps 1% and adjustable time delay (for definite time) of 0 to 60 sec in steps 0.05s. This protection shall trip each side CB of transformer.

The under voltage protection shall consist of inverse and definite time characteristics. The under voltage protection shall only operate for low voltages in all three phases with a setting voltage range of 50% to 100% of the rated voltage, adjustable in steps of 1%. Adjustable time delay shall be provided

between0and60sec in steps 0.1sec.Under voltage protection shall trip LV and MV side circuit breaker of the transformer.

The function is necessary to avoid spurious tripping due to removal of fuses in the measured voltage circuit.

After the relay's operation, the tripping signal shall be interrupted after about 2s.

E) Fuse failure device (97)

All technical specifications of fuse failure protection and related functions shall be considered similar to sub1 line protection of transmission line protection (5.4.1.D item).

The VT supervision unit shall be faster than the voltage protection relay's measuring units under all circumstances.

5.6.2. Power transformer protection (Backup)

Backup power transformer protections shall consist of following Relays/Functions:

A) Over Current and Earth Fault protection (50/51, 50N/51N)

Definite and inverse time over current protections shall be provided for each side of the power transformer (primary, secondary and tertiary). This relay shall have adjustable characteristics for inverse (i.e. normal inverse, very inverse and extremely inverse) and adjustable time setting for definite characteristic.

Over current and earth fault protection shall have a pick up current range from 0.1 to 2 times of the nominal current in steps of 1% for inverse characteristic, a current range from 0.5 to 20 times of the nominal current in steps 0.05 for definite characteristic and a time setting adjustable from 0 to 60s in steps of 50ms for definite characteristic. Time Multiplier Setting (TMS) shall be adjustable between 0.05 and 1.2 with steps 0.01 for inverse characteristic. The characteristic of over current protection shall define independently from earth fault protection.

The relay shall have binary input for blocking relay. Relay shall have at least 2 setting group with automatic switching.

The earth fault element shall be connected to the power transformer neutral CTs, if applicable, otherwise it should be provided from phases CTs.

All over current and earth fault protections shall be considered to avoid mal-operation under various inrush currents (harmonic restraint preferably) and switching conditions.

The relay shall be of high speed type and its total operating time shall not exceed 35ms.

B) High Set and Low Set Over Current protections for tertiary side (H.S, L.S)

The delta connected tertiary windings shall also be provided with tertiary over current protection. The relay shall be connected to a CT located inside the tertiary windings and not in the tertiary bushings. In case of no load connection, the CTs should be single phase but in load connection case, three single phase CTs should be supplied while each one is installed on a separate phase of tertiary winding. The protection shall comprise of two single phase over current relays whose coils are connected in series and contacts in parallel.

C) Sensitive Earth Fault protection for Auxiliary/Earthing transformer (50NS)

The sensitive earth fault protection shall be provided with a very low current setting range 0.2% to 20% of the rated current, adjustable in steps of 0.1%. The time delay should be adjustable between 0.5 and 15 sec. This relay shall only operate the alarm initiation.

This relay shall have a drop off to pickup ratio greater than 95%.

The sensitive earth fault relay shall be connected to neutral CT of auxiliary/earthing transformer.

5.6.3. Mechanical protection

Mechanical protections of power transformer are discussed in "Power transformer specification", in complete detail.

Mechanical protections usually have two stages. First is the alarm stage and second is the trip stage. Alarm signals shall be sent to alarm and recorders system.

Trip commands of mechanical protection shall be sent directly to trip coils of the related CB(s) using trip-lockout auxiliary relays which have flag indicators.

Mechanical protections are divided into two categories of main and backup. Buchholtz, oil temperature, pressure relief for main tank no.2, Johnson, non-return valve are considered as main protection and pressure relief for main tank no.1, pressure relief for tap changer are considered as backup protection.

5.7. Short transmission line protection

This section specifies the protection system and devices required for protecting the transmission line (more than 200kV) with short length according to protection single line diagram.

The feeder protection shall be divided into SUB 1 and SUB 2 categories comprising of the following protection relays. The protection shall be connected to measuring transformers.

5.7.1. Short transmission line protection (SUB 1)

SUB 1 short transmission line protection shall consist of following Relays/Functions:

A) Current differential protection (87L)

Current differential protection detects faults in the zone between the relays (Module) that are installed in both sides of feeder. Contractor shall supply all requirement accessories for completing line protection such as two protection modules and panels for both sides, communication devices, fiber optic cable and etc.

The mentioned protection shall be stabilized from through faults and CT saturations with suitable operating characteristics. Relay shall have percentage characteristic with at least 1 slope.

Current differential protection relay shall have fast clearance of heavy internal faults with high set differential element. Current setting of this function shall be adjustable between 0.8 and 30 times of rated current with step 0.1 of rated current.

The pickup current range of percentage characteristic of differential relay shall be adjustable between 0.1and 1 times of rated current in steps 0.05 times of rated current. The slope of the characteristic is adjustable between 0.1 and 1 in steps 0.05.

Relay shall have different setting for phase-phase and phase-ground faults. Current differential relay shall trip 1 phase or 3 phase (for A/R).

Three phases Directional over current protection functions shall be included in two differential modules. If the communication link is impaired, current differential protection shall be rearranged into directional over current/ directional earth fault protection.

Current differential function shall be equipped by fault locator function. So relay shall have AC voltage input.

Each terminal shall have an internal compensator function for CTs having different specifications, which are installed at both feeders.

Relay shall have binary input for blocking relay.

CT supervision circuit shall be provided for current differential protection.

The relay shall be of high speed type and its total operating time shall not exceed 35ms.

B) Under and Over Voltage Protection (27/59)

All technical specifications of under and over voltage protection of short transmission line protection shall be considered similar to under and over voltage protection of transmission line protection part (5.4.1.C item).

C) Fuse Failure Device (60)

All technical specifications of fuse failure protection and related functions shall be considered similar to sub1 line protection of transmission line (5.4.1.D item).

The VT supervision unit shall be faster than the voltage protection relay's measuring units under all circumstances.

5.7.2. Short transmission line protection (SUB 2)

SUB.2 short transmission line protection shall consist of following Relays/Functions:

A) Distance Protection (21/21N)

All technical specifications of short line distance protection and related functions shall be considered similar to line distance protection (5.4.1.A item)

B) Single and three phase auto reclosing with synchro check relay (79/25)

All technical specifications of short line auto reclosing (just for OHL) shall be considered similar to line auto reclosing (5.4.2.C item)

5.8. Power Plant Protection

This section specifies the protection system and devices required for protecting the feeder which connects the power plant transformer as shown in drawing.

The power plant feeder protection shall be divided into Main and Backup categories comprising of the following protection relays. The protection shall be connected to measuring transformers as shown in the appended drawings.

5.8.1. Power Plant Feeder Protection (Main)

Main power plant feeder protection shall consist of following Relays/Functions:

A) Current Differential Protection (87I)

All technical specifications of power plant current differential protection shall be considered similar to short transmission line current differential protection (5.7.1.A item)

B) Under Voltage Protection (27)

All technical specifications of under voltage protection of power plant shall be considered similar to under voltage protection of short transmission line protection part (5.7.1.B item).

5.8.2. Power Plant Feeder Protection (Backup)

Backup power plant feeder protections shall consist of following Relays/Functions:

A) Directional Over Current and Earth Fault (67/67N)

All technical specifications of Directional over current and earth fault protections and related functions shall be considered similar to the backup protection of sub-transmission over head line (5.5.2.A item).

B) Fuse Failure Device (60)

All technical specifications of fuse failure protection and related functions shall be considered similar to sub1 line protection of transmission line protection (5.4.1.D item).

The VT supervision unit shall be faster than the voltage protection relay's measuring units under all circumstances.

5.9. Short sub-transmission line protection

This section specifies the protection system and devices required for protecting of short sub-transmission line feeders (between 63kV to 132kV) according to protection single line diagram.

The short line feeder protection shall be divided in Main and Backup categories comprising of the following protection relays. The protection shall be connected to measuring transformers as shown in appended drawings.

5.9.1. Short sub-transmission line protection (Main)

Main Feeder Protection shall consist of following Relays/Functions:

A) Current Differential protection (87L)

All technical specifications of current differential protection and its related functions shall be considered similar to the sub1 protection of short transmission line feeder (5.7.1.A item).

B) Under and Over Voltage protection (27/59)

All technical specifications of under and over voltage protection of short sub - transmission line protection shall be considered similar to under and over voltage protection of transmission line protection part (5.4.1.C item).

5.9.2. Short sub-transmission line protection (Backup)

Backup short line Feeder Protection shall consist of following Relays/Functions:

A) Directional Over Current and Directional Earth Fault protection(67/67N)

All technical specifications of Directional over current and directional earth fault protections and their related functions shall be considered similar to the backup protection of sub-transmission over head line (5.5.2.A item).

B) Fuse failure device (60)

All technical specifications of fuse failure protection and its related functions shall be considered similar to sub1 line protection of transmission line protection (5.4.1.D item).

The VT supervision unit shall be faster than the voltage protection relay's measuring units under all circumstances.

C) Three phase auto reclosing with synchro check relay (79/25)

All technical specifications of the above protection and its related functions shall be considered similar to sub2 line protection of sub-transmission line (5.5.2.B item).

5.10. Bus Coupler and Bus Section protection

This section specifies the protection system and devices required for protecting the bus section/coupler and comprising of the following protection relays/functions. The protection shall be connected to measuring transformers as shown in the appended drawings.

A) Over current and earth fault protection (50/50N, 51/51N)

The definite and inverse time over current protections shall be provided for bus section. This relay shall have adjustable characteristics for inverse (i.e. normal inverse, very inverse and extremely inverse) and adjustable time setting for definite characteristic.

The over current and earth fault protection shall have a pick up current range from 0.1 to 2 times of the nominal current in steps of 1% for inverse characteristic, a current range from 0.5 to 20 times of the nominal current in steps 0.05 for definite characteristic and a time setting adjustable from 0 to 60s in steps of 50ms for definite characteristic. Time Multiplier Setting (TMS) shall be adjustable between 0.05 and 1.2 with steps 0.01 for inverse characteristic. The characteristic of over current protection shall define independently from earth fault protection.

Relay shall have binary input for blocking relay. Relay shall have at least 2 setting group with automatic switching.

The relay shall be of high speed type and its total operating time shall not exceed 35ms.

All over current and earth fault protections shall be coordinated with others over current and earth fault protection relays.

5.11. Shunt reactor protection

The shunt reactor protection shall be divided into Electrical and Mechanical protections. The electrical protection of reactor (with or without neutral reactor) shall be divided into main and backup categories comprising of the following protection relays. The protection shall be connected to measuring transformers.

5.11.1. Shunt reactor protection (Main)

Main protection of shunt reactor shall consist of following Relays/Functions:

A) Differential protection (87T)

All technical specifications of differential protection and its related functions shall be considered similar to the main protection of power transformer (5.6.1.A item).

B) High Impedance type restricted earth fault protection (87N)

All technical specifications of restricted earth fault protection and its related functions shall be considered similar to the main protection of power transformer (5.6.1.C item).

Protection zone of restricted earth fault relay shall be comprised of shunt reactor and neutral reactor (if available), so neutral CT for restricted earth fault protection shall be located in neutral of neutral reactor according to protection single line diagram.

5.11.2. Shunt reactor protection (Backup)

Reactor's backup protection shall consist of following Relays/Functions:

A) over current and earth fault protection (50/51, 50N/51N)

All technical specifications of over current and earth fault protection and related functions shall be considered similar to backup protection of power transformer (5.6.2.A item).

Over current and earth fault element shall be connected to phase bushing CTs.

5.11.3. Mechanical protection

Mechanical protections of reactor are discussed in "Reactor specification", in complete detail.

Mechanical protections usually have two stages. First is the alarm stage and second is the trip stage. Alarm signals shall be sent to alarm and recorders system.

Trip commands of mechanical protection shall be sent directly to trip coils of the related CBs using trip-lockout auxiliary relays which have flag indicators.

Mechanical protections are divided into two categories of main and backup. Shunt reactor buchholtz, neutral reactor oil temperature, reactor pressure relief, reactor non return valve are considered as main protection and neutral reactor buchholtz, reactor oil temperature, reactor winding temperature, neutral reactor pressure relief are considered as back up protection.

Mechanical protections of relay shall trip CBs if reactor disconnector switch is closed.

5.12. Shunt capacitor bank feeder protection

The shunt capacitor bank feeder protection shall be comprised of the following protection relays. The protection shall be connected to measuring transformers as shown in appended drawings.

A) Over current and earth fault protection (50/50N, 51/51N)

All technical specifications of over current and earth fault protection and related functions shall be considered similar to backup protection of power transformer (5.6.2.A item).

B) Sensitive earth fault protection (50NS)

The sensitive earth fault protection shall be realized with an over current relay having a very low burden operating through the residual or earth fault current. It should be provided with a low current setting range of 0.2% to 20% of the rated current, adjustable in steps of 0.1%. The time delay should be adjustable between 0.5 and 15 sec. This relay shall have drop off to pickup ratios greater than 95%.

This relay shall operate in two stages. At its first stage, the relay should send an alarm and at its second stage, it should send a trip command to the circuit breaker and also, initiate the lockout relay. Separated trip and alarm output contacts shall be provided.

If applicable, the sensitive earth fault relay shall be connected to a core balance CT.

C) Unbalance current protection (46)

In order to protect the capacitor bank a sensitive definite time over current relay is used. The relay detects unbalance currents by sensing the current passing through neutral points of jointed stars (harmonic restrained). The relay shall have two stages, first an alarm stage and second the trip stage.

Unbalance protection is normally provided for arcing faults within a capacitor bank and other abnormalities that may damage capacitor elements/units. In same capacitor arrangement, for unbalance protection, voltage sample could be used. This protection shall send a trip command to load breaker switch of related capacitor.

D) Under current protection (37)

Special requirements must be considered in closing the capacitor bank's circuit breaker. Once disconnected from the system a shunt capacitor bank cannot be reinserted immediately due to the electrical charge trapped within the capacitor units, otherwise catastrophic damage to the circuit breaker or switch can occur.

Undercurrent relay with timer are used to detect the bank going out of service and prevent closing the breaker until the set time has elapsed.

5.13. Distribution feeder protection

Medium voltage Distribution feeders include 33kV, 20kV, 11kV and 6.6kV and etc outgoing feeders. The distribution feeder protection shall be comprised of the following protection relays. The protection shall be connected to measuring transformers as shown in appended drawings.

A) Over current and earth fault protection (50/50N, 51/51N)

All technical specifications of over current and earth fault protections and their related functions shall be considered similar to protection of bus section/coupler (5.10.A item).

B) Sensitive earth fault protection (50NS)

All technical specifications of sensitive earth fault protection and its related functions shall be considered similar to the shunt capacitor bank feeder protection (5.12.B item).

C) Three phase auto reclosing (79)

All technical specifications of above protection and related functions shall be considered similar to sub2 line protection of transmission line protection (5.4.2.C item), except following items:

- In MV outgoing feeders, just three phase auto reclosing shall be executed. So all features related to single pole auto reclosing that describe in part 5.4.2.C shall be omitted.
- A two position ON/OFF selector switch shall be provided for each feeder.
- This relay only shall be initiated by over current and earth fault protection tripping.

5.14. Load shedding

Load shedding is divided into over current load shedding and under frequency load shedding.

5.14.1. Over Current Load shedding (51/LSH)

Over Current load shedding shall be provided on each Transformer secondary side. This relay shall trip the sub-transmission outgoing feeders.

The Over Current load shedding relay shall be numerical type. It shall have four stages. Current and time of one stage shall be set separately from other stage.

A selector switch shall be provided for each outgoing feeder in order to define the priority in which the feeder is tripped according to the current stages. The selector switch shall have 5 positions (4 position & OFF).

All necessary equipment including bus wirings, cross trip relays and etc. shall be provided and overall scheme is subject to the approval of the Engineer.

5.14.2. Frequency Load Shedding (81)

Under frequency load shedding shall be provided on each individual section of the sub-transmission busbars.

The under frequency load shedding relay shall be of numerical type. It shall have four stages with adjustable time setting. It shall have three modes of operation for under frequency time delay (f+t) scheme, time delayed change rate of frequency load shedding scheme (df/dt+t) and time delayed frequency supervised change rate of frequency load shedding scheme (df/dt + f + t).

The frequency settings shall be adjustable between 47 and 50Hz in steps of 0.05 Hz. The frequency elements shall respond to an under frequency condition in less than 5 cycles. Accuracy of detection shall be better than ± 0.05 Hz. The relay outputs shall be time delayed. The time delay settings shall be adjustable between 0 and 10s in 0.05s steps.

Under frequency load shedding shall be blocked due to reducing voltage. Voltage setting shall be adjustable between 30% and 90% of nominal voltage with steps 5%.

A selector switch shall be provided for each outgoing feeder in order to define the priority in which the feeder is tripped according to the frequency stages. The selector switch shall have 5 positions (4 position & OFF).

The under frequency load shedding shall energize trip relays which are independent from the feeder protection trip circuits. Diodes shall not be used in trip circuits.

The pickup and drop out difference shall be less than 20 mHz.

Relay shall be blocked with binary input. Also relay shall provide with phase-phase or phase-ground voltage input.

Time duration of drop out of relay shall be less than 100ms.

Sufficient separated binary input and output shall be provided. These output shall not used for logic programming and just used for relay command functions.

Input and output of relay shall be isolated by opt-coupler.

All necessary equipment including bus wirings, cross trip relays and etc. shall be provided and overall scheme is subject to the approval of the Engineer.

5.15. Busbar protection

5.15.1. General requirement

This section describes the functional, performance requirements and the facilities to be provided for the high or low impedance differential protection at transmission and sub-transmission levels with any busbar arrangements according to appended drawings. Each distribution busbar shall be protected by under voltage protection and if required, by under frequency load shedding protection. Busbar protection shall provide fully discriminative protection for phase-to-phase and phase-to-earth faults occurring within the substation.

Where the primary arrangement of the substation permits the substation to be split into a number of sections delimited by circuit breakers or disconnectors, the numerical busbar protection shall provide fully discriminative protection for phase-to-phase and phase-to-earth faults occurring within each section. Separate protection zones shall be provided for each busbar section. Position of disconnector switches shall be used to determine the primary arrangement of each busbar section.

The busbar protection shall discriminate between faults in the protected busbar section and faults elsewhere in the substation or the primary system.

When a busbar fault occurs, all circuit breakers connected to the faulted busbar shall be tripped simultaneously, whether they can feed fault current or not.

Where a fault occurs in the overlap between two zones, e.g. at a bus section or bus coupler, with the circuit breaker closed, both zones shall be tripped simultaneously.

Where a discrepancy in switchgear positional information occurs, the busbar protection shall have user selectable options either to remain in service using the last verified switchgear position or to block protection operation for the affected zone.

Extension of the busbar protection system shall be possible easily. The protection cubicles shall already be wired for the possible total number of feeders. Thus, later on, the respective modules or parts for extensions can easily be fitted to the protection system. The extension of busbar protection cubicles shall be possible for any future feeders and/or busbar configuration by adding additional cubicles.

5.15.2. CT supervision (95)

Automatic and continuous supervision of CT circuits shall be provided. When CT supervision is operating, the busbar protection shall have user selectable options either to remain in service or to block the protection operation. Operation of the CT supervision shall generate an alarm after a time delay settable in the range of 0 to 10 s.

5.15.3. Low Impedance type busbar protection (87 LI)

The system shall consist of a distributed set of bay units and a single central unit. The protection shall collect current and switchgear positional information at bay units. Bay units shall preferably be mounted with the bay's secondary equipment. The central unit shall perform the busbar protection algorithm using the current and positional information transmitted from the bay units. The central unit shall transmit tripping commands to the required bay units to operate the required outputs. Communication between bay units and central unit shall be implemented using optical fiber and shall not be affected by electrical noise.

Busbar protection shall not give spurious tripping on maximum DC offset and maximum short circuit power on external faults under CT saturation of any related feeders.

The busbar protection system shall be capable of accepting inputs from current transformers having different ratios in different bays. There shall be no auxiliary switch contacts or relay contacts in the current transformer circuits.

A local in/out switching facility shall be provided to enable each bay unit to be taken out of service whilst the remainder of the busbar protection remains in service. In/Out switching functions shall be latched in the last selected position.

The Bay Unit shall provide the following information:

- Fault type.
- Phase currents.
- Records of recent faults shall be stored and be available for downloading either locally or remotely.

The Central Unit shall provide the following information:

- Faulted zone.
- Fault type.
- Current substation configuration.
- Differential currents for each zone.
- Records of recent faults shall be stored and be available for downloading either locally or remotely.

The operating time of the busbar protection shall not be greater than 25ms and the resetting time of the busbar protection shall not be greater than 50ms.

When a setting change, a configuration change or other software changes require the busbar protection to be switched off using selector switch, the period of unavailability shall not exceed 15 minutes.

5.15.4. High Impedance type busbar protection (87 HI)

The unbiased high impedance busbar protection relay shall be considered for each busbar (for each section of busbar) and shall consist of three single pole elements. Each element shall trip all circuit breakers connected to busbar. All 3 phases shall be tripped by each element. This protection shall trip phase-phase and phase-earth faults.

High Impedance protection shall have adjustable differential current between 5% and 80% times of rated current for current setting type and24V to 240V for voltage setting type.

The relay shall provide high degree of stability for any type of fault occurring outside the protected zone. The complete relay shall generally comprise of relay itself and a continuously adjustable stabilizer resistor in series with the relay element of each phase.

Non linear resistors (metrosil) shall be used across the relay circuit in order to limit the peak voltage developed by the current transformers under internal fault conditions to a value below the insulation level of the CTs, relay and interconnecting pilots which are normally designed to withstand 2000 V peak.

Contractor shall calculate technical specification of stabilizer and metrosil resistors and submit for consulting engineers for approval as well as CT calculation.

Relay shall have appropriate LED indicators on its front view.

The relay shall be of high speed type and its total operating time shall not exceed 35ms.

All necessary equipment such as sufficient quantity of high speed auxiliary trip relay (for repeating and tripping) shall be provided for completing high impedance busbar protection scheme.

For double busbar arrangements two independent busbar protections shall be provided for each busbar fed from separate current transformers, one designated as the discriminating zone and other designated as check zone.

The check zone protection shall be connected in parallel across the busbar protection CT bus wiring associated with all incoming and outgoing feeders. Each discriminating busbar protection shall be connected in parallel across the busbar protection's CT, bus wiring associated with incoming and outgoing feeders, bus coupler and bus section circuits connected to a particular busbar. Coincident operation of the Check zone protection relay and the Discriminating busbar protection relay shall be arranged to initiate tripping of the appropriate busbar.

Any disconnector auxiliary contacts employed in current transformer circuits shall be of the heavy duty and two contacts in parallel shall be used per current transformer connection. Early make and late break type auxiliary contact of main disconnector shall be employed for discriminating zone of double busbar protection. The auxiliary contact shall not be repeated by auxiliary relays.

5.15.5. Under Voltage protection (27)

Each distribution busbar shall be protected by under voltage protection. The under voltage protection isolates the busbar feeders. The under voltage protection shall consist of inverse and definite time under voltage. The under voltage protection shall only operate for low voltages in all three phases with a setting voltage range of 50% to 100% of the rated voltage, adjustable in steps of 1%. Adjustable time delay shall be provided between 0.01 and 60sec in steps 0.05s. Pick up to drop off ratio shall be between 1.01 and 1.05. The function is necessary to avoid spurious tripping due to removal of fuses in the measured voltage circuit.

After the relay's operation, the tripping signal of under voltage shall be interrupted after about 2s.

6. Packing, Transportation and Storage

All the equipment shall be suitably protected and covered to prevent damage or deterioration during transit, handling and storage at site till the time of erection. The packing shall provide complete protection from water penetration, moisture, termites and mechanical shocks etc. The packages shall have sufficient strength to prevent damage during handling, warehousing and shipment.

The panel with all protection, control and metering equipment shall be packed by appropriate bubble plastics around the panel and pallet wood tray under the panel for lifting and shall withstand during the transport and outdoor storage. All coated surfaces shall be protected against abrasion, impact, discolouration and any other damages. Panels shall be packed in appropriate crates for marine shipping.

The equipment shall be thoroughly cleaned of slag, grit, dirt, moisture and other foreign matters before packing.

All packages clearly marked with gross weight, signs showing `UP' and `DOWN' sides of boxes, contents of each package, order no., name of the substation, name and address of the client, and any handling and unpacking instructions considered necessary. It shall be ensured that all markings on crates are clear, legible, water proof, not affected by sunlight and are securely fixed or painted thereon.

The contractor shall submit packing details and associated drawing for any equipment to facilitate the client to repack any equipment at a later date, in case the need arises.

The contractor shall ensure that all packages are suitable for the storage conditions. The contractor shall provide temporary heating, weatherproof shelters, loading and unloading facilities as required for the substation. Temperature of the store shall be in permissible operating temperature range of the equipment.

The contractor shall ascertain, prior to shipment, from concerned authorities, the transport limitations like weight and maximum allowable package size for transportation.

Each consignment shall be accompanied by a detailed packing list in a waterproof envelope containing name of the consignee, details of consignment and destination.

The contractor shall be responsible for any damage to the equipment during transit due to improper and inadequate packing.

7. Supervision over Installation and Erection Procedure

The supervision over installation, erection and commissioning of protection and control panels in accordance with the drawings and manufacturer's instruction shall be executed by the contractor under the supervision of client and consulting engineer to ensure satisfactory and proper operation in every aspect.

The contractor shall also perform visual inspection to insure that there is no damage. This supervision and inspection includes but is not be limited to the following:

- Install, level, align panels and fasten to floor and adjacent panels.
- Remove shipping blocks.
- Clean interiors.
- Examine Connections to ensure that they are not loose and to tighten them as required.
- Install cables for Interconnections.
- Touch up all damaged paintwork.
- Inspect and make necessary adjustments.

The contractor shall also perform field tests to include continuity test of all low voltage circuits, meggering on all low voltage circuits, energizing of all low voltage circuits, check of the operation of all relays, timing tests, functional testing of all equipment and etc.

The contractor shall also provide all instruments and equipment required for the site acceptance tests. These instruments will remain the contractor's property and can be removed after the successful completion of the tests.

8. Inspection and Test

In order to demonstrate the protection functionality the supplier shall test the complete system in factory (FAT) in accordance with related IEC standard. The Inspection and Test Plan (ITP) shall be submitted for client and consulting engineers review at least three weeks prior to testing. The plan shall include all necessary tests to prove compliance of the equipment with this specification. FAT shall be done in the country of origin.

In addition to above mentioned tests, following routine tests are required for all of protection, control and metering equipment:

- Acceptance tests at the manufacturer's works in Iran.
- Site acceptance test (SAT) in the substation.

The Inspection and Test Procedure shall include details such as all of relay's configurations logic, sequences of the tests, blank test sheets, the number of equipment, test circuits along with related IEC standard and detail of the testing equipment to be used and its calibration information. ITP documents shall be submitted to the consulting engineer or approval at least four weeks before starting of tests in above routine tests.

Test Reports shall be submitted after test for client and consulting engineer's approval.

The routine tests include the following items but are not limited to:

- Visual check,
- Continuity test of all circuits in all panels,
- Insulation test of all wiring, devices and components,
- Polarity test,
- Setting verification of protection relays,
- Relay's tests by secondary injection,
- Remote communication test,
- Functionality test of all circuits,
- Operating time of relay,
- output signals,
- Fiber optic equipment Test; the supplier shall guaranty to verify the compatibility and the functionality of line differential relays, and
- Etc.

Under this contract it is the contractor’s obligation to check and analyze the protection under random conditions together with the current and voltage transformers to fulfill the required stability, selectivity and function availability of the protection at all included network levels.

9. Submittals

The Contractor shall submit, in accordance with Section 3; drawings, calculations, test reports and literature pertaining to specified items of material to be supplied under this section.

10. Spare part

The Contractor shall be provided spare parts as per schedule of quantities and prices.

TECHNICAL SPECIFICATION

SECTION 21

DISPATCHING SYSTEM

MONENCO – IRAN CONSULTING ENGINEERS CO.

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1. General Requirements

1.1 General

Acceptance by the Engineer of the design of the RTU or its components shall not relieve the Contractor of his obligation to supply RTU fully capable of meeting the service requirements. Each and every part of the RTU shall be of such design and construction as to give long and continuous service and low maintenance cost.

1.1.1 Environmental Conditions

Environmental requirements are as follows:

1. The RTU shall be capable of operating continuously with no degradation of performance which ambient temperature and relative humidity ranging specified in datasheet (item 1);
2. Fans or Electro-Mechanical cooling devices shall not be used in the RTUs;
3. Dust storms are common and therefore equipment must be fully protected against the affects of air-borne dust and sand. The dust can be expected to contain a high salt content, which presents serious electrical insulation problems for equipment;
4. In certain areas there may be a high level of hydrogen sulphide in the air as by product of the petrochemical industry. The contractor shall therefore not employ exposed silver contacts or plating as such materials are subject to the formation of non-conductive sulphide coating. A tarnish resistant metal such as gold or palladium shall be used for all exposed contacts.
5. The Contractor must recognize that the RTU will be exposed to relatively severe electrical transients. The Contractor shall therefore, make adequate provision for the protection of all input and output circuits, including power supply and signal circuits, to prevent improper operation or damage of equipment as a result of such transients. RTU shall comply with the following operating standards:

   a. Electrostatic discharge IEC 61000-4-2 level 4;

   b. RFI/EMI susceptibility IEC 61000-4-3 level 3 & ENV 50204 level.3;

   c. Fast transient IEC 61000-4-4 level 4;

   d. Surge immunity IEC 61000-4-5 level 4;

   e. Conducted disturbance IEC 61000-4-6 level 3;

   f. High frequency disturbance EC 255-22-1 level 3;

   g. Power frequency magnetic field IEC 61000-4-8 level 5;

h. Power frequency interference: CM 500 Vac @ 2 sec;

i. Interference CISPR 11 class A.

Tenders are required to state specifically and in detail the differences if the proposed RTU has been designed and tested according to any other standards than the above.

1.2 Design, Manufacturing and Installation Requirements

1.2.1 Quality Control and Quality Assurance

The products and systems to be supplied and installed under this Contract shall conform to the requirements of the specification, to the best accepted international standards and to the severe requirements imposed by the service conditions. As a means of ensuring these objectives the Contractor shall maintain a documented quality control and quality assurance which shall be generally in accordance with ISO standard ISO 9001 or approved equivalent.

The Contractor shall ensure that the same requirements are applied to products, systems, and service supplied by sub-contractors and suppliers.

The Contractor shall submit with his tender and outline statement of his quality control and quality assurance policies and procedures. As required by the Engineer, the Contractor shall submit a more detailed statement of his quality system as applied to materials, manufacture, installation, and testing, supported with samples of documentation used for quality assurance certification. The Contractor shall file all quality certification documents relating to the products and systems supplied under the Contract. The Engineer shall have full access to such files.

1.2.2 Standards

The Specification and the Codes and Standards quoted herein define minimum levels of quality for materials, products and the whole range of contract, supply, and performance.

Where no Purchaser's National Standards has been issued to cover a particular subject then the relevant IEC or ISO Code or Standard shall be applied. Where no IEC or ISO code or standard has been issued to cover a particular subject then a recognised National Standards shall be applied.

Where specific standards are laid down in this Specification they are as such binding. However, the Contractor is free to propose alternative authorative standards provided they give an equivalent degree of quality and performance as the Specification codes and standards. Where alternative standards to those quoted in the specification are being proposed or agreed the Contractor shall supply two copies of each alternative standard, one to the Engineer at the work site and one to the Purchaser. The copies of the codes and standards shall be provided before the commencement of work on site. Codes and standards shall be in the English language.

1.2.3 System of Units

The SI system of units shall be used throughout the Contract. Temperature shall be in degree Celsius.

1.2.4 Suitability of the Design Proposed

The design shall make adequate provision for:

- Safety of operation and maintenance personnel
- Reliability and continuity in service
- Ease of inspection and maintenance
- Ease and clarity of operation
- Avoidance of spurious alarms
- Ability to withstand the severe service conditions specified
- Freedom from undue vibration and noise
- Exclusion of vermin, birds, and animals
- Precautions to minimize fire risk

1.2.5 Inter changeability

To limit the required stock of spare parts all equipment and parts thereof performing similar duties shall be interchangeable.

1.2.6 Mechanical Construction

1. The workmanship, material and finish of all equipment supplied shall be free of all defects;

2. Module or unitized construction shall be utilized throughout;

3. Module extenders shall be provided to facilitate maintenance, adjustment and test on operating units;

4. Maximum utilization shall be made of plug-in printed circuit boards (PCBs) of standardized design using long-life, high-reliability components. All plug-in modules shall be either mechanically keyed to prevent improper placement or otherwise protected against damage or improper operation, which might result from a module being plugged into a socket for which it was not intended. PCBs shall be fabricated from glass-epoxy or better material and shall be at least 1.58 mm thick;

5. Routine adjustment control shall be readily accessible from the front of the equipment without removal of the units;

6. All thread sizes for screws, nuts, and bolts shall conform to a standard system, preferably the metric system;

7. The RTU equipment shall be substantially fire-resistant in construction and care shall be taken to keep the acoustical noise generated by the equipment to a minimum;

8. The RTU equipment shall be designed, constructed and arranged for optimum ease and speed of operation and maintenance;

9. The RTU cubicle shall be of fabricated steel construction. Layout of equipment within the cubicle shall be such as to provide convenient access to all modules, cable terminations, test points etc. In this respect both front and rear access should normally be provided with swing frame;

10. All the components shall be clearly marked or otherwise identifiable so that no ambiguity exists;

11. All metallic cabinets and rack parts shall be electrically bonded together;

12. All equipment racks shall conform to a uniform standard rack width;

13. Test points shall be clearly marked and readily accessible from the front of the equipment.

14. All terminals and terminal blocks shall be clearly identified.

15. All connectors, cable harnesses and inter-rack wiring shall be clearly identified so that no ambiguity can occur. Connector pin numbering shall be identical at each and of the cable.

1.2.7 Electrical Construction

1. The electrical construction of all units shall be such as to ensure the highest standards of reliability, long life, and ease of maintenance. Cubicle doors shall be bonded to the main frame so as to ensure electrical continuity.

2. The layout of components on cards and modules shall be neat and orderly with no overcrowding. All components should be so mounted that they can be readily inspected without disturbing other components. It should be possible to replace any component without disturbing other parts or wiring.

3. Components which generate a significant amount of heat shall be adequately spaced away from other components, and also from the mounting cards or panels. The mounting of components across tags on wiring terminal blocks is not favored, and shall normally be avoided.

4. RTU wiring shall conform to a recognized international standard. The applicable codes and standard shall be so stated in the detail design documentation. Copies of the applicable codes in English shall be provided with the detail design documentation;

5. RTU and relative accessories shall be suitably protected against over-voltage, over-current, and ground leakage. In addition Direct Current devices shall be suitably protected against voltage polarity reversal;

6. Under this contract reliability, Low power consumption and noise immunity shall be a major consideration in selection of RTU;

7. Convenient outlets shall be provided at the base of RTU to supply power at 220V, 50Hz for test equipment and related applications;

8. All metering and test circuits shall not affect the operation of the RTU;

9. Signal cables shall be of a type and installed in a manner so to reduce common-mode and induced noise to a minimum. Metallic shields shall be employed on all cables. All grounding of shields and signal circuits shall be at one point only to prevent ground loops, except where double shielded cable is used, in which case the outer shield may be grounded at both ends.

1.2.8 Electromagnetic Compatibility

Many of the locations where equipment will be installed will be in harsh electromagnetic environments such as electrical substations, radio transmitter sites, etc. Much of the equipment will also be required to operate in close proximity to other telecommunications and SCADA equipment.

Therefore, RTU being proposed shall be designed to high standards of electromagnetic compatibility both in terms of immunity and emission.

Equipment being proposed shall have been designed and tested in accordance with relevant, internationally recognized standards.

Equipment shall conform to the following standards, or equivalent standard which is acceptable to the Purchaser, where appropriate:

EN 55022	Limits and methods of measurement of radio interference characteristics of information technology equipment.
IEC 801 (Pars 1-4):	Electromagnetic Compatibility for Industrial Process, Measurement, and Control Equipment.

In addition, remote terminal units and interposing equipment shall be designed and tested in accordance with the following standards:

IEC 255.4:	Single Input Energizing Quantity Measuring Relays with Dependent Specified Time (Appendix E: Impulse Voltage Withstand Tests and High-Frequency Disturbance Tests)
ANSI C37.90a:	IEEE Standard Guide for Surge Withstand Capability (SWC) Tests.

The Contractor shall state the level or class of compliance with the above standards for all equipment. The minimum requirements for the various types of equipment are as indicated in the following sub-sections.

Specific Requirements for RTU and Interposing Equipment

RTU and interposing equipment shall in general meet the following classes of EMC immunity/emission for the stated standard:

EN 55022	Class B:	Limits on generated interference
IEC 801-2	Level 4:	Immunity to static discharges
IEC 801-3	Level 3:	Susceptibility to radiated energy

Input/output circuits and power supply inputs for all RTU and associated interposing equipment shall be provided with dielectric withstand capability as per IEC 255.4 and surges withstand capability (SWC) as per IEC 255.4 or ANSI C37.90a. The levels for both dielectrics withstand and SWC for the various inputs, output and power supply circuit shall be as specified elsewhere in this specification.

2. Remote Terminal Unit Technical Specification

1.1 General

This section specifies the scope of supply, essential features and characteristics and design requirements for Remote Terminal Units (RTU) and associated equipment.

RTU shall be fully equipped with input/output modules, Sequence of Event recording, interposing relays and other features called for later in this section.

1.2 RTU Power Supply Unit

In RTU supplies which values specified in datasheet (item 2), power interruptions in the A.C. supply or D.C. supplies shall not cause equipment damage, and interruptions in the D.C. supply of less than 20 ms shall not cause a break in normal operation of the RTU. Power supply shall be protected from input power polarity reversal and output short circuit.

- The power supply shall provide the 48 VDC isolated power for "wetting" of contact inputs and for the coils of interposing relays of the control output points;
- Low voltage and high voltage CUT-OFF facility shall be provided;
- The RTU power supply shall be protected from input power polarity reversal;
- The power supply shall be provided with power switch, test points and indicators mounted on the front of the power supply module;
- The RTU shall sustain slow variation of the power supply voltage input from nominal value to zero and zero to nominal;
- The RTU shall sustain AC component (ripple) of ~ 12%;
- The RTU power supply should have short circuit protection in its output.

1.3 RTU Clock

- The RTU shall be equipped with a crystal-controlled, battery backed clock;
- The clock shall have an accuracy and minimum RTU clock resolution as specified in datasheet (item 3);
- RTU shall be configured to be synchronized by Master Station and also shall be able to be synchronized by Control Centre Network.
- RTU shall be capable to connect to GPS receiver for Time synchronization;
- RTU shall meet all the requirements for Time Tagging in different protocols and because of master slaving, enough documents for time tagging should be provided;

1.4 Equipment Design and Performance

RTU equipment shall meet the specifications laid down in the general technical requirements. Failure rates for each item of RTU equipment shall be determined and declared in the reply to this specification.

Protection devices and alarm circuits shall be to the approval of the Engineer and shall minimize equipment outages and facilitate rapid fault location.

The equipment shall not cause interference with other equipment and the noise and vibration levels shall be stated. The performance of the equipment shall be such as to meet the requirements specified elsewhere in this specification for information update times and speed of execution of commands.

RTU design shall be based on microprocessor controlled equipment and shall include the following mandatory facilities:

a. Indications/alarms to be transmitted from RTU to control centres shall be on a user-defined priority basis;

b. Information being prepared for transmission from RTU to control centres shall be on a change of state basis, indications being prepared for transmission spontaneously and metered values when the current value exceeds the previously transmitted value by an adjustable preset dead band amount;

   In addition to the transmission of change-of-state or significant change

information, a full cyclic update of all indications and metered values shall take place at intervals of not more than the time specified in datasheet (item 4). Full updates shall also be carried out on request by the Control Engineer or following the return to service of an out-of-service RTU;

RTU should acknowledge the polling cycle of a master station in specified time in datasheet (item 5);

c. The maximum update time, exclusive of any system disturbances of any analog measurand to the AOC and SCC data base shall be 1 second with the exception of water level and unit MWH which shall be 15 minutes.

d. The maximum response time from the change of state of a device at a remote station to display of the new state to the dispatchers at the associated control centers shall be 0.5 second, if the change of state is as a result of a remote control command. If the change of state is spontaneous the maximum response time or the above change of state can be few seconds.

e. Time-stamping of indications/alarms shall be carried out in the RTU, and also ability of time-stamping metered values shall be provided;

f. Minimum data bus width of RTU microprocessor design as specified in datasheet (item 6) and also Watch-dog monitoring for modules that have CPU;

g. Hot plug-in capability for all RTU cards and modules;

h. Self-monitoring for individual modules and components, such as memory, I/O modules and communication module, to diagnose defective parts and transmit corresponding alarms to control centres;

i. Ability of RTU to automatic Start-Up and Initialization following restoration of power after an outage without need of manual intervention. All restarts shall be reported to the connected master station(s). Full Database updates shall also be carried out following the return to service of an out-of-service RTU;

j. Ability of RTU to group and rationalize alarms e.g. only one alarm per bay or only one alarm resulting from a number of circuit breakers in the same substation changing state is sent to the Control Centre;

k. Capability to download the RTU dynamic parameters and database from the Control Centre(s) (Via file transfer function of the protocol);

l. The Protocol interoperability list should be compatible at least to the SCADA centres interoperability lists, and Supplier is responsible for solving any probable defect in connecting RTUs to these SCADA centres;

m. Supplier shall supply any required RTU equipment, software, and toolboxes in order to normal commissioning, maintenance and operation i.e. RTU Firmware downloading and any security passwords (if it is applicable) without any restriction;

Features which are not mandatory but are considered desirable are listed below. The Contractor shall state whether they comply with these features:

n. Decentralized intelligence i.e. RTU shall reduce load on main control centre computers by processing substation information such as alarm limit checking, invalid status indication checks etc

o. Hierarchical RTU structure which shall allow an RTU to act as a data concentrator for other sub-ordinate RTUs

p. RTU ability to connect to local graphical HMI Computer or local networked computers for monitoring and controlling the substations locally.

The Contractor shall also indicate if their RTU have the ability to carry out local sequence or closed loop control actions. Such local control and calculation functions shall preferably be programmed using software tools in accordance with IEC 1131. The Contractor shall provide details of the facilities available and possible uses of the local sequence or closed loop control functions of their RTU.

1.4.1 Standardization

As far as economically and technically practicable RTU shall be equipped with identical boards or modules. The layout of equipment in cabinets shall be standardized, but each RTU may not necessarily be fitted with the same number of plug-in modules or interface modules. Each RTU shall be easily expandable to a common maximum capacity without the necessity of additional wiring. Deviation from the above requirements will be acceptable and preferred where cost or other considerations indicate compliance is not in the purchaser's best interest.

Also, each I/O module shall be interchangeable with every other similar module without any need for Jumper or DIP Switch setting. In addition, RTU shall have LED indications for all digital I/O points.

1.4.2 Availability

The availability of the RTU shall be specific value which stated in datasheet (item 7) over the 12 month period of maintenance exclusive of communication channel and other purchaser caused down time

A = MTBF/ (MTBF + MTTR)

Where:

A = Availability
MTBF = Mean Time between Failure
MTTR = Mean Time to Repair

The system hardware architecture shall be fault tolerant to ensure that any single hardware failure does not result in the loss of a critical function.

In key locations with many connected RTUs it is necessary to install highly available RTU systems that can continue to function after a single software or hardware failure.

Contractors shall submit their proposed design for achieving the high availability of critical functions and data requirements specified above.

Contractors are required to describe the failover/back to normal process in detail.

The contractor is required to provide details covering all possible aspects of maintenance of their equipment and recommended maintenance routines and schedules as well as safety procedures for problem- free RTU operation.

The method and procedures recommended should be effective and suitable for the equipment under actual operational environment conditions.

1.4.3 Equipment Installation and Construction

Equipment shall be mounted in freestanding, swing-type and steel cabinet. Cabinets housing electronic equipment shall be so arranged that access to front and rear is provided; this shall be accomplished by providing swing-out unit. Cabinets which exclusively contain terminations of cabling from the process may have front only access. Cable access shall normally be from below. Cabinets shall be to uniform dimensions and finish.

In addition, cabinet shall have degree of protection provided by enclosure according to IEC 529 as specified in datasheet (item 8);

Additional ducts required for SCADA cabling shall be provided by the Contractor. Incoming cables shall be terminated on rail mounted terminals of screwed anvil clamping type except in the case of telephone type cables where soldering or wire wrapping may be employed.

Capacity sufficient for the envisaged ultimate development shall be provided for each type of termination employed in each cabinet. In addition spare terminations shall be provided as specified in datasheet (item 9).

All terminations shall be above floor level as specified in datasheet (item 10). All cabinets, bays, shelves, modules, cards and other components including terminals shall be clearly marked for identification purposes. All cabinets shall be equipped with lighting and AC mains convenience sockets. All metalwork which is or can be made accessible and which is not live circuitry shall be earthed in accordance with the "Guide for Safety in Alternating Current Substation Grounding" IEEE No. 80, January 2000.

1.5 Communications Network Interface

The RTU shall be capable of supporting the point to point communication configuration, however, the star, series, multi-drop or loop communication configurations as well as a combination of these could be proposed. The interface between RTUs and the communications network shall conform to ITU-T standards. The communication rate shall be adjustable in the range as specified in datasheet (item 11).

The Contractor shall provide details of their communications protocol with supporting calculations which indicate transmission times for indications and measurands from RTUs in a party line configuration under the different power system activity levels (i.e. normal, peak and overload).

a. Each RTU shall have at least 2 CPUS for communication with Centers and IEDs and be expandable to 8 CPUs.
b. Communications protocol complying with the protocols as specified in datasheet (item 12) for communicating with masters, official certificate must be presented to demonstrate this matter;
c. Communications protocol complying with the protocols as specified in datasheet (item 13) for communicating with IEDs and protection relays. official certificate must be presented to demonstrate this matter;

d. The RTU shall have several serial ports as specified in datasheet (item 14);
e. RTU shall have Loop Key for communication Test;
f. The RTU shall have individual LAN interfaces with configurable static IP addresses, as specified in datasheet (item 15);
g. Each RTU shall be capable of communicating with at least 4 IEDs at the same time. (With different protocols).
h. Visual indications of current port selection and indications of transmit and receive line activity for all serial communication channels shall be provided.
i. All communication ports shall be protected against transient over voltage by restricting "let – through" voltage below damage levels of interface and shall be optically isolated.
j. Each communication port shall function independently from other ports, and unaffected by simultaneous activity on other communication ports.

1.6 RTU Features and Facilities

1.6.1 Capacity

RTU shall initially be equipped to cater for the ultimate development as detailed in the station single line diagrams, documents and the points list tables. Provision shall be made for expansion above these quantities by the addition, in the future, of extra plug-in modules as specified in datasheet (item 16). The Contractor shall indicate the capacity of each RTU, "as delivered", and the absolute expansion possibilities of each RTU, stating the points at which additional racks/cabinets are required.

1.6.2 Sequence of Event Recording (SOE)

SOE shall be provided for RTU forming part of this Contract. The SOE shall time-stamp events on occurrence in the RTU prior to their transmission to the control centres. SOE facilities shall be available for handling all of digital inputs in all RTUs.

The resolution between any two events occurring anywhere in the power network shall be the same as the time specified in datasheet (item 17) or better. The Resolution between recorded events within each substation shall be the same as the time specified in datasheet (item 18) or better. The Contractor shall provide details of how the RTU time clocks are synchronized with the control centre time system. This shall preferably be carried out over the RTU communications channel. The Contractor shall state how often synchronization is carried out and shall indicate how communications transmission delays are allowed for in the synchronization procedure. Alternatively, the Contractor may

provide some means of off-air time synchronization such as "Global Positioning System (GPS).

Based on the above requirements The Contractor shall provide calculations to indicate the worst possible system-wide time resolution for the control centre i.e. the Contractor shall state the maximum time error which could be recorded between two simultaneous events occurring anywhere in the system under conditions of very high activity.

RTU shall be capable of storing events in the order in which they occur. The number of time-stamped events which can be stored shall be the amount as specified in datasheet (item 19). Overflow events from time tagged memory shall be stored in non-time tagged memory.

As an option the Contractor shall quote for an SOE system which provides a resolution as specified in datasheet (item 20) within any RTU and a system wide resolution as specified in datasheet (item 21).

The Contractor shall state whether local time-tagging of events (i.e. at the RTU) can be carried out for non-SOE points. If so, the resolution and accuracy of the non-SOE time-tagging shall be stated.

1.6.3 SCADA Test Facilities

As an additional check on the correct functioning of the SCADA system it shall be possible to transmit dummy commands to RTU and to receive corresponding indications at the control centres.

This facility shall take the form of a dummy circuit breaker in RTU which can be opened or closed and which will transmit status information corresponding to either successful or unsuccessful switching and can thus be used for training purposes also.

It shall be possible to completely check the proper functioning of a remote terminal unit by means of tests carried out locally, with the communication link to the control centre disconnected. Suitable test sets, as specified elsewhere, shall be provided for this purpose.

1.7 RTU Input/output Circuits

All RTU input/output circuits shall be galvanically isolated from each other and from ground. All process connections to and from the RTU shall be galvanically isolated from the RTU internal logic.

The power supply and input/output circuits shall be provided with protection against induced voltages in accordance with ANSI C37.90 or IEC 255.4. In the case of power supplies, digital inputs and digital outputs, the required level of isolation for dielectric and surge withstand shall be the same as values specified in datasheet (item 22).

1.7.1 Command Outputs

A separate command output shall be provided for each control function (i.e. a separate control output for each trip and close function). The outputs shall be potential free and suitably rated to operate the OLTC (on-load transformer tap changer) mode control interposing relays via the SCADA 48Vdc supply. The contacts of the interposing relays shall have the appropriate substation power supply applied and shall switch both positive and negative polarities of the substation supply onto the switchgear control circuits.

The closure time of command outputs shall be programmable in the range specified in datasheet (item 23). This shall be programmable either on a group basis (i.e. output card) or, preferably, individually for each output. The Contractor shall state the maximum number of different closure times per RTU.

An "RTU Control on/off" switch shall be provided in the RTU which when operated will inhibit completely any remote control from the RTU. The status of this switch shall be brought back via the RTU and displayed at the control centre.

Commands shall be initiated at the control centre. Checks carried out at the RTU shall ensure that the correct item and interposing relay has been selected and that not more than one relay is selected, also this feature should be configurable to apply on one board or different boards or a group of boards.

In the execution phase of a command operation it shall be ensured that only one mode is activated, i.e. only "open" or "close". If the execution phase is not received from the control centre within a preset time of 1 second or the "cancel" control mode is selected, the RTU shall return to the quiescent state automatically and an entirely new "select", "check-back", "execute" sequence shall be required to carry out a command. It is preferable to measure resistance of command output circuit for detecting short circuit or malfunction of command output circuits.

1.7.2 Digital Inputs

Digital inputs will be used to monitor the state of devices and alarms through the sensing of the state of contacts. Digital input will be from dry contacts. All digital input circuits shall include optical isolation of no less than 500 volts. Digital input card should have LED indicator for each input.

Digital input shall function independently of any other and may be assigned as any type of digital point:

a. Events alarms/momentary change detect / BCDs
b. Sequence of Events (SOE)
c. Pulse counters
d. Single and double bit indications.

Digital input shall consist of 2-bit indications for status indication, single bit indications for alarm inputs as well as BCD inputs and 1-out-of-N coded inputs. It is preferable that a single type of digital input card can be used for all of the above, with the card or input point function being determined by the software configuration of the RTU.

In order to reduce the communications traffic generated by "chattering" contacts or poor power supplies, it shall be possible for the RTU to automatically block spurious recurring indications. The Contractor shall state the criteria that can be used to distinguish a faulty chattering indication from a genuine series of changes-of-state. The fact that an input has been automatically blocked shall be reported as an event to the central system and the relevant point shall be marked as bad or suspect in the central system database and displays. It shall be possible for the Control Engineer to manually block or unblock an indication.

Status Indications

The switchgear status indications shall consist of double potential free contacts one normally open and the other normally closed. These contacts shall be used to activate two separate input devices in the RTU to give three separate status possibilities, namely "closed", "open" and "fault". A delay mechanism shall be incorporated into the supervisory equipment so that false or spurious indications, resulting from contact bounce or contact changeover in the case of slow operating devices such as isolators, shall not be transmitted to the control centres. Delays shall be programmable on a group basis and adjustable in the range specified in datasheet (item 24).

Alarm Inputs

Alarms shall be represented by single bit indications. Alarm inputs shall be handled by the same type of digital input card that is used for status indications. The alarm inputs will be available as a switched relay contact. Alarms may be sustained or fleeting and RTU shall be capable of handling both types.

Alarm signals will generally be derived from power equipment control and protection panels. In some substations, alarm signals will be taken from communications equipment such as fibre optic or multiplexer equipment. In addition, RTU shall provide access to alarm status information via maintenance port.

Binary Coded Decimal / 1-out-of-N Codes

The RTU shall be equipped with interface cards capable of handling BCD and 1 out of N input codes. These will be used for transformer tap position indications etc. In this case means shall be provided to filter out invalid indications while tap changing is in progress. The Contractor shall state the codes their RTU are capable of supporting and shall state the number of inputs (e.g. BCD, 1 out of N, etc) which can be accommodated per input card.

Accumulator Input

Pulse accumulators shall be provided at RTU for accumulating and storing KWh and KVarh readings. Each pulse counter input shall consist of a minimum 16-bit counter and a corresponding 16 bit storage register. An automatic "roll- over" capability is required. All necessary filtering techniques shall be employed in order to suppress contact bounce. Freeze capabilities with storage of data counts for later retrieval shall be provided on a global, RTU by RTU and individual reading basis. Reset facilities on a global, RTU and individual reading basis shall also be provided.

1.7.3 Analog Inputs

It is preferred that the outputs of CTs and PTs are directly applied to RTU's analog inputs, without any need for transducers. However, Transducer outputs, representing power network quantities can be input to the RTU.

Analog inputs shall be grounded or common connected at the RTU. In the case of using transducers, it is desirable that some means of maintaining the output current loop of the transducer is provided when the analog input board is unplugged for maintenance.

Analog input units shall present impedance to the transducer of not more than the value specified in datasheet (item 26).

The analog to digital conversion of analog values shall be accomplished by means of converters with a resolution of at least one part in one thousand of the full-scale value. Measuring circuits shall be of high stability and accuracy shall be readily checked. Recalibration shall be a straight forward task for field maintenance staff.

The Contractor shall give full details of their analog input units with particular regard to input isolation, input impedance and resolution. The RTU shall accept analog inputs in the ranges that specified in datasheet (item 27).

Measurand Filtering

RTU being supplied under this Contract shall be provided with measurand filtering features. It shall be possible to specify the amount by which a measurand must change before the new value is transmitted to the control centre. The amounts by which filtering takes place shall be downloaded from the control centre(s) to the RTU. Software shall be provided to enable the filtering amounts to be defined and modified by control centre staff before transmission to the RTU. Each measurand shall have a unique filtering band.

Raise/Lower Control

Raise/lower outputs shall be available for the control of substation and power plant equipment such as certain types of tap changers, generators or synchronous condensers. Raise and lower commands received from the control centre(s) shall be translated into output pulses of variable length. The length of each individual pulse shall be definable in the database. The control outputs of the RTU shall activate the corresponding raise or lower contractors at the substation or power plant equipment for duration of the pulse signal.

Set Point Control

RTU shall be capable of providing an output suitable for driving the set point or closed loop control of devices such as generators or synchronous condensers. As a minimum, this shall take the form of either of output types specified in datasheet (item 30), which can be used to set the target output of the device's set point controller.

As an alternative, the set point control function may be implemented entirely in the RTU. The RTU shall monitor the output of the device and send commands

to the device until its output matches the set point value received from the control centre. This may be achieved by the controller sending pulses of variable lengths, automatically calculated by the RTU, to the device. The pulse length shall be based on the difference between the actual and desired output of the device and also on device characteristics e.g. max ramping rate etc.

The device output shall be monitored at least at a rate which is specified in the datasheet (item 31) and control commands shall be sent at least in intervals which are specified in datasheet (item 32).

It shall be possible to suspend and re-initiate the set point control function on request from the control centre.

1.7.4 Analog Output

a. Each analog output point shall consist of a digital to analog converter D/A and signal conditioning Multiplexing of the D/A converter is acceptable providing no more than eight output signals are driven by the same D/A converter .
b. Each 4-20mA DC analog output shall provide a 4 to 20mA signal into 1 to 750 ohm impedance.
c. The output of the analog output point shall settle to +0.15% of the digitally encoded value within too milliseconds of an updated input.
d. Resolution of the D/A shall be at least 12 bits plus sign.
e. The D/A converter shall have an output suitable to drive the signal isolation transmitter.
f. An isolation transmitter for each analog output should be supplied by contractor.

1.8 RTU Configuration Tools

RTU configuration software shall be supplied to configure and program any RTU function.

The system shall include information on operating parameters, physical arrangement of external communication lines, card type and their parameters.

1.8.1 Data base and configuration update

The RTU database and configuration shall be editable locally or remotely with a GUI[1] application or other secure means, it shall be possible to save/restore

[1] Graphic User Interface

and replicate the complete configuration of the RTU on persistent external storage.

To minimize human errors, the RTU database (configuration) shall be programmatically generated (script or equivalent) from the Master database. As such the RTU configuration and database shall be integral part of the SCADA database management system.

During each start-up the RTU shall verify the integrity and the version of its local persistent database and configuration, and if necessary shall request an update from the current active control centre.

Program update

It shall be possible to securely Upgrade/Downgrade the RTU program or firmware and also new licence locally or remotely;

It shall be possible to reset the configuration of the RTU to the initial factory settings in order to recover from a failed upgrade attempt. In addition, all the test software tools and configuration should be in English

Access security

All access and configuration transmission to the RTU shall be secured and encrypted regardless of the type connection LAN or WAN.

1.8.2 RTU Test Equipment

The Contractor shall provide appropriate equipment and software for test and maintenance of RTU such as Protocol Analyzers for each separate protocol, and Substation I/O Simulator to be carried out. It is anticipated that this will take the form of a portable PC (Laptop), together with additional equipment such as communications leads, etc. plus appropriate software.

A complete set of test equipment shall be included in this contract:

a) A Portable PC (Laptop) with modem and all relevant test software. The specification for the PC shall at least include latest prevalent resources.

b) Protocol analyzer capable of monitoring synchronous and asynchronous data traffic at speed between 300 bit/s and 2 Mbit/s. In addition Protocol analyzer should be able to support IP based protocols. The facility to monitor transmit and receive data simultaneously is required. BER (Bit

Error Rate) test facilities shall also provided,

c) One Multimeter with tools bags, which shall have a constant current output facility to enable testing of RTU analog inputs,

d) All test equipment shall be provided with an extensive set of test leads which shall have a comprehensive set of different types of connectors. Other necessary test equipment, as recommended by the Contractor shall also be provided.

The RTU test set shall be suitable for testing, exercising and performing fault diagnosis on an RTU. It shall be possible for the RTU test set operator to use the device to fully replicate the dialogue that would take place with the master station. Commands may be issued or interrogations engaged in as seen from the RTU. The dialogue shall be identical with that entered into in normal operations. The operator of the RTU test set shall be able to selectively access and display the contents of RTU memory.

The RTU test set may also be used in conjunction with the master station to enable testing and diagnosis to be performed. In this mode the RTU test set shall appear to the master station, via the front-end computers as an RTU. It shall be possible to simulate RTU behaviour such as normal response, or to simulate frequently encountered error conditions e.g. noisy communications line, vibrating contact indications etc.

The RTU test set shall be housed in a rugged portable carrying case. It shall have a 3 metre power lead for connection to a local power source. A keyboard for command input and a logging printer for recording the results of tests shall be provided. All inputs shall have a surge withstand capability as defined in ANSI C37.90a or IEC 255.4.

1.8.3 Substation Simulator

A substation simulator shall be provided for the purpose of exercising the RTU inputs and outputs. The simulator shall have the following facilities:

(a) toggle switches to provide on/off signals to digital inputs,

(b) LEDs to show the execution of control outputs,

(c) Potentiometers and meters to provide input test currents for analog inputs,

(d) Test leads to provide the connections between the simulator and the RTU. Two types of test lead shall be provided, namely:

- Leads suitable for rapid connection to the RTU I/O cards or terminations,

- Flying leads suitable for connection to SCADA terminals in marshalling cabinets, substation plant, etc.

The simulator shall be so constructed as to allow for the testing of a complete I/O card at a time, i.e. the number of toggle switches, LEDs, analog values, etc. shall be equal to the number of inputs/outputs on each type of RTU card.

The simulator shall be housed in a rugged portable carrying case. It shall have a 3 metre power lead for connection to a local power source, if independent powering of the unit is required. All inputs shall have a surge withstand capability as defined in ANSI C37.90a or IEC 255.4.

1.9 Local Control and Monitoring Facilities (option)

Preferably, RTU can have facilities for local control and monitoring. These facilities shall be in the form of keyboard and LCD display on the front panel of RTU and at least shall include:

a) Display of digital inputs status
b) Send command control outputs
c) Display of analog input values. It shall be possible to display analog values as binary, hex, decimal and scaled values
d) Calibration of analog input / outputs
e) Definition and configuration of the RTU's internal database in an off-line mode, including such items as RTU address communication settings, I/O point type and other parameters.

Note: This LCD display shall be an integrated part of the RTU and LCD panels that need to be configured separately are not acceptable.

1.10 Spare Parts and Calculation of Quantity

It is the intention of the Purchaser to acquire sufficient numbers of spare parts to suffice for at least five year's normal operation. To take account of the various MTBF figures for different items in the Contract, the following algorithm shall be used to calculate the Spares levels to be delivered.

The number of spare units shall be the greatest of:

(I) Manufacturer's normal recommended level of spares required for five years of operation
(II) Percent which specified in datasheet (item 33) by number of units installed under the contract

(III) One spare unit where the number of units installed is less than ten.

A lump sum price for the Spares required for each subsystem shall be given in the relevant schedule including all costs for delivery to the Purchaser's stores. Following award of contract the Engineer shall be provided with a detailed list of all spares recommended by the manufacturer. The Vendor shall satisfy the Engineer that the numbers of spares proposed is in agreement with the algorithm described earlier. The Vendor shall deliver the number of spares required by the algorithm for the lump sum price given in the Price Schedules.

The Tenderer shall list in the Technical Schedule all major items of spares proposed for each section of the works.

1.11 Modem

The contractor shall provide modems of sufficient baud rate and reliability to meet the response and availability requirements for the system as a whole as specified. The contractor shall provide full details of the communication protocol proposed and of the modulation methods employed.

Modems shall be capable of supporting standard modes of operation. It is desirable that the modems support a command set such as the Hayes command set and that they can be managed and tested remotely.

The minimum requirements are presented at the associated datasheet

In addition, modems suitable for use on "voice over data" communications links over PLC shall be available. These modems shall be programmable to operate at normal data rates and with adjustable centre frequencies. PLC modems shall comply with relevant ITU-T standards.

2 Power system interface equipment

2.1 Transducers

Transducers shall have at least the following specifications: Transducers shall be provided to convert primary power system measured quantities into a form which can be accepted by the RTU. The transducers shall be of the static, solid state design with no moving parts.

Transducers shall be housed in self-contained units which shall be suitable for mounting either a dedicated transducer cabinet or in existing control panels.

Transducer inputs and outputs shall be galvanically isolated from each other and from the auxiliary power supply.

Transducers shall have accuracy rating in accordance with VDE 0410 as stated in table 1; Transducers shall be capable of providing a load independent dc output current into a load of up to 500 ohms. The maximum ripple in the dc output signal shall be less than 1%. The transducer burden on voltage circuits shall not exceed 2 VA and current transducer burden shall not exceed 1 VA.

Transducer input circuits shall be capable of operating continuously with a 20% overload on voltage circuit and a 50% overload on current circuits. The input circuits shall be capable of sustaining a short time surge overload of twice the rated input voltage and 10 times the rated input current.

Active and reactive power transducers shall be of the two-element type and shall be suitable for three-phase connection.

Current, voltage, and frequency transducers shall be suitable for single phase measurement. The particular requirements for each type of transducer are given in table 1. Transducers shall be equipped with 48/110/127 VDC auxiliary power supply.

All transducers shall be equipped with calibration screw or knob for fine-tuning adjustments. This screw shall be accessible while in service and without having to open up the case or remove transducers from the rail where they are installed.

2.2 Relays and Contactors

All relays shall be sealed to prevent the ingress of dust and moisture.

Relays shall be DIN rail mounting and shall be preferably of the direct mounting type. Where plug-in type relays are offered, a keying arrangement shall be used to prevent different relay types (i.e. different contact arrangements, contact ratings, coil voltages, etc.) from being plugged into an incorrect base.

Relays shall be provided with shunt connected "free-wheeling" diodes to prevent over voltage transients during switching and shall incorporate a series connected diode to ensure that the relay can be energized only by the application of a correct polarity voltage. No local display of relay energized status is required (no LED required on each relay).

It shall be possible to operate any relay by mechanical means, such as by means of a "test" facility which directly actuates the relay armature.

Relays shall have the characteristics as outlined in table 2. Galvanic isolation and surge withstand characteristics shall be measured and defined in accordance with IEC 255.4.

The design of relay contacts, and the choice of contact material, shall be such as to ensure a long and reliable working life. Relays for switching high current loads shall be provided with heavy duty contacts. Relays for driving LEDs and RTU digital inputs shall be designed to ensure the reliable and consistent switching of low currents at low voltages (i.e. the design shall minimize the effects of contact tarnishing, dirty contacts, etc.)

2.2.1 Command Interposing and Latch Relays

Command interposing relays shall be designed to operate from the SCADA switching supply. The contacts of command interposing relays shall be suitably rated for their anticipated switching and full-load carrying duties.

In general, command interposing relays shall have three normally open (N.O.) contacts (3 PDT type) which shall be used to switch both the positive and negative of the substation switching supply (where available). The type of relays for closing commands should be in case of pulse relays.

Latch relays shall be used where permanent commands are needed, as in AVR system. Details shall be finalized during design review stage.

Note: Where contacts of command interposing relays are directly connected to operating mechanism or Trip and Close coils, contactors of suitable ratings shall be provided.

2.2.2 Isolation and Contact Multiplying Relays

Isolation relays shall be used where additional dielectric or surge withstand capability is required between the power system equipment and the RTU.

Contact multiplying relays shall be used to generate volt-free contacts where there are either no spare auxiliary contacts available or where it is uneconomic to use existing spare contacts (e.g. in substations where spare contacts exist at the switchgear but where cable ducts to control room are unavailable).

As isolation and contact multiplying relays may be permanently energized, it is important that they are carefully selected to have low power consumption.

Preferably all isolation and contact multiplying relays shall be of the same product family, with coil operating voltage and contact configurations chosen to suit particular requirements. The number of different coil/contact permutations shall be kept to a minimum to reduce the number of different relays types being used.

Isolation and contact multiplying relays shall be of 3 PDT (3 Pole – Double Through) type.

Where new relays are substituted with existing relays in the substation, as in the case of multiplication of indications of CB's, DS's, and relays shall be the same as the existing relays or be of 4 PDT type.

2.3 Remote Control On / Off Switches

Where new switches are to be provided, these shall generally be similar to existing switches already in use, both in physical appearance and function.

Remote control On/Off switches shall be provided with two positions as follows:

- Remote/On: remote control possible, local control inhibited
- Local/Off: local control possible, remote control disabled

Remote control On/Off switches will be provided with sufficient numbers of contacts to allow separate (double pole) switching o circuits for both remote and

local operation, together with auxiliary contacts for indication of switch position to the SCADA system. The sets of contacts shall generally be as follows:

- 2 contacts: Closed in remote position, otherwise open (for enablement of remote operation)
- 2 contacts: Closed in local position, otherwise open (for enablement of local operation)
- 1 contact: Closed in remote position, otherwise open (for remote indication of remote control enabled).

The remote control On/Off switch shall be provided with facilities to allow it to be locked in any position. This shall either be by means of an integral locking mechanism or by means of a separate padlock. All locks shall be provided with the same key.

Table 1: Transducer Specifications

Parameter	**Transducer Type**			
	Volts	Amps	MW	MVAr
Rated input voltage, 50 Hz (U)	100/110 V	-	100/110 V	100/110 V
Rated input current (I)	-	1A/5A	1A/5A	1A/5A
External Load Resistance (Ω)	0-500	0-500	0-500	0-500
Accuracy Class (VDE 0410)	Class 0.2	Class 0.2	Class 0.2	Class 0.2
Overload Capacity : - Continuous - Short Time Surge	 1.2U 2U	 1.5I 10I	 1.2U/1.5I 2U/10I	 1.2U/1.5I 2U/10I
Test Voltage (50Hz for 1 min)	2kV	2kV	2kV	2kV
Output Current (mA)	4-20	4-20	4-20	4-20
Auxiliary Supply	48Vdc	48Vdc	48Vdc	48Vdc
Output Ripple	± 1%	± 1%	± 1%	± 1%

Table 2: Relay Characteristics

PARAMETER	RATING
Duty rating (coil and contacts)	Continuous
Rated continuous voltage (coil)	1.2 x U (where U is the nominal rated voltage)
Minimum pull-in voltage	80 % of U
Drop-off voltage (maximum)	50 % of U
Voltage withstand: - coil to contacts - contacts to contacts (i.e. between separate poles - Across open contacts	 2 kv ac / 1 min 2 kv ac / 1 min 500v ac / 1 min
Contacts rating (make/break) :	2x rated current

2.4 Power System Interface Equipment

Facilities shall be required for the marshalling of SCADA related wiring and the mounting of additional equipment required for the power system interface. The facilities that may be required, depending on the design of the power system interface in individual substation may include the following item:

- Marshalling cabinet
- Command interposing relays
- Transducer cabinet
- Signal interposing relays (for isolation and contract multiplying relays)

2.4.1 Marshalling (and HVI) Cabinets/Facilities

Where required by the scope of work, marshalling cabinets shall be provided to facilitate the marshalling of SCADA relating signals and outputs. The marshalling cabinet shall provide facilities for the termination of incoming cabling from the power system equipment, for communing and grouping signals and for their subsequent connection to the RTU.

The marshalling cabinet shall be provided with DIN rails, terminal blocks and internal trunking. Trunking shall be arranged as to allow for the segregation of power system and RTU cabling.

The number of cables installed in any section of the trunking shall be in accordance with the appropriate code or standard but in any case shall not exceed 55% of the total cross-sectional area of the trunking. Width and depth of truncking shall not be less than 6 cm.

Termination facilities for cables shall include gladding plates, grommets and earthing bars for the connection of cable screens.

The termination facilities shall include disconnection and test points for use during commissioning and testing. Terminal blocks of the Marshalling panel shall be grouped according to the functional requirement. For control, status indicators, alarm, measurands the connection shall be grouped into separate groups of terminal blocks. The color of the body shall be of electro-static type.

20% spare terminals of each type shall be provided in each terminal rack for future extensions.

The termination facilities for indication control and alarm and metering shall include test switches for use during commissioning and testing. Terminals used for CT or transducer outputs shall have suitably rated short-circuiting facilities to allow for maintenance and testing. CT Terminals shall also be equipped with test socket and plug accessories to inject current during test.

Open circuiting links shall be incorporated to all other terminals to permit isolation and testing of circuits separately.

Each panel shall be connected to the existing grounding system of the substation using 2 soft annealed copper conductors with 35 mm2 cross section. All necessary clamps shall also be provided.

2.5 Intelligent Electronic Devices

IED's shall have at least the following specifications:

- LCD display
- Voltage, Current, Active and Reactive Power, Active and Reactive Energy metering, demand, ...
- Ability to communicate with MODBUS and IEC 870-5-103 protocol

- Ability to store the measured quantities for some suitable time
- Ability to be mounted on control panels

2.6 Standards

Publications listed below form part of this technical specification:

- IEEE STD 472
- IEC 255-4
- IEC 521
- IEC 688
- IEC 502

Interface standards of 63/20 kV, 132/20 kV, 400 kV and 230 kV substations with dispatching systems (Iranian Ministry of Energy)