# GENERAL TECHNICAL SPECIFICATIONS (GTS)

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# 1. General

These General Technical Specifications, together with Particular Technical Specifications, shall ensure that the delivered equipment is manufactured and assembled in complete and following all the details according to the designed purpose. Thus, it is understood that the Contractor, by accepting the Contract, agree to properly manufacture and properly inspect & test the complete equipment, regardless of the omissions in the text and/or drawings in the General and/or Particular Technical Specifications.

Wherever possible, these General Technical Specifications shall be applied in conjunction with the Particular Technical Specifications for specific equipment. In case of discrepancies between the General and Particular Technical Specifications, the Particular Technical Specifications shall prevail.

Furthermore, in case of discrepancies between this Technical Specifications and the Conditions of Contract, the Conditions of Contract shall prevail.

Single line diagrams, layout and cross section drawings of the substations and main equipment have been presented within tender d*rawings*.

All the equipment presented on drawings, which is not mentioned or described in General and Particular Technical Specifications, shall be considered included in the Contract, in the same way as if it were described in the General and Particular Technical Specifications.

The Contractor shall be responsible for any discrepancies, errors or omissions in the particulars and guarantees, whether or not such particulars and guarantees have been approved by the Client.

## 2. Scope of Works

This project seeks to establish a 400/132/33kV and 33/11 KV electrical substation in Jordan, with the primary objective of strengthening the regional power infrastructure and ensuring the capacity to accommodate anticipated future load growth and feed the demand load for National conveyor project (Aqaba-Amman Water Desalination and conveyance project "AAEWDCP").

The Substation Contract Scope is relevant to the Design, Engineering, Manufacture, Inspection, Testing in Factory, packing for export, Shipment, Insurance, DAP at the below Substation, off-loading on site, Erection, testing on site, Completion, Commissioning, setting to work, and a Defect Notification Period of 1095 days from Taking-Over Certificate (TOC) for substation equipment.

1. **New Aqaba 400/132/33KV (AAWDCP) GIS substation. (NEW SUBSTATION)**
2. **33/11 kV BPS01 substation AT PROJECT LAND. (NEW SUBSTATION) and feeding IPS & RO SS**

The substations will consist of:

1. New 400kV GIS switchgear (8 OHL bays, 3 auto TR bays, BS bay and BC bays)
2. Two (2) new 400MVA 400/132/33kV Auto Transformers, earthing and auxiliary transformer and RTCC (AVR) panels
3. New 132kV GIS switchgear (4 OHL bays, 3 interconnected bays, 7 power transformer bays, BS bay and BC bay).
4. Seven (7) 132/33 kV power Transformers, earthing and auxiliary transformer and RTCC (AVR) panels.
5. New 33kV (Metal Enclosed) switchgear connect with tertiary winding of 400/132/33 KV (2 bays incomer, 4 bays capacitor, 2 bays reactor and bus section).
6. Two (2) 33kV 25 MVAR reactors.
7. Four (4) 33kV 20MVA Capacitor banks.
8. New 33kV (Metal Enclosed) switchgear to feed the demand load of (IPS, BPS1 and RO system as required in SLD.
9. Earthing & LPS.
10. All related outdoor equipment's 400 kV, 132 kV, 33 kV… etc.
11. Substation cable (LV, control and power cable… etc.) between all substation equipment's.
12. The substation protections and control system for the local control of the substation and for facility for remote control from the National Dispatching Centre, and all protection and control scheme for the interconnecting connections
13. The substation auxiliary equipment consisting of all LVAC and DC power supplies for the substation. The main LVAC supply shall be obtained from two 0.40kV auxiliary transformers. The Standby LVAC supply shall be obtained from a diesel generator. The supply, installation, routing, termination and commissioning of the associated LV power cables (0.4kV) are included in this contract as detailed in the tender schedules.
14. 33 kV power cable to feed the demand load of IPS, BPS1 and RO system with all cable route and all accessories.
15. 33kV (Metal Enclosed) switchgear to feed the demand load of BPS1 at BPS01 location.

16. 33/11 kV transformer and ancillary equipment's.
17. Construction of New Building (400kV GIS, 132 kV GIS, control and service building, 33kV SWG building, Capacitor Banks…etc.)
18. Construction of also serving
19. All ancillary systems as water deluge, Fire alarm (FA), HVAC, potable water, Generator … etc.
20. Civil works and all ancillary systems as Fire alarm (FA), HVAC, and Generator etc.

Particular details as SLDs, layouts, specifications and schedules are enclosed in this Tender.

Scope is quantified in the enclosed tender Schedules.

The Contract Works to be supplied under the lump sum price shall include all work incidental thereto whether specified in detail or not and in general is to be carried out by the Contractor in accordance with the Conditions of Contract and shall comprise the following:

1. Management, Project Control and Administration
2. Design and Detailed Engineering
3. Procurement, Supply and Transportation of the equipment supplied
4. Plant Construction, erection and installation including facilities for construction and Civil Works
5. Commissioning
6. General Services, including Construction Camp, worker, facilities, utilities and services for SITE and Camp
7. All pertinent manuals (e.g., Installation, Operating, Maintenance manuals): three Copies in English language + 2 CD.
8. Material Catalogue, Bill of Materials (BOMs) lists.
9. Mandatory spare parts. As mentioned in price Schedule.

- Spare apparatus and materials. The manufacture, testing, supply and delivery to stores as the Employer may require in accordance with the Conditions of Contract at the prices stated in the Schedules, of such quantities of the apparatus and materials enumerated and such repeats (if any) thereof as the Employer shall order from the Contractor at any time before the expiration of the Defects Notification Period of the Definite Work.

Contractor shall perform all the Tests to guarantee required performance according to International Codes and shall operate the Plant up to the handover to the NEPCO.

The Contract Works to be supplied shall include all work incidental thereto whether specified in detail or not. In general, The Contract Works shall be carried out by the Contractor in accordance with the Conditions of Contract and shall comprise the following:

- **Optional Work (at the option of the Client): This shall include, but not be limited to:**

  - Tools and appliances. The supply and delivery to stores as the Employer may require in accordance with the Conditions of Contract at the prices stated in the Schedules, of such quantities of the apparatus enumerated and such repeats (if any) thereof as the Employer shall order from the Contractor at any time before the expiration of the Defect Notification Period of the Definite Work.
  - Supervision and experts: The Contractor shall include in his Tender, the team work rate prices for potential supervision for erection and commissioning for equipment require in accordance with the Conditions of Contract at the prices stated in the price Schedules, of such quantities of the

apparatus enumerated and such repeats (if any) thereof as the Employer shall order from the Contractor at any time before the expiration of the Defect Notification Period of the Definite Work.

Each separate order for Work at the Option of the Employer shall constitute a Section for the purpose of payment and taking over.

## 3. BASIC REQUIREMENTS AND GUIDELINES

A. All components and accessories required for the completion and successful operation of the WORK covered under the scope of this contract, either specified in detail or not, shall be supplied by the CONTRACTOR as necessary.

B. The drawings enclosed with this Scope of Work and Technical Specifications are conceptual and for the information of the CONTRACTOR only. The CONTRACTOR should read these drawings in conjunction with this Scope of work and Technical Specifications. The successful CONTRACTOR shall develop detailed design drawings for construction purposes.

C. Copies of existing / ongoing project drawings, design calculations, technical reports and other information as deemed appropriate by the NEPCO might be provided to the CONTRACTOR upon request, if available. However, if such information is not available, then the CONTRACTOR should be responsible for the independent development of the information required to complete the specified CONTRACT.

D. The specification of equipment and materials specified herein are to be considered as the minimum requirements, and the bidders shall carry out their own basic and detailed design necessary for their proposed specifications.

E. NEPCO acceptance of the CONTRACTOR'S design does not relieve him of any part of his obligations to meet all the requirements of the CONTRACT nor the responsibility for the correctness of the design and construction drawings of the PROJECT.

F. The CONTRACTOR'S organizational chart shall be submitted for approval with their technical proposal

G. All the CV for the design team should be submitted for approval by NEPCO.

H. NEPCO has the right to change any engineer of the contractor's engineers during any period of the project, according to what the owner deems appropriate, the contractor must restrict and implement the change order, and he will bear the responsibility for the delay in design / project in the event that the owner does not respond by changing the engineer.

I. Sub-contracts

The Contractor shall supply three copies of all orders placed with sub-contractors. Information is to be given on each sub-order sufficient to identify the material or equipment to which the sub-order relates and to notify the sub-contractor that the conditions of the Specification apply.

All purchase order should be submitted within 10 days after letter of award as accepted on the evaluation stage on the technical offer.

## 4. Battery limits

The battery limits between the substation Contract and Other facilities are listed here below:

### i) Battery limits with new 400 kV and 132kV Over Head Lines Contract

1. The limit between substation and overhead lines is the line gantry inside the S/S, being the gantry (and its grounding) included in the substation Contract and the insulating string, line conductor (slack span) and shielding wire included in the line Contract.

2. The Overhead Line Contractor shall be responsible for providing the “slack-span” complete with tension insulators and install these between the substation terminal gantry and the last overhead line tower.

3. The substation Contractor shall be responsible for providing the terminal gantries, which shall be suitable for accepting a 200- meter for 400 KV OHL and 100-meter for 132 kV OHL slack span from terminal towers.

4. The substation Contractor shall be responsible for providing and connecting all dropper connections between the overhead line and the substation equipment terminals.

5. The substation Contractor shall also provide ducts, cable trenches, cable trays and conduits between the first overhead line tower of each line (connection point with telecom connection outside) and the Telecommunications room and LV switchgear or with any earthing thereto.

6. Over Head Line Contractor will provide hood closure for OPGW and after testing the OPGW splice the approach cable (by NEPCO) to the tested OPGW. Further end-to-end testing will be done by NEPCO while final protection test will be done by both NEPCO and Contractor.

### ii) Interface with communication and SCADA system

1. Control and measurement signals of S/S will be connected to the control system within the S/S control building and Transmission equipment are included in substation scope of work, OPGW for the transmission line is included in 400 kV and 132kV lines Contract.

2. The connection between the control and the SCADA system at the National Control Centre (NCC) is not included in the scope of work but the associated confidence testing of operation of the substation plant from the NCC SCADA system via the control from the Substation and the NCC is included in the Works. The equipment shall be entirely compatible with the communications protocol as may be required by the National Control Centre and with the communications media available at substation.

3. Another tender will supply the OPGW and non-metallic fibre cable.

4. All communication equipment required for the project (including but not limited to fiber transmission equipment, PLC equipment, teleprotection communication equipment, and associated panels) shall be **excluded from the EPC contractor’s scope**. **(NEPCO)** shall be fully responsible for the **supply, installation, configuration, integration, and commissioning** of this equipment.

5. The substation design scope shall explicitly include the necessary **infrastructure provisions** to accommodate the communication systems, including:
    a. Adequate **space allocation** for communication panels and racks in all substations.
    b. Dedicated **50 V DC battery rooms/systems** for communication equipment at each location, including appropriate ventilation and environmental conditions.
    c. Cable trays, ducts, sleeves, and entry points required for communication cabling.
6. The EPC contractor shall be responsible for the procurement and installation of all auxiliary cables required to support communication systems, including but not limited to:
    a. 240 V AC power supply to communication equipment locations.
    b. Teleprotection interface cables between protection relays and teleprotection communication equipment.
    c. All related cable containment works (trays, conduits, grounding, labeling, and termination).
7. All transmission lines associated with the project shall be designed to include line traps installed on the CVTs.
    a. The supply of the line traps shall be the responsibility of the NEPCO Communication Systems Department and will be provided from NEPCO stock.
    b. The installation, mechanical fixing, and integration of the line traps on the CVTs shall be included within the EPC contractor's scope, in full coordination with the Communication Systems Department.
8. End-to-end teleprotection testing (including coordination with protection relays and protection schemes) shall be included in the contractor's scope, to be carried out in close coordination with the NEPCO Communication Systems Department, and subject to NEPCO approval.
9. NEPCO Communication Systems Department shall have the full right to access sites, install, connect, test, and commission its equipment, without any interference, restriction, or dependency imposed by the EPC contractor.

### iii) Interface with project company for National conveyor project (RO south, RO North, IPS and BPS01)

- **Cable routing works**

The works include all associated 33kV cable routing and interconnection works between the AAWDCP station, BPS1 station, RO North, RO South, and IPS, including all cable routing paths, installations, concrete works, cable support systems, fixing works, and termination/connection points, as follows:

1. 33kV cable routing and connection works from the AAWDCP station to the BPS1 station.

2. 33kV cable interconnection works between the AAWDCP station and the connection points at RO North, RO South, and IPS.

3. For all cable routing works outside the substation boundaries, the Contractor shall coordinate with Aqaba Development Corporation (ADC) and Aqaba Special Economic Zone Authority (ASEZA) and comply with their applicable regulations and instructions.

- At SWRO south, north and IPS:

1. feed in 33kV to SWRO switchgear.

2. 33kV busbar and outgoing feeder located on the new NEPCO substation. is directly connected with several kilometres of cables to 33kV busbar and incomer feeder, located in SWRO location is scope of work of contractor.
3. 33kV cables described above are in contract scope of work.

- **At BPS01:**

1. 11kV is supplied via 33kV/11kV,
2. 33kV busbar and outgoing feeder located on the new NEPCO substation. is directly connected with several kilometres of cables to 33kV busbar and incomer feeder, located in BPS01 location is scope of work of contractor.
3. 33kV (Metal Enclosed) switchgear to feed the demand load of BPS1 at BPS01 location is scope of work of contractor.
4. 33/11 kV transformer and ancillary equipment's is scope of work of contractor.
5. All accessories and ancillary equipment's are scope of work of contractor.

## 5. Site Conditions

Aqaba, Jordan's only seaport can be reached by sea via the Red Sea and by air either from Amman or directly from Europe.

Amman can be reached by road from Aqaba or by air directly from Europe.

All substations can be reached by existing roads. Rail access is not available to any of the substation sites.

The Site Conditions prevailing at the Sites has been given in the Table below.

| Site and substation condition | 400/132/33 kV AAWDCP (MAIN SS) substation |
|---|---|
| | New SS |
| Substation type | GIS |
| Site Altitude (m a.s.l.) | ≤1000 |
| Minimum ambient temperature (°C) | -10 |
| Design temperature | |
| Outdoor | 50 (°C) |
| Indoor | 40 (°C) |
| Highest average daily temperature (°C) | 38 |
| Relative humidity (%) | 4÷100 |
| The climate –day | Dry & Hot |
| The climate – night | Cold |
| Pollution level | Heavy airborne contamination |
| Insulator creepage distance (mm/kV) | 38 |
| Wind velocity (m/s) | 50 |
| Ice loading, radial thickness (mm) | 10 |
| Isoceraunic level (days/annum) | 15 |
| Average annual rainfall (cm) | cca. 23 |
| Seismic Conditions | Zone 2B |
| Solar radiation (W/m2) | 1150 |
| Short circuit rating | |
| 400 kV switchgear | 40 / 1 sec. |
| 132 kV switchgear | 40 / 3 sec. |
| 33 kV switchgear | 31.5 / 3 sec. |
| 11 KV side | 40 kA / 1 sec. |
| BUSBAR current rating (A) | |
| 400 kV switchgear | 3150 |
| 132 kV switchgear | 3150 |
| 33 kV switchgear | 2500 |
| 11 KV side | 3150 |
| • All outdoor equipment must be suitable for live washing.<br>• The insulator outdoor creepage distance should be based on 420 kV for 400 kV, 145kV for 132kV, 36kV for 33kV and 12kV for 11 kV. | |

# 6. General Requirements (PROJECT MANAGMENT CRITERIA)

## 6.1 Compliance with Technical Specifications

All equipment and materials supplied under this Contract shall be approved by Client.

The Contractor shall be responsible for any discrepancies, errors or omissions in the particulars and guarantees, whether or not such particulars and guarantees have been approved by the Client.

No deviations from the Technical Specifications shall be permitted.

Notwithstanding any description, drawings or illustrations, which may have been submitted with the tender, all details other than those shown in the Schedule of Departures from the Specification will be deemed to be in accordance with the Specification and the standard specifications and codes referred to therein.
No departures from the Specification, except those shown in the Schedule of Departures and approved by the Employer, shall be made without the written approval of the Engineer.

## 6.2 Compliance with Standards

The equipment covered by these Specifications shall be manufactured and tested on the basis of the currently approved publications of the corresponding technical regulations, standards and norms accepted and recognized in the world.

The Contractor shall state, for the particular elements, as well as for the complete equipment, exactly the regulations, recommendations, standards etc., he applied or he will apply for dimensioning, selection of material, inspection and quality assurance, manufacture, installation and testing of equipment (in English language).

The latest publication of the following standards and codes, in particular, shall be used where applicable:

- IEC International Electro technical Commission,
- ISO International Standardization Organization,
- BSI British Standard Institution,
- ANSI American National Standard Institute,
- IEEE Institute of Electrical and Electronic Engineers,
- ASTM American Society for Testing Materials,
- NEMA National Electrical Manufacturer Association,
- DIN German Industrial Norms.

The Contractor can also use other internationally recognized standards or codes in the country where the equipment shall be manufactured provided that they are equal or higher quality than above mentioned but must have the approval of the Client obtained in writing. To obtain this approval the Contractor is obliged to submit in advance to the Client with copy of standards or codes he intends to use and to clearly explain the extent, reason and advantage for their application (in English language).

The Contractor shall provide one original copy of the latest standards (IEC, BS, ANSI, IEEE, DIN or other applicable standards) which are applicable to this Contract.

## 6.3 Compliance with Regulation

All supplied equipment and material, and all works carried out shall comply in all respects with such of the requirements of the Regulations and Acts in force in the Country of the Client as are applicable to the Contract Works and with any other applicable regulations.

## 6.4 Quality Assurance

The Contractor shall establish and maintain throughout the whole period of the Contract a project quality plan according to ISO 9001 which will ensure that a quality system of regular inspection, test and check procedures are carried out on every aspect of the work. Such work shall include but not be limited to materials, workmanship, design, preparation of drawings, factory acceptance tests (FAT), packing, shipping, storing, construction, supervision, erection, site testing & commissioning and maintenance.

Samples of all materials used shall be taken and tests performed to ensure compliance with the specifications. All test results shall be recorded, and test certificates supplied as required. Samples of materials and workmanship shall be provided to the Client from manufacturers as required.

All records shall be kept available for inspection by the Client.

## 6.5 Language and System of Units

The English language shall be used in all written communications between the Client and the Contractor with respect to the related services to be rendered as erection & commissioning supervision, training and with respect to all documents and drawings procured or prepared by the Contractor pertaining to the work, unless otherwise agreed by the Client.

All equipment labels or plates and the Operating and Maintenance Manuals shall be written in English.

The International System of Units, i.e., SI System Unit (System International d'Unites), shall be applied.

## 6.6 Technical Documentation, Data, Information, Samples and Models

### 6.6.1 Documentation and Information to be Submitted to the Client

#### *6.6.1.1 General*

For the equipment to be delivered by the Contractor according to this Contract, the following shall be submitted to the Client for approval: drawings, design data, calculations, samples, catalogues, brochures, test programs, instructions for installation and testing, operation and maintenance manuals, training programs, certificates, test protocols, reports and other documentation, which might be necessary, or reasonably requested by the Client, or requested by the Particular Technical Specifications.

Documentation submission schedule must be such as to make them available for inspection of each particular document upon its reception. Above mentioned documentation of the Contractor formally submitted, must be accompanied by official statement of the Contractor that thus presented information are checked by the Contractor and correct for application.

Preliminary documentation, submitted as information, must be clearly identified.

For the equipment to be supplied and assembled according to this Contract, the Contractor shall not make any changes, or deviations in execution of works in comparison to the technical documents, which is an integral part of the Contract. However, if the necessity arises, the Contractor shall previously obtain written assent of the Client.

The Contractor shall, within the deadlines stated in the Particular Technical Specifications, submit drawings, presenting the procedure of the equipment assembly, together with corresponding information, for preparation of appropriate foundations on which the equipment shall be assembled and for realization of all the necessary links.

The Contractor is due to indicate all possible changes into the documentation, if made during Works execution.

All designs and other documentation shall be submitted by the Contractor to the Client in three (3) hard copies and one (1) electronic copy (pdf and editable version: word, excel, AutoCAD, etc.).

*6.6.1.2 Program of Works*

The Contractor shall, within one (1) month upon Contract Commencement Date (Letter of Acceptance), submit the Program of Works with key dates showing detailed partition of activities related to substations and equipment data acquisition, preparation of design documentation, manufacturing of the equipment including factory acceptance tests, transport of the equipment & materials to the delivery place DAP, installation, commissioning and taking-over.

If at any time during the execution of the Contract, it is found necessary to modify the approved Program of Works, the Contractor shall inform the Client and shall submit a modified Program of Works for approval. Such approval shall not be deemed to be consent to any amendment of the completion dates stated in **schedule B** - *Delivery and Completion Requirements*.

*6.6.1.3 Reports on the Works Progress*

The reports on the works progress shall be submitted to the Client monthly, containing information on the progress of works from the previous month, as well as the actual condition and expected trends of works in the factory and on the Site. The condition and trends of the works progress shall be illustrated by plans, schemes, diagrams, graphic charts, drawings, photographs, tables.

Each particular task, such as designing, materials acquisition, fabrication, testing in the factory, delivery to the Site, equipment installation, testing on the Site, commissioning, shall be included in separate chapters. The complete works will be presented in the chapter with summary.

At monthly intervals after approval of the programme chart the Contractor shall submit to the Engineer two copies of written detailed progress reports in an approved form, indicating the stage reached in the design, ordering of material, manufacture, delivery and erection of all components of plant.

If during execution of the Contract, the Client considers the progress position of any section of the work to be unsatisfactory, he will be at liberty to call such meetings, either at the Amman Office at Contractor Works or at Site, as deemed to be necessary. If required by the Client, a responsible representative from the Contractor's works shall attend such meetings.

The Work Progress Report shall be submitted in Primavera or MS Project.

*6.6.1.4 Program*

Upon signing the Contract, the Contractor shall submit for the Client's approval the Detailed Test Program for the equipment in the Factory and recommended Test Program for the equipment on the Site.

The progress reports shall include good quality colour photographs of approximately half-plate size for the site where erection or construction work is in progress. A minimum of ten photographs shall be incorporated.

*6.6.1.5 Drawings*

A list of the drawings shall be submitted by the Contractor with his Tender. The list of drawings shall be submitted after the Contract Commencement Date stated in the general Technical Specifications GTS and the Particular Technical Specifications PTS.

The Contractor shall submit all drawings for approval in sufficient time to permit modifications to be made if such are deemed necessary, and the drawings shall be re-submitted without delaying the completion dates stated in the **schedule B-** *Delivery and Completion Requirements*.

Three (3) hard copies and one (1) electronic copy of all drawings shall be submitted for approval and three (3) copies of any subsequent revision. Following approval, three (3) further paper copies and one (1) soft/electronic copy shall be submitted for Issue of Construction to the Client.

The Contractor shall submit to the Client's approval outline drawings of the equipment which shall be delivered according to the Contract together with the estimated weights, forces, details on anchoring and sufficient total dimensions.

All dimensions marked on the drawings shall be correct ones.

All detailed drawings submitted for approval shall be to scale not less than 1:20. All-important dimensions shall be given and the material of which each part is to be constructed shall be indicated.

The Contractor shall also provide free of charge any additional drawings and/or copies of any drawing required by the Client.

Drawings submitted by the Contractor and approved by the Client shall not be departed from, without the instruction in writing of the Client.

The Contractor shall be responsible for any discrepancies or errors or omissions from the drawings, whether such drawings have been approved or not by the Client. Approval given by the Client to any drawing shall neither relieve the Contractor from his liability to complete the Contract Works in accordance with this Specification and the Conditions of Contract nor exonerate him from any of his guarantees.

All drawings shall be submitted in accordance with the provisions of this Technical Specification and shall become the property of the Client.

#### *6.6.1.6 Electric Diagrams*

The Contractor shall submit to the Client's approval complete connection diagrams, as well as circuit diagrams for control, regulation, measurements, protection, signalling, synchronization, etc., covering all the delivered equipment under the Contract, as well as existing equipment to which the equipment from this Contract is connected.

Cables between parts or apparatus shall be properly enumerated and marked. Individual drawings and diagrams shall show reference numbers for all outgoing cables, but the other accompanying drawings shall show all the data required for mutual interconnections.

Circuit diagrams shall be with particularly marked contacts and enumerated columns. Relays and control switches shall be shown on the same diagram with their coils and their contacts, with indication of columns where the contacts are used.

Circuit diagrams shall be completed with the indication of the reference numbers of the terminals to which apparatus are connected, the numbers being taken from the wiring diagram.

In circuit diagrams of measurements, all the measurement devices and transformers, measuring transmitters, indication instruments and all other equipment using measuring signals shall be provided.

#### *6.6.1.7 Technical Solution (Design Principle & Concept)*

Before starting with the manufacture of equipment to be delivered by the Contract, the Contractor shall submit for approval the Technical Solution (Design Principle & Concept) which shall contain the necessary technical descriptions, calculations, technical data, drawings, etc., to completely demonstrate that all equipment is in compliance with the provisions and the purpose of the Contract, as well as the installation, operation and maintenance requirements.

Equipment manufacturing can start only after approval of the Technical Solution by the Client.

#### *6.6.1.8 Detailed Design*

Prior to starting with equipment factory testing, the Contractor shall submit to the Client for approval the Detailed Design.

The Detailed Design shall be prepared in accordance with the provisions stated under Clauses 6.6.1.5, 6.6.1.6 and 6.6.1.7 above.

*6.6.1.9 Instructions for Equipment Installation*

For the equipment to be delivered, the Contractor shall submit to the Client for approval all required documentation providing satisfactory equipment installation on the Site. Special instructions for equipment installation shall be submitted together with reduced copies of applied drawings showing the installation sequence. Instructions and drawings shall include information on handling of equipment, installation tolerances and special safety measures to be undertaken during installation.

*6.6.1.10 Operation and Maintenance Manuals*

The Contractor shall submit to the Client complete and special Operation and Maintenance (O & M) Manuals for equipment and all special tools which are a part of the Contract. Such manuals shall be as clear as possible and contain complete plans and diagrams.

*6.6.1.11 Program of Training*

The Contractor shall prepare and submit for the Client's approval the Program of Training for the installation, operation, maintenance and testing of the equipment to be delivered, which will include training of the Client's personnel on the Site.

*6.6.1.12 As Built Design*

After completion of site works, the Contractor shall be obliged to perform Site Visits to all substations in order to collect all information necessary to prepare As Built Design.

As Built Design shall include introduction to the scope of work, design principle & concept, technical descriptions, substation layouts & cross sections, approved civil drawings, detailed circuit diagrams, wiring diagrams, cable lists, block schemes, technical data, panel views, approved calculations submitted during engineering/design stage, operation and maintenance manuals, detailed Manufacturer's catalogues for supplied equipment revised where necessary to show equipment as installed.

Furthermore, As Built Design for replacement and extension projects shall include all modifications on existing equipment and systems necessary for proper functioning of complete substations.

All drawings and other documentation shall be revised where necessary to show the equipment as installed, and two (2) copies shall be submitted for approval.

After Client's approval, three (3) copies of final As Built Design shall be submitted to Client and shall be reproduced as follows:

- three (3) copies as Books of approximately square size bound into strong black durable imitation of leather with covers inscribed with gold letters,
- One (1) main electronic copy in mutually agreed version of AutoCAD format on CD or similar storage media.

After receiving the final version of As Built Design, the Client shall issue the Taking-Over Certificate (TOC) to the Contractor.

### 6.6.2 Review of Contractor Documentation

Each Contractorσ document shall be submitted to the Client for approval.

A copy will be returned to the Contractor marked with "*Approved*", "*Approved with corrections*" or "*Not approved*", or as agreed between the Contractor and the Client after the Contract Commencement Date. The approval does not release the Contractor from the obligation to deliver the equipment according to the Contract, completely

fulfilling its purpose. No corrections are to be made upon return of the document marked "*Approved*" to the Contractor.

When documents copies are marked with "*Not approved*" or "*Approved with corrections*", the Contractor shall undertake the necessary corrections and to indicate them clearly in the documents and submit again for review and approval.

The Contractor shall be responsible for not clearly indicated corrections. Each revision shall be marked by number, date and subject, in the revision block. Besides, each revised document must have clearly written number, date and subject of all previous revisions.

If an omission is found on the Contractor document during equipment erection, corrections, including all required changes, shall be marked on the document and it will be submitted for approval once again, without additional expenses to the Client.

The Contractor shall be responsible for all discrepancies, omissions or errors on its documents notwithstanding the fact whether such documents and details are approved or not by the Client.

The Contractor shall make all the changes in the documentation necessary for the completion of Works in compliance with the provisions stated in the **schedule B** - *Delivery and Completion Requirements*, without additional expenses to the Client.

### 6.6.3 Documents Review Period

All documentation submitted by the Contractor to the Client for review shall be returned to the Contractor with the revision seal of the Client, or with any other remark he may make, within 21 (twenty-one) days upon the reception in the Client's office.

Exception is documentation of complicated assemblies, Detailed Design and As Built Design, for which this procedure shall be completed within 30 days.

If the Contractor needs urgent approval of any document in order to avoid delay in the completion of the Contract Works, he shall inform the Client to such effect when submitting the document.

If the Client deems it necessary to take more time for review of some documentation, he shall inform the Contractor in written within 10 (ten) days after their reception.

### 6.6.4 Samples and Models of the Equipment/Materials

A list of the equipment/material samples and models shall be submitted by the Contractor after the Contract Commencement Date as stated in the Particular Technical Specifications.

The list of the equipment/material samples and models shall include at least the cable samples, conductor samples, earthing conductor samples, earthing rods, cable glands, HV connectors, clamps, fittings, etc.

The Contractor shall submit samples of materials for approval as required from time to time by the Client.

The Contractor shall submit samples and models for approval in sufficient time to permit modifications to be made if such are deemed necessary, and the samples and models to be re-submitted without delaying the completion dates stated in the **schedule B** - *Delivery and Completion Requirements*.

All dimensions of the samples and models shall be exact as on the pertaining drawings.

The Contractor shall also provide free of charge any additional sample or model required by the Client.

Samples and/or models submitted by the Contractor and approved by the Client shall not be departed from, without the instruction in writing of the Client.

Approval given by the Client to any sample and/or model shall neither relieve the Contractor from his liability to complete the Contract Works in accordance with this Specification and the Conditions of Contract nor exonerate him from any of his guarantees.

All samples and models shall be submitted in accordance with the provisions of this Technical Specification and shall become the property of the Client.

### 6.6.5 Language

All Contractor's documents, drawings and submittals shall be in **English language.**

## 6.7 Packing, Shipping and Transport

The Contractor shall be responsible for the packing, loading and transport of the equipment and materials from the place of manufacture, whether this is at his own works or those of any supplier, to the Site including off-loading.

All apparatus shall be carefully packed for transport by sea, rail and road as necessary and in such a manner that it is protected against climatic conditions.

Where oil for the first filling is to be provided it shall be supplied in non-returnable drums or non-returnable oil tank.

Precautions shall be taken to protect parts containing electrical insulation against the ingress of moisture.

All parts liable to rust shall receive a coat of anti-rusting composition and shall be suitably protected. The machined face of all flanges shall be protected by means of a blank disc bolted to each face.

Where appropriate all parts shall be boxed in substantial crates or containers to facilitate handling in a safe and secure manner. Each crate or container shall be marked clearly on the outside of the case to show where the mass is bearing and the correct position for the slings. Each crate or container shall also be marked with the notation of the part or parts contained therein, contract number and port of destination, and shall become the property of the Client after delivery.

The Client may require inspecting and approve the packing before the items are dispatched but the Contractor shall be entirely responsible for ensuring that the packing is suitable for transit and such inspection will not exonerate the contractor from any loss or damage due to faulty packing.

All the equipment shall be protected against damage during various transport manipulations. For these manipulations, hooks and/or slings shall be provided in adequate places so as to avoid damaging of equipment. These places shall be marked precisely on the drawings and manuals, and special protection against climate influences shall be also adequately provided.

Parts of equipment susceptible to dust and moisture shall be properly protected in an airtight package, along with utilization of moisture absorbers.

Fragile and sensitive equipment and its parts have to be adequately packed in shock resistant boxes and clearly marked by an adequate warning.

The Contractor shall be responsible for all damages to the equipment in transport, and for all damages resulting from insufficient packing, improper packing, negligent handling and loading and insufficient protection against tumbling during transport, and such damages or defects shall be brought into proper condition by the Contractor, on his own expense.

## 6.8 Erection at Site and accommodation

The Contractor shall provide, at his own cost and expenses, all labour, plant and material necessary for unloading and erection at the Site and shall be entirely responsible for its efficient and correct operation.

The Contractor shall be responsible for arranging and providing all living accommodation services and amenities required by his employees. He shall also provide at the site, accommodation suitable for the sole use by the Employer's Representative's Offices NEPCO & Consultant Staff as specified in VOL. 4 of the Tender Documents.

## 6.9 Erection and Shipping Marks

Before leaving the Contractor's Works all equipment and materials shall be painted or stamped in two (2) places with a distinguishing number and/or letter corresponding to the distinguishing number and/or letter on an approved drawing and material list.

All members comprising multipart assemblies, e.g. steel frameworks, piping installations, etc., shall be marked with distinguishing numbers and/or letters corresponding to those on the approved drawings or material lists. These erection marks, if impressed before painting or galvanising, shall be clearly readable afterwards.

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

All markings shall be legible; weatherproof tags, where used, shall be durable, securely attached and duplicated.

Prior to dispatch each separate box, crate or package of equipment shall be clearly labelled in the English language and bear the markings shown on the appropriate Tender Drawings.

Marking shall be by means of block letters not less than 13 mm high, stencilled on the box, crate or package with black paint in an easily read location. When stencilling is not possible the information shall be marked on a durable metal tag that shall be securely wired to the box, crate or package.

## 6.10 Supervision and checking of work on site

The carrying out of all work on Site included in the Contract shall be supervised throughout by a sufficient number of qualified representatives of the Contractor.

Before putting any plant or apparatus into operation the Contractor shall satisfy himself as to the correctness of all connections between the plant and apparatus supplied under this Contract and plant and apparatus supplied under any other contract and shall give reasonable notice in writing to the Engineer when the plant and apparatus is ready to be energised.

The Contractor shall ascertain from time to time which portion of the work on the site the Engineer desires to check, but such checking shall does not relieve the Contractor of the liability to complete the Contract Works in accordance with the Contract or exonerate him from any of his guarantees.

The Contractor shall be deemed to have allowed for working such hours per week at the site as are consistent with completing the Contract Works in the time specified whilst maintaining working conditions for his personnel on a level comparable with that for other kindred classes of work being carried out on the site.

If it appears to the Engineer that the Contractor will be unable to complete any section of the Contract Works in the time stipulated, then the Contractor shall, if required by the Engineer, increase the number of personnel or carry on such work outside of normal working hours and shall not claim for any extra expense thereby incurred unless in the opinion of the Engineer the delay is due to causes for which the Contractor would be entitled to an extension of time under the Conditions of Contract.

If the Engineer certifies that defects have shown themselves in the Contract Works, the Contractor shall, for the purpose of the maintenance after completion of the Contract Works provided by the Conditions of Contract, send to or keep on site a supervisory staff of such numbers and for such periods as the Engineer may require.

## 6.11 Maintenance and clearing of site

The placing of materials and plant near the erection site prior to their being erected and installed shall be done in a neat, tidy and safe manner. The Contractor shall at his own expense keep the site area allocated to him and also the erection area of the Contract Works reasonably clean and shall remove all waste material as it accumulates and as directed by the Engineer from time to time.

## 6.12 Clearances

The clearances for busbars and connections, based on the BS EN 50522 and IEC 61936-1, are given in the Table below.

| Rated System Voltage | 12 kV | 36 kV | 145 kV | 420 kV |
|---|---|---|---|---|
| Basic Insulation Level (BIL) | 95 kV | 170 kV | 650 KV | 1425 |
| Switching Insulation Level (SIL) | --- | -- | -- | 1050 |
| Minimum clearance between live metal and earth | 0.2 m | 0.32 m | 1.3 m | 3.4 |
| Minimum clearance between live metal of different phases | 0.3 m | 0.43 m | 1.5 m | 3.9 |
| Safety working clearance horizontal | 1.8 m | 2.3 m | 3.2 m | 5.4 |
| Safety working clearance vertical | 2.0 m | 2.9 m | 3.7 m | 6.4 |
| Minimum height to base of insulation | 2.4 m | 2.4 m | 2.4 m | 2.7 |

Clearances apply only to equipment not subject to impulse voltage type tests and they apply to conditions of maximum conductor swing and sag.

# 7. Equipment and Material Requirements

## 7.1 General

The Contract works shall be designed to facilitate inspection, cleaning, and repairs, and for operation where continuity of supply is the first consideration. All apparatus shall also be designed to ensure satisfactory operation in all atmospheric conditions prevailing at the Site(s) and during such sudden variation of load and voltage as may be appeared with working under conditions on the system, including those due to faulty synchronising and short circuit.

The design shall incorporate all reasonable precautions and provision for the safety of those responsible for the operation and maintenance of the Contract Works and of associated works supplied under other contracts.

All outdoor apparatus and fittings shall be designed so that water cannot collect at any point.

All water and oil pipe flanges shall be according to BS EN 1092 as regards both dimensions and drilling, unless otherwise approved.

Cast iron shall not be used for chambers of oil filled apparatus or for any part of the equipment which is in tension or subject to impact stresses.

Kiosks, cubicles, and similar enclosed compartments shall be adequately ventilated to restrict condensation. All contactor or relay coils and other parts shall be suitably protected against corrosion.

All apparatus shall be designed to avoid the risk of accidental short circuit due to animals, birds, insects, mites, rodents, or micro-organisms.

Corresponding parts shall be interchangeable. Where required by the Client the Contractor shall demonstrate this quality.

All equipment is to operate without undue vibration and with the least possible amount of noise and is not to cause a nuisance.

## 7.2 Substation Design

The substation arrangement within substations shall be as shown on the Tender Drawings. These drawings are intended to show the basic requirements to be fulfilled, i.e., general equipment arrangement, location of busbars, site location and available area, line terminations, etc. It shall be the Contractor's obligation to prepare a detailed layout drawing showing the manner in which the proposed equipment shall be accommodated to best advantage within the available area.

The arrangement shown on the Tender Drawings may be modified as necessary to accommodate the various equipment, provided the basic principles are maintained.

The substation design shall minimise the number of levels of conductors and shall ensure that the consequences of a failure of one set of high-level conductors are limited to the loss of that circuit and a single busbar section. This principle shall also be applied to earth wire conductors.

Vehicle access for transport of the major substation equipment shall be provided. This shall be achieved without the need to de-energise circuits. Access for vehicles that requires the de-energisation of circuits shall be kept to a minimum.

The Contractor shall design all cable tranches and cable ducts within the substation, both in the outdoor part and in the control building as well. All cable tranches shall be designed with adequate cable trays and ladders. Particular attention shall be paid to the adequate drainage of cable tranches.

The Contractor shall design adequate transformer's oil pits taking into account the amount of oil for each transformer. The necessary documentation and inputs related to the transformers (transformer outline drawing, etc.), which are in scope of supply in other contact shall be submitted by Client.

Rooms within substations control buildings may be smaller or, if necessary, larger than shown on the Tender Drawings to meet the requirements of the equipment being supplied. Site boundaries cannot be extended.

All prescribed clearances indicated on the cross-section drawings shall be fulfilled.

All gantry type structures supporting conductors shall include facilities for ready access to all insulator sets. There shall be permanently attached climbing devices with guardrails and access to high level beams shall not be possible without proper authorisation. Safety screens shall be provided between adjacent circuits to maintain the specified safety clearances and to prevent accidental access to live circuits.

All gantry and lightning mast structures shall be steel lattice type, the same as already used in NEPCO substations. The typical drawings of currently designed gantries will be submitted to the Contractor. Contractor will need to verify the design according to EN standards. Furthermore, the Contractor is obliged to obtain the necessary information related to existing gantries and lightning masts at existing substations by performing the necessary surveying personally at the Site.

New gantries shall be suitable for future extensions. End gantry towers shall be designed to withstand the same loading as middle ones.

Where the connection to the substation is by overhead line, overhead line conductors shall be terminated at the substation gantry structures. The overhead line conductors complete with pertaining tension insulators are not in Scope of Supply for this tender and shall be supplied and erected, between the substation terminal gantry and the last overhead line tower, under a separate Contract.

The Contractor shall be responsible for providing and connecting all dropper connections between the overhead line and the substation equipment terminals. Connectors and clamps (bi-metallic where necessary) required to connect the down droppers to equipment provided under this Contract, shall be provided under this Contract as well.

The Contractor shall also provide ducts, cable trenches, cable trays, conduits for road crossing and conduits between the first overhead line tower of each line and the Telecommunications room and LV switchgear room in the control building through which the other Contractor will install the fibre optic cables and accessories as required.

The Contractor shall also provide strain plates or anchor bolts, as necessary, for the anchorage of the tension insulators and OPGW tension clamps and terminal boxes, provided under a separate Contract, together with any earthing thereto.

## 7.3 Selection of Materials

In choosing materials and their finishes, due regard shall be given to the humid tropical conditions under which equipment is to work, and the recommendations of British Standard Institution shall be observed, unless otherwise approved by Client. Some relaxation of the following provisions may be permitted where equipment is hermetically sealed, but it is preferred that tropical grade materials shall be used wherever possible:

- Metals: Iron and steel shall generally be painted or galvanised as appropriate. Indoor parts may alternatively have chromium or copper-nickel plated or other approved protective finish. Small iron and steel parts (other than rustless steel) of all instruments and electrical equipment, the cores of electromagnets and the metal parts of relays and mechanisms shall be treated in an approved manner to prevent rusting. Cores, etc., which are built up of laminations or cannot for any other reason be anti-rust treated, shall have all exposed parts thoroughly cleaned and heavily enamelled, lacquered or compounded.

  When it is necessary to use dissimilar metals in contact, these should, if possible, so be selected that the potential difference between them in the electrochemical series is not greater than 0.5 volts. If this is not possible, the contact surfaces of one or both of the metals shall be electroplated or otherwise finished in such a manner that the potential difference is reduced to within the required limits, or if practicable, the

two metals shall be insulated from each other by an approved insulating material or a coating of approved varnish compound.

- Screws, nuts, springs pivots, etc.: The use of iron and steel is to be avoided in instruments and electrical relays wherever possible. Steel screws, when used, shall be zinc, cadmium or chromium plated, or when plating is not possible owing to tolerance limitations, shall be of corrosion-resisting steel.

  All wood screws shall be of dull nickel-plated brass or of other approved finish. Instrument screws (except those forming part of a magnetic circuit) shall be of brass or bronze. Springs shall be of non-rusting material, e.g. phosphor-bronze or nickel silver, as far as possible. Pivots and other parts for which non-ferrous material is unsuitable are to be of approved rustless steel where possible.

- Fabrics, cork, paper, etc.: Fabrics, cork, paper and similar materials, which are not subsequently to be protected by impregnation, shall be adequately treated with an approved fungicide. Sleeving and fabrics treated with linseed oil or linseed oil varnishes shall not be used.

- Wood: The use of wood in equipment shall be avoided as far as possible. When used, woodwork shall be of thoroughly seasoned teak or other approved wood which is resistant to fungal decay and shall be free from shakes and warp, sap and wane, knots, faults and other blemishes. All woodwork shall be suitably treated to protect it against the ingress of moisture and from the growth of fungus and termite attack, unless it is naturally resistant to those causes of deterioration. All joints in woodwork shall be dovetailed or tongued and pinned as far as possible. Metal fittings where used shall be of non-ferrous material.

- Adhesives: Adhesives shall be specially selected to ensure the use of types, which are impervious to moisture, resistant to mould growth, and not subject to the ravages of insects. Synthetic resin cement only shall be used for joining wood. Casein cement shall be used.

- Rubber: Neoprene and similar synthetic compounds, not subject to deterioration due to the climatic conditions, shall be used for gaskets, sealing rings, diaphragms, etc., instead of the standard rubber-based materials.

## 7.4 Equipment and Materials Workmanship

The materials to be used in fabrication of particular equipment shall be of such kind, composition and physical properties, which would best correspond to their purpose, and compliant with the most advanced practice in engineering. All the equipment shall comply with the standards applied regarding materials, fabrication, design and testing. Tolerance, adjustments, and final processing must comply with the most advanced contemporary practice in manufacture of products similar to those enclosed in the Special Technical Specifications.

All the equipment must be of reliable structure, designed for frequent putting into operation.

All the equipment shall operate without excessive vibrations and with minimum noise.

When the Contractor wishes to use materials which are not manufactured for the purpose of execution of the Works under this Contract, he must submit evidence that such materials correspond to the requirements of the General and Particular Technical Specifications, and in such case, material tests may be omitted, unless decided otherwise by the Client.

All the works shall be performed in detail and skilfully, and in compliance with the contemporary practice in the most advanced equipment fabrication, disregarding any possible shortages in the General and Particular Technical Specifications. All the works shall be performed by skilled labourers of various professions. All the parts shall be accurately produced according to the standard measure, wherever possible, to facilitate replacement and repair. Similar parts shall be interchangeable unless the Client approves otherwise. Basic equipment elements and their spare parts shall be manufactured of the same material.

Equipment, accessories for adjustments, fastening and other, shall be brand new, of the approved fabrication and standards, and of the first-class quality.

In case any deviation from the contracted drawings may occur in the course of manufacture, a written report on the nature of the deviation shall be submitted to the Client by the Contractor, and the Client will decide whether the modified part of equipment should be accepted or not.

The Client's acceptance of the deviation shall in no way release the Contractor of his obligation to deliver the equipment according to the Contract.

Materials and equipment, manufactured, used or installed without the Client's consent can be subsequently rejected.

All apparatus, connections and cabling shall be designed and arranged to minimize the risk of fire and any damage which might be caused in the event of fire.

## 7.5 Bolts and Nuts

All bolts, studs, screw threads, pipe threads, bolt heads and nuts shall comply with the appropriate IEC, ISO or BS Standards for metric threads, or the technical equivalent.

Except for small wiring, current carrying terminal bolts or studs, for mechanical reasons, shall not be less than 6 mm in diameter.

All nuts and pins shall be adequately locked.

Wherever possible bolts shall be fitted in such a manner that in the event of failure of locking resulting in the nuts working loose and falling off, the bolt will remain in position.

All bolts, nuts and washers placed in outdoor positions shall be treated to prevent corrosion of the threads and electrolytic action between dissimilar metals.

Where bolts are used on external horizontal surfaces where water can collect, methods of preventing the ingress of moisture to the threads shall be provided.

Each bolt or stud shall project at least one thread but not more than three threads through its nut, except when otherwise approved for terminal board studs or relay stems. If bolts and nuts are placed so that they are inaccessible by means of ordinary spanners, special spanners shall be provided.

The length of the screwed portion of the bolts shall be such that no screw thread may form part of a shear plane between members.

Taper washers shall be provided where necessary.

## 7.6 Galvanizing

All galvanizing shall be applied by the hot dip process and shall comply with BS EN ISO 1461. The thickness of the coating shall be such to secure 25 years of coating durability without maintenance, depending on site conditions, as per BS EN ISO 14713, but shall not be less than 0.61 kg/m$^2$. Coating thickness is subject to NEPCO approval.

All welds shall be de-scaled, all machining carried out and all parts shall be adequately cleaned prior to galvanizing. The preparation for galvanizing and the galvanizing itself shall not adversely affect the mechanical properties of the coated material.

The threads of all galvanized bolts and screwed rods shall be cleared of spelter by spinning or brushing. A die shall not be used for cleaning the threads unless specially approved by the Client. All nuts shall be galvanized with the exception of the threads which shall be oiled.

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

Partial immersion of the work shall not be permitted, and the galvanizing tank must therefore be sufficiently large to permit galvanizing to be carried out by one immersion.

Galvanizing of wires shall be applied by the hot dip process and shall meet the requirements of BS EN 10244-2.

## 7.7 Rating Plates, Labels and Markings

On each main and auxiliary item of equipment, permanent mark shall be fastened on a visible place and the mark shall be made of resistant material to atmospheric influence. It shall have engraved or impressed the name of the manufacturer and its hallmark, as well as type, serial number and mark of the equipment position and details related to performance characteristics.

On each panel, board, cubicle, boxes as well as on each equipment installed in such panel, board, cubicle and boxes, adequate rating plates shall be provided.

Rating plates for panels, boards, cubicles and boxes shall be fixed on front and rear side and shall contain the name of panel, board, cubicle and box including item designations.

Rating plates for equipment on which the item designations of equipment are indicated shall be fixed on the equipment themselves and in their immediate vicinity, to facilitate interchangeability, dismantling and assembly.

The rating plates of the equipment and data on them shall be in accordance with applicable IEC standards. NEPCO property plates of equipment shall be indicated as well. During engineering/design stage, the Client shall submit those details to the Contractor.

Thickness of rating plate shall be at least 2 mm.

Rating plates, labels and markings shall be subject of the Client's approval. The material of all labels and the dimensions, legend, and method of printing shall be subject of the Client's approval as well.

Colours shall be permanent and free from fading.

The surface of indoor labels shall have a matt or satin finish to avoid dazzle from reflected light.

All labels and rating plates for outdoor use shall be of stainless-steel material with black engraving.

Protective washers of suitable material shall be provided front and back on the securing screws.

All apparatus shall be clearly labelled indicating, where necessary, its purpose and service positions. Each phase of alternating current and each pole of direct current equipment and connections shall be coloured in an approved manner to distinguish phase or polarity.

Phases of three-phase alternating current systems shall be identified as follows:

| Phases | Phases for Transformers | Colour |
|---|---|---|
| A R | U | Red |
| B S | V | Yellow |
| C T | W | Blue |

Phases on outdoor equipment shall be identified by coloured discs attached to the structures at the following locations:

- On tubular busbars midway between taps and at tapping points,
- On tensioned busbars or other tensioned connection spans, next to the anchor points at one end of every span,
- On overhead line gantries, transformer gantries, next to the anchor points,
- On each transformer and circuit breaker.

Such nameplates or labels shall be of non-hygroscopic, non-transparent or translucent heat resisting material with engraved or impressed lettering of a contrasting colour or, alternatively, in the case of indoor circuit breaker, etc., of transparent plastic material with suitably coloured lettering engraved on the back. Size, colour and engravings shall be subject to acceptance by the Client.

All inscriptions on rating plates, labels and markings shall be in English except for "*Danger*" and "*Warning*" signs which shall be in both English and Arabic. Colour for "*Danger*" and "*Warning*" signs shall be approved by the Client.

Items of equipment, such as valves, which are subject to handling, shall be provided with an engraved chromium plated brass nameplate or label not less than 3 mm thick with engraving filled with enamel.

The interior of each piece of equipment shall be clearly marked to show the phases and for this purpose either coloured plastic discs screwed to fixed components or identification by means of plastic sleeve or tape shall be used.

In addition, each item of switchyard & switchgear shall have number plates bearing the switch number allocated by the Client according to his standard operational switch numbering scheme. Details of the number plates shall comply with NEPCO standard operational numbering system.

## 7.8 Cleaning and Painting

### 7.8.1 General

All paints shall be applied in strict accordance with the Manufacturer's instructions.

All painting shall be carried out on dry and clean surfaces and under suitable atmospheric and other conditions in accordance with the Manufacturer's recommendations.

### 7.8.2 Works Processes

All steelwork, equipment supporting steelwork and metalwork, except galvanised surfaces or where otherwise specified, shall be shot blasted to BS 7079 (second quality finish) or Swedish Standard SA2½.

All surfaces shall then be painted with one coat of epoxy zinc rich primer, two pack type, to a film thickness of 50 microns. This primer shall be applied preferably by airless spray and within twenty minutes (20 min) but not exceeding one hour (1 h) of shot blasting.

All rough surfaces of coatings shall be filed with an approved two pack filler and rubbed down to a smooth surface.

The interior surfaces of all steel tanks and oil filled chambers shall be shot blasted in accordance with BS 7079 (first quality finish) or SA3 and painted within a period of preferably twenty minutes (20 min) but not exceeding one hour (1 h) with an oil resisting coating of a type approved by the Client.

The interior surfaces of mechanism cubicles, boxes and kiosks, after preparation, cleaning and priming as required above, shall be painted with one coat zinc chromate primer, one coat phenolic based undercoating, followed by one coat phenolic based finishing paint to a light or white colour. For equipment for outdoor use this shall be followed by a final coat of anti-condensation paint of a type approved by the Client, to a light or white colour. A minimum overall paint film thickness of 150 microns shall be maintained throughout.

All steelwork and metalwork, except where otherwise specified, after preparation and priming as required above shall be painted with one coat metallic zinc primer and two coats of micaceous iron oxide paint to an overall minimum paint film thickness of 150 microns.

Galvanized surfaces shall not be painted in the works.

All nuts, bolts, washers etc, which may be fitted after fabrication of the equipment shall be painted as described above after fabrication.

### 7.8.3 Site Painting

After erection at site, the interior surfaces of mechanism cubicles and kiosks shall be thoroughly examined, and any deteriorated or mechanically damaged surfaces of such shall be made good to the full specification described in the Clause above.

All surfaces of steelwork and metalwork included in the Clause above shall be thoroughly washed down, any deteriorated or otherwise faulty paintwork removed down to bare metal and made good to the full specification described in the Clause above, then painted one further coat of phenolic based undercoating and one coat phenolic based hard gloss finishing paint to provide an overall minimum paint film thickness of 200 microns.

Any nuts, bolts, washers, etc, which have been removed during site erection, or which may be required to be removed for maintenance purposes shall be restored to their original condition.

All paintwork shall be left clean and perfect on completion of the works.

## 7.9 Oil and Insulating Compounds

The insulation oil shall comply with Standard IEC 60296.

The transformer oil shall be a highly refined uninhibited mineral naphthenic / Inhibited Super Grade type oil suitable for use as an insulating and cooling medium in transformers. The oil shall be free from corrosive sulphur (as per IEC 62535), PCB, DBDS (dibenzyl disulphide), Antioxidant, passivator, metal deactivator and other additives.

Each 132 kV outdoor instrument transformer shall be impregnated and filled with oil of the grade specified in IEC 60296.

Where oil for the first filling is to be provided it shall be supplied by the manufacturer in non – returnable drums.

Resin insulation shall comply with the requirements of IEC 60455.

## 7.10 Impact on Environment

The equipment and materials shall be designed and manufactured with maximum care on environment.

## 7.11 Electromagnetic Compatibility

The equipment and materials shall comply with requirements for electromagnetic compatibility stated in IEC 61000 Standard.

## 7.12 Earthing

All metal parts, other than those forming part of any electrical circuit, shall be connected to the main substation earthing system by means of a hard drawn high conductivity copper earthing conductor with a cross sectional area such that the current density is not greater than 200 A/mm$^2$ for 1 second fault durations and not greater than 100 A/mm$^2$ for 3 second fault durations with a minimum of 60 mm$^2$.

## 7.13 Lubrication

Bearings, which require lubrication either with oil or grease, shall be fitted with nipples.

Grease lubricators shall be fitted with nipples complying with latest related IEC. Where necessary for accessibility, the nipples shall be placed at the end of extension piping. The Contractor shall supply at least one grease gun for

each type of nipple provided. Where more than one special grease is required a grease gun for each special type shall be supplied and permanently labelled.

## 7.14 Motors

All motors shall comply with IEC 60034 and shall have dimensions according to with IEC 60072. They shall be capable of operating continuously under actual service conditions without exceeding the specified temperature rises, determined by resistance method, at any frequency between 48 and 51 Hz together with any voltage between ±5% of the nominal value.

All motors shall be totally enclosed, and if they shall be situated outdoor, they shall be weatherproof and suitable for outdoor working. They shall be provided with a suitable means of drainage to prevent accumulation of water due to condensation and with suitable means of breathing.

Motors operating in an ambient temperature not exceeding 40 °C shall have insulation Class F. The temperature rise shall be restricted to that associated with Class B insulation. Where the motor may be appreciably affected by conducted heat, the class of insulation shall be subject of the Client's approval.

All motors shall be suitable for direct starting at full voltage.

Motors shall have sealed ball or roller bearings.

The three-line connections of AC motors shall be brought out to a terminal box. Terminal markings shall be made in a clear and permanent manner and shall comply with IEC 60034. A permanently attached diagram or instruction sheet shall be provided giving the connections for the required direction of rotation. All terminal boxes shall be of the totally enclosed type designed to exclude the entry of dust and moisture and sealed from the internal air circuit of the motor. All joints shall be flanged with gaskets of neoprene or other approved material. Natural rubber insulation shall not be used.

Where single phase motors shall be used the motors will be grouped to form, approximately, a balanced three phase load.

## 7.15 Motor Control Gear

Motor control gear shall comply with the requirements of IEC 60947-4-1, and they shall be designed according to the duty imposed by the particular application.

Motor contactors shall comply with IEC 60947-4-1 and shall be capable of switching the stall current and shall have a continuous current rating of at least 50% greater than the full load current of the motors they control.

The operating currents of overload relays fitted to motor contractors shall be substantially independent of ambient temperature conditions, including the effect of direct sunlight on the enclosure in which the contactors are installed.

Where small motors are connected in groups, the group protection shall be arranged so that it will operate satisfactorily in the event of a fault occurring on a single motor. The control and protection equipment shall be accommodated in the control cabinet or marshalling kiosk.

Each motor or group of motors shall be provided with control gear for starting and stopping by hand and automatically. Overload and single-phasing protection shall be provided.

## 7.16 Cable Boxes

Cable boxes shall be suitable for cables entering from above or below as specified. They shall be weatherproof, rodent and insect-proof and shall be complete with all gaskets, glands and associated fittings as may be required to make-off the cables.

Gland plates shall be insulated from the cable boxes and in the case of single-core cables shall be of non-magnetic or insulating material. If metallic gland plates are used, single-core cable glands shall be insulated from the gland plate. Gland plate insulation shall be capable of withstanding a dry high voltage test of 2000 V AC for one minute (1 min).

Where cable boxes are provided for three-core cables, the sockets on the outer phases shall be inclined towards the centre to minimise opening of the cable cores. Cable sockets shall be supplied under this Contract.

Cable boxes for LV cables shall be suitable for XLPE or PVC insulated, steel-wire armoured, PVC covered cables with copper conductors. The boxes shall be air insulated and designed to accommodate all the fittings required by the cable Manufacturer. Front covers and gland plates shall be removable and a 12 mm diameter breathing hole covered with wire gauze shall be provided.

Cable boxes for 33 kV cables shall be air insulated and suitable for 3-core XLPE insulated, PVC covered cables with copper conductors.

Cable boxes shall be capable of withstanding on site the cable high voltage test in accordance IEC 60502.

## 7.17 Cubicle Wiring

Cubicle wiring shall be insulated with PVC according to IEC 60227. Wires shall not be jointed or tied between terminal points. Bus wires shall be fully insulated and shall run separately from one another along the top or bottom of the cubicle. Miniature circuit breakers or fuses and links shall be provided to enable all circuits in a cubicle, except a lighting circuit, to be isolated from the bus wires.

The DC trip and AC voltage circuits shall be segregated from each other. Circuits to main protection shall be segregated from those for back-up protection and also from protection apparatus for special purposes. Each such group shall be fed through separate miniature circuit breaker or fuse from the bus wires. There shall not be more than one set of supplies to the apparatus comprising each group. All wires associated with the tripping circuits shall be provided with red ferrules marked "*Trip*".

It shall be possible to work on small wiring for maintenance or test purposes without making a switchboard dead.

Insulated stranded wire shall have not less than seven (7) strands and each strand shall be not less than 0.67 mm diameter. If single conductor is used, it shall be annealed copper of circular cross-sectional area of not less than 2.5 $mm^2$. Flexible conductors of 1.5 $mm^2$ may be employed on indoor, independently mounted control and protection panels. Single strand 1.5 $mm^2$ or smaller sizes shall only be employed with a written approval of a Client.

Claw washers or crimped connectors of approved type shall be used to terminate all small wiring.

When connections rated at 380 V and above are taken through junction boxes they shall be adequately screened, and "*DANGER*" notices shall be affixed to the outsides of junction boxes or marshalling kiosk.

All metallic cases of instruments, control switches, relays, etc. mounted on control & protection panels or cubicles shall be connected by copper conductors of cross-sectional area not less than 3.5 $mm^2$ to the nearest earthing bar.

Where connections to other equipment and supervisory equipment are required, the connections shall be grouped together.

For internal wires the identification ferrules shall have at each end the equipment and terminal number to which it connected and the other end equipment and terminal number destination.

Internal wiring shall comply with the following:

Fire performance: Flame retardant to IEC 60332,

Insulating material: PVC moisture resistant,

Insulation grade: 600 V,

Conductors: Tinned stranded copper,

Color and Minimum core size:

| | | |
|---|---|---|
| **Control wiring** | 1.5 mm2 | Gray or black |
| **AC circuit** | 2.5 mm2 | - single phase: Red/ Black<br>- three phase: Red/yellow/blue/black |
| **DC circuit** | 2.5 mm2 | Red/ Black |
| **CT and VT circuit** | 2.5 mm2 | Red/yellow/blue/black |
| **Earthing** | 4 mm2 | Green with yellow |
| **Trip signal** | 1.5 mm2 | Gray with red color ferrules with “T” marks |

Multi-strand conductor ends shall be fitted with a crimped terminal device with an insulating straight shank.

Wiring across door hinges shall be protected against mechanical damage, e.g. by the use of flexible conduits.

Wiring between compartments shall be carried within a duct and shall be accessible without the need for de-energising any circuits. Sufficient space shall be left in ducts and trunking for at least 10% of the wires to be installed after delivery to the Site.

Separate supplies for the circuit breakers shall be run for indication, tripping and closing circuits.

All wiring shall be traceable from the Contractors/Manufacturers drawings.

## 7.18 Multicore and Conduit Wiring

All LV AC & DC power cables, control, signalling and measuring cables, communication cables, cable glands, ferrules, cable numbers, cable shoes, etc. shall be provided by Contractor

The design of cabling between the main equipment and the ancillary equipment shall be a part of the Contract.

The cables shall be XLPE, or PVC insulated, steel-wire armoured, PVC covered cables with copper conductors, according to IEC 60228.

In addition, wiring diagrams, cable lists, cable markers, etc. shall be provided.

Where conduit is used, the runs shall be laid with suitable falls and the lowest parts of the run shall be external to the equipment. All conduit runs shall be adequately drained and ventilated. Conduits shall not be run at or below ground level.

Multicore cable tails shall be so bound that each wire may be traced to its cable without difficulty. The spare cores of all multicore cables shall be numbered and terminated at a terminal block in the cubicle. Where cables are terminated in a junction box and the connections to a control and protection panel are continued in conduit, the spare cores shall be taken through the conduit and terminated in a cubicle.

The DC trip and AC voltage circuits shall be segregated from each other. Circuits to main protection and circuits to back-up protection shall be segregated from each other as well.

The screens of screened multicore cables shall be earthed at only one end of the cable. The position of the earthing connections shall be clearly indicated on the diagram.

All wires on panels and all multicore cables shall have ferrules that bear the same number at both ends. At those points of interconnection, between the wiring carried out by separate Contractors, where a change of number cannot be avoided double ferrules shall be provided on each wire. The change of numbering shall be shown on the appropriate diagram of the equipment. The same ferrule number shall not be used on wires in different circuits on the same panels.

## 7.19 Termination of Cables and Wires

Where cables leave the apparatus in an upward direction the cable boxes shall be provided with a barrier joint to prevent leakage of cable compound into the apparatus. Where cable cores are liable to contact with oil or oil vapour the insulation shall be unaffected by oil.

PVC sheathed cables shall be terminated by compression glands complying with BS 6121-1 and IEC 62444 (or equivalent).

Auxiliary cables in which the individual cores are not insulated with paper shall be terminated with compression type glands, clamps or armour clamps complete with all the necessary fittings.

Colours shall be marked on cable box tail ends and single core cables at all connecting points and/or any positions the Client may determine. Cable boxes shall be marked with stamped brass labels indicating the purpose of the supply where such supply is not obvious or where the purpose of the supply where such supply is not obvious or where the Client may determine.

All cables shall be identified and shall have phase colours marked at their terminations.

All incoming and outgoing connections shall be terminated at a terminal block. Direct termination into auxiliary switches shall not be accepted.

## 7.20 Terminal Blocks

Terminal blocks shall be of good quality non-flammable insulating material, with a Comparative Tracking Index (CTI) of not less than 500 according to IEC 60112.

Terminal boards shall be spaced not less than 100 mm apart and the bottom of each board shall not be less than 200 mm above the incoming cable gland plate. For relay panels, they shall be mounted at the sides of the cubicle and set indirectly towards the rear doors to give easy access to terminations and to enable ferrule numbers to be read without difficulty. Separate studs shall be provided on each terminal strip for internal connection and outgoing cables including spare cores.

Studs of stud type terminal boards shall be locked in the base to prevent turning and all connections shall be made on the front of the terminal block using lock nuts or lock washers. Where crimped type terminations are provided, at least two (2) sets of crimping tools shall be supplied for each installation.

Terminals shall be of the insertion clamp type incorporating captive pressure screws, which do not bear directly on the wire but on a serrated clamping plate. The pressure screws shall have an inherent locking feature and terminal entries should be shrouded such that no current carrying metal is exposed.

Where connections are to be made between the multicore cables supplied and telephone type multicore cables, then the terminal block shall comprise a stud or clamp type terminal for the multicore cable and a soldered tag for the telephone cable joined by a withdrawable insulated link. These terminals shall also be provided with facilities for the insertion of test probes on both sides of the link.

Terminations shall be grouped according to function and labels shall be provided on the fixed portion of the terminal blocks showing the function of the group.

The use of terminal blocks as junction points for wires which are not required in the associated cubicle shall be avoided wherever possible.

Terminal blocks shall include short circuiting links for CT circuits and open circuiting links for VT and other circuits as necessary and shall be suitable for the connection of test plugs.

All terminal blocks shall have a minimum of 20% spare terminals.

## 7.21 Miniature Circuit Breakers, Fuses and Links

For protection and isolation of circuits associated with protection, control and instruments, miniature circuit breakers or fuses and links shall be used, although miniature circuit breakers are preferred.

Miniature circuit breakers (MCBs) shall be designed and tested in accordance with IEC 60947-5-1 and supplementary requirements of this Technical Specification. They shall be suitable for use over the full range of expected voltage variations as specified in these Technical Specifications.

They shall be suitably rated for both the continuous and short circuit loadings of the circuits they are protecting under all service and climate conditions at the Site defined within Clause 3 of these General Technical Specifications.

For three phase circuits, the miniature circuit breakers shall be of the three-pole type, for single phase circuits they shall be of the single-pole type and for DC circuits they shall be of the double-pole type.

Where miniature circuit breakers are used in circuits containing inductive loads, e.g. operating coils, it is essential that they are suitable for satisfactory operation in the circuit in which they are used, i.e. account of the circuit time constant shall be considered.

All miniature circuit breakers shall be provided with an auxiliary contact(s) for remote indication of circuit breaker operation.

Means shall be provided to prevent the miniature circuit breakers being inadvertently switched to the "*OFF*" position.

Miniature circuit breakers shall be mounted in such a manner to give easily visible indication in order to facilitate identification and easy replacement.

Carriers and bases for fuses and links shall be in accordance with IEC 60269 and shall be colour coded to permit identification of the circuit rating.

The fuses and links mounted in cubicles for tripping circuits and protective gear test links shall be mounted on the front of the panel. Other links and fuses shall be accommodated within the cubicle or above the cubicle doors. Fuses and links shall be grouped and spaced according to their function in order to facilitate identification.

All incoming circuits in which the voltage exceeds 125 volts shall be fed through insulated fuses and/or links, and the supplies shall be connected to the bottom terminal. The contacts of the fixed portion of the fuse or link shall be shrouded so that accidental contact with live metal cannot be made when the moving portion is withdrawn.

Main supply fuse links shall be of the high rupturing capacity cartridge type.

Where fuse carriers are mounted vertically the incoming (supply) side shall be the bottom terminal.

Where either fuses or circuits breakers shall be used, it should be ensured that proper discrimination between main and sub-circuits is achieved.

## 7.22 Marshalling Kiosks and Junction Boxes

The Contractor shall provide, on the site adjacent to each circuit breaker as appropriate, a marshalling kiosk to which all outgoing connections from the associated main equipment will be run for housing ancillary apparatus.

Marshalling kiosks shall be made of steel sheet with minimum thickness of 2 mm, formed on a framework of standard rolled sections.

All outdoor kiosks and boxes shall be protected in accordance with the IP55 degree of mechanical protection according to IEC 60529 and shall be insect and rodent proof. Each marshalling kiosk and/or cabinet shall be provided by interior light, door switches, and heaters with thermostat.

Ventilation louvers shall be provided and divisions between compartments shall be perforated.

All cables shall enter kiosks and boxes at the base.

Each compartment of all kiosks and junction boxes shall be provided with access doors at the front and rear side. Doors and access covers shall not be secured by nuts and bolts but shall be fastened with integral handles with provision for locking.

Doors for kiosks shall be of the lift-off and hinged type and shall be provided with glazed windows of adequate size to facilitate reading of indicators from outside the kiosk.

Doors and covers under 15 kg mass may be of the slide-on pattern but above this mass hinged doors shall be used.

If three-phase connections are taken through a kiosk or box they shall be adequately screened or insulated and suitably marked with the phase colour code. A "*Danger*" notice, stating the voltage shall be fixed on the inside and outside of the kiosk or box.

A durable copy of the circuit and wiring diagram shall be affixed to the back of the kiosk door and labels shall be provided inside each kiosk or box to describe the functions of the various items of equipment.

A watertight 16 A, 3-pin, interlocked switched socket with plug for a 240 V AC supply shall be mounted externally on a marshalling kiosk. This switched socket shall be connected to the kiosk heater supply circuit through a 16 A fuse in the line lead. The earthing terminal shall be earthed.

## 7.23 Padlocks

non-ferrous padlocks with different key changes and three (3) keys for each lock and a master key for each substation, shall be provided.

Cabinets for the accommodation of padlocks and keys, whilst not in use, shall be provided and shall be suitably labelled so that keys will be readily identifiable.

## 7.24 Locking Facilities

Locking facilities shall be provided on each item of substation equipment as detailed below and shall be additional to the mechanical interlocking devices where specified.

Locks and keys shall be in accordance with the requirements of this specification.

Where a mechanism is to be locked in a specific position, the locks shall be fitted to that part of the mechanism where the operating power is applied and not remote or ancillary linkages.

The following locking facilities shall be provided:

- Circuit breaker mechanism in the open position and any associated manual operating device in the neutral position,
- Disconnector and earthing switches in both open and closed positions,
- Access doors or gates to circuit enclosures,
- Circuit breaker control switches in the neutral positions,

- Control position selector switches in all position provided,
- Marshalling, operating and terminal kiosks or cubicle access doors and panels,
- Air system isolating valves in open or closed positions.

Locks shall be designed construction and located on the equipment so that they will remain serviceable in the climatic conditions specified without operating or maintenance for continuous periods of up to two (2) years and with suitable maintenance shall be fit for indefinite service.

## 7.25 Special Tools

A complete set of spanners shall be supplied for each substation to fit every nut and bolt head on the apparatus supplied under this Contract, together with all special tools required for the adjustment and maintenance of the equipment. These tools shall be mounted in a lockable cabinet at each substation and shall also be provided under this Contract.

Eyebolts that have to be removed after use shall be accommodated in the cabinets.

Spanners and other maintenance equipment provided under the Contract shall not be used for the purpose of erection of the equipment.

## 7.26 Spare Parts and Materials

The Tenderer shall include in his Tender, the spare parts and materials which are stated in Price Schedules.

The prices for these defined additional goods shall be stated within the Price Schedules – Optional Goods and the price of those additional activities shall not be included in the Total Tender Price.

The Client may order all or any of the stated spare parts and materials. These items shall be optional and shall be included in the definite work only with the written request from the Client.

Any spare apparatus, parts and tools shall be subject to the same technical specifications, tests and conditions as similar equipment supplied under the Definite Work section of the Contract. They shall be strictly interchangeable and suitable for use in place of the corresponding parts supplied with the equipment and must be suitably marked and numbered for identification and prepared for storage by greasing or painting to prevent deterioration.

All spare apparatus or materials containing electrical insulation shall be packed and delivered in cases suitable for storing such parts or material over a period of years without deterioration. Such cases shall have affixed to both the underside and topside of the lid a list detailing its contents. The cases shall remain the property of the Client.

## 7.27 Degrees of Mechanical Protection

The following degrees of protection shall be provided in accordance with IEC 60529:

- For outdoor applications: IP55.
- For indoor applications, where purpose-built building is provided, e.g. switch, control, and relay rooms in auxiliary/control buildings: IP41.
- Where dust can adversely affect equipment within the enclosure, this equipment should be separately housed with a degree of protection of IP51.

## 7.28 Supply Voltage

All incoming supplies, greater than 125 V (phase-to-earth) shall have their terminations shrouded by a suitable insulating material.

## 7.29 Control and Protection Panels and Facilities

All remote control, protection relay, alarm and instrumentation facilities shall be located in a control room within the substation control building, and mounted on panels arranged in suites according to their function i.e. control, protection, metering, etc.

All control, alarm and indication facilities shall be grouped on a per circuit basis each on its own section or complete control panel.

Protection relays shall also be panel mounted on a per circuit basis, each circuit being allotted its own panel.

All power operated equipment shall be operable either locally on site or remotely from the control room, but the two systems shall not be in operation simultaneously. Facility for selection of "*remote*" or "*local*" control shall be provided on site adjacent to the equipment being controlled.

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

All circuits, equipment, control switches, etc shall be clearly labelled with their purpose and function.

Indicating devices shall preferably be of the hand dressed discrepancy type.

Panels shall be constructed from steel sheet, designed to be self-supporting and be vermin and termite proof. They shall not be less than 600 mm wide, and in no case shall the depth exceed the width. The doors shall be hinged to lie back flat to avoid restricting access. Hinges shall be of the lift-off type. Doors shall be secured by lockable handles, which shall be placed not more than 1.8 m above floor level.

Circuit labels shall be provided on the front and back of each panel and on the outside of the cubicle doors.

Where specified, accommodation shall be provided for ancillary apparatus (remote metering and signalling equipment, transducers and interposing current transformers, etc.).

Alarm and indication equipment as specified, shall be provided in the control room to indicate the operation of the main and back-up system protections, operation of the equipment alarms including those on the power transformers, switchgear and all other alarms which are required for the satisfactory operation of the complete substation.

Alarm annunciator equipment as specified, shall be mounted adjacent to the mimic diagram panel, capable of accepting all the alarms required within the substation, and compatible with the relay equipment provided, i.e. capable of accepting the alarm signal generated.

Where mimic diagrams are not specified, indicating devices shall be provided adjacent to the circuit breaker control handle or switch to show whether the circuit breaker is open or closed.

A common bell or buzzer shall be provided to give audible alarm when any circuit breaker has tripped automatically. Means shall be provided for silencing the audible alarms whilst leaving it free to sound when the tripping of any other circuit breaker occurs.

Indicating lamps and lamp-holders shall be so arranged that replacement of lamps and the cleaning of glasses and reflectors can be readily carried out.

Indicating lamp glasses on control & protection panels shall be white.

All control and protection panels shall have a continuous earthing bar of sectional area not less than 70 $mm^2$, run along the bottom of the panels, each end being connected to the substation earthing system. Metal cases of

instruments and metal bases of relays on the panels shall be connected to this bar by conductors of cross-sectional area not less than 3 $mm^2$.

The closing circuit, signalling circuits and each tripping circuit shall be separately fused.

All control circuits shall be provided with suitable means of isolation.

Control and protection panels shall be equipped with single-phase, service socket-outlet of an approved type and an interior light controlled by a door operated switch. Anti-condensation heaters controlled by thermostat shall be provided as well.

## 7.30 Control and Selector Switches

Switches shall comply with the requirements of IEC 60947, and they shall be designed according to the duty imposed by the particular application.

Switches shall be designed to prevent them from being operated inadvertently.

Means shall be provided for locking the control switches when they are in the "*neutral*" position.

Control switches of the discrepancy type shall require two independent movements to effect operation. The control switch shall be so designed that when released by the operator it shall return automatically to the "*neutral*" position after having been turned to the "*closed*" position and shall at the same time interrupt the supply current.

Means shall be provided for locking selector switches in the "*remote*" position. Where selector switches are required to have a "*neutral*" position, means for locking in this position shall be provided.

## 7.31 Indicating Lamps and Fittings

Indicating lamps shall be fitted onto the front of the cubicles & panels and shall be adequately ventilated. Lamps shall be easily removed and replaced from the front of the panel by manual means not requiring the use of extractors.

The base of metal or other approved material holding the lamp glass shall be of an approved finish and shall be easily removable from the body of the fitting so as to permit access to the lamp and lamp glass.

The lamps shall be clear and shall fit into an accepted standard form of lamp holder. The rated lamp DC voltage shall be 10% in excess of the auxiliary, supply voltage.

| Colour | Class of Indication | Example |
|---|---|---|
| Red | Circuit breaker or contactor closed | Reserved only for the function mentioned. |
| Green | Circuit breaker or contactor open | Reserved only for the function mentioned. |
| White | Lamp normally alight | Voltage healthy, trip supply healthy, equipment in normal service, etc. |

Annunciator Windows

| Colour | Class of Indication | Example |
|---|---|---|
| Crimson Red | Trip indication on which action is necessary | Circuit breaker tripped due to fault, etc. |
| Amber | Alarm indication on which action is necessary | Transformer over temperature alarm, charger failure, circuit breaker tripped due to fault, etc. |

| | | |
|---|---|---|
| Blue | Signal (with label) | Circuit breaker closing spring being charged, tap change in progress. |

The colour shall be in the glass and not an applied coating and the different coloured glasses shall be interchangeable. Transparent synthetic materials may be used instead of glass, provided it can be shown that such materials have bright colours and are completely suitable for operating in tropical climates.

## 7.32 Instruments

All indicating instruments shall comply with IEC 60051 and shall have adequate scale. Unless otherwise indicated all indicating instruments shall have 100 mm dials. Instruments dials shall in general be white with black markings and shall be reversible where double scale instruments are specified.

Induction type watt hour meters shall comply with IEC 62053-11 and 62052-11. They shall be suitable for working from a 3-phase, 3-wire supply and be of the 2 or 3-element unbalanced load type (where applicable). Test terminals shall be provided to permit calibration checks to be made when required.

All instruments shall be flush-mounted.

## 7.33 Auxiliary Switches

Where appropriate, each item of equipment shall be equipped with all necessary auxiliary switches, contacts and mechanisms for indication, metering, control, interlocking, supervisory and other services. All auxiliary switches shall be wired up to a terminal block on the fixed portion of the equipment, whether they are in use or not in the first instance.

All auxiliary switches and mechanisms shall be mounted in approved accessible positions clear of the operating mechanisms and shall be protected in an approved manner. The contacts of all auxiliary switches shall be strong and shall have a positive wiping action when closing.

Groups of auxiliary switches and associated terminal blocks shall be arranged to facilitate extension.

Banks of auxiliary switches and associated terminal boards shall be arranged to facilitate extension when required.

Apart from auxiliary switches used for the control and interlocking of circuit breakers, disconnectors and earth switches the following numbers of normally open (NO) and normally closed (NC) auxiliary switches are required:

- Circuit breakers: 12 NO and 12 NC

- Disconnectors: 10 NO and 10 NC

- Earth switches: 6 NO and 6 NC

The timing of the auxiliary contacts shall suit the particular application.

Auxiliary switch repeat relays may only be used where the requirements cannot be met by actual auxiliary switch contacts and with the specific approval of the Client.

## 7.34 Digital Multifunction Meters

The digital multifunction meters characteristics shall be as follows:

- Measurement of current and voltage, active, reactive and apparent power, active and reactive energy, power factor and frequency,
- Accurate measured values with error limits of less than 0.5% for U and I,

- Good legibility with high-contrast 14 mm LED displays,
- Electrically isolated current inputs,
- 4-quadrant operation,
- Connection options: single-phase or three-phase, 3 and 4-wire, suitable for balanced or unbalanced load,
- Nominal voltage input: phase-to-phase, up to 240 V, programmable (primary and secondary),
- Nominal current input: 1 A (primary shall be programmable),
- Current and voltage ratio programming shall be wide range from 1 ÷ 9999,
- The programming of the device shall be from the front panel keypad and via PC software separately,
- Dimensions: 96×96×..... mm,
- Auxiliary power supply: 110 V DC,
- Multiple displays (at least three lines).

The connection between the multi-function meter and the RTU in the substation shall be done through Modbus/TCP on Ethernet and Modbus ASCII and Modbus RTU modes with the following frame structure on RS-485 interface:

- ASCII framing (7-bit ASCII characters),
- RTU framing (8-bit characters).

The RS-485 serial communication must have a configurable range of communication speeds:

- 4800 Bits/seconds,
- 9600 Bits/seconds,
- 19200 Bits/seconds.

With any of the following transmission settings for the RS-485 interface:

- Even parity, 1 stop bit,
- Odd parity, 1 stop bit,
- None parity, 1 stop bit.

Note: (none parity, 2 stop bits) option can be supported in addition to any of the above mentioned and the multi-function meter should also support Modbus/TCP with the following speeds for Ethernet interfaces, where it uses default TCP port number (502):

- 10 MBit/s
- 100 Mbit/s

The message length on both serial and Ethernet should be ≤ 255 characters it shall be Contractor's responsibility to troubleshoot together with NEPCO team and try to resolve and rectify the problems if occurred during connection between the meters and RTU 560 from ABB.

The multi-function meter shall provide the following basic (but not limited to) function codes as per the Modbus standard:

< 03 > Read Holding Registers

< 04 > Read Input Registers

1 - Range (16 bit): 0 ... 65535 (unipolar)

-32768 ... 32767 (bipolar)

2 - Range (32 bit): 0 ... 2147483647 (unipolar)

-2147483648 ... 2147483647 (bipolar) (High word in first register or High word in second register)

All the values shall have the option to be scaled or not.

## 7.35 Transducers

The Transducers shall have the following characteristics:

- Type of connection: 3-phase, 4- wire,
- Programmable inputs primary and secondary for CT, VT and programmable analog outputs between full range (-20 mA DC to +20 mA DC) the programmable shall be done via software programming without changing hardware jumper,
- Multi outputs 4 analog outputs (MW,MVAr,V,A), each output to be programmed for any quantity (not fixed or dedicated output, i.e. each output shall be programmable via software to choose any quantity of the above mentioned quantities),
- Response time: ≤ 300 ms,
- Auxiliary supply: 125 V DC,
- Accuracy class: 0.5 for (MW, MVAr, V, A) or better,
- The continues overload rating of the transducers shall not be less than 1.3 times rated voltage and 2 times the rated current,
- Programming kit (software and communication cables) via RS 485 port,
- Additional USB programming port is preferable,
- The transducer shall support Modbus Protocol.

The connection between the transducer and the RTU in the substation shall be done through Modbus/TCP on Ethernet and Modbus ASCII and Modbus RTU modes with the following frame structure on RS-485 interface:

- ASCII framing (7-bit ASCII characters),
- RTU framing (8-bit characters).

The RS-485 serial communication must have a configurable range of communication speeds:

- 4800 Bits/seconds,
- 9600 Bits/seconds,
- 19200 Bits/seconds.

With any of the following transmission settings for the RS-485 interface:

- Even parity, 1 stop bit,
- Odd parity, 1 stop bit,
- None parity, 1 stop bit.

Note: (none parity, 2 stop bits) option can be supported in addition to any of the above mentioned and the transducer should also support Modbus/TCP with the following speeds for Ethernet interfaces, where it uses default TCP port number (502):

- 10 MBit/s

- 100 Mbit/s

The message length on both serial and Ethernet should be ≤ 255 characters it shall be Contractor's responsibility to troubleshoot together with NEPCO team and try to resolve and rectify the problems if occurred during connection between the meters and RTU 560 from ABB.

The transducer shall provide the following basic (but not limited to) function codes as per the Modbus standard:

< 03 > Read Holding Registers

< 04 > Read Input Registers

1 - Range (16 bit): 0 ... 65535 (unipolar)

-32768 ... 32767 (bipolar)

2 - Range (32 bit): 0 ... 2147483647 (unipolar)

-2147483648 ... 2147483647 (bipolar) (High word in first register or High word in second register)

All the values shall have the option to be scaled or not.

The following real time measurements shall be supplied by the meter:

- Total Power,
- Total Reactive Power,
- Line to line voltage,
- Current,
- Power factor.

## 7.36 Supervisory Control Facilities

Facilities shall be provided on all equipment to permit the repeat of appropriate indications, alarms and controls by telemetry to a remote-control centre. This shall suit a conventional SCADA system with hard wired connections taken to an interface-marshalling cubicle.

## 7.37 Power Supply Voltages

The available power supply voltages at the Substations shall be:

- 400 V, 50 Hz, 3-phase, 4-wire,
- 230 V, 50 Hz, single-phase,
- 110 V DC & 50 V DC.

Equipment provided under this Contract shall operate reliably within the voltage limits stated in the Particular Technical Specifications or in the appropriate IEC Standard. Where different limits are stated in the Particular Technical Specifications and the IEC Standard, the Particular Technical Specifications shall prevail. Where no limits are specified, the equipment shall be capable of operating reliably within the following operation ranges:

- AC equipment: From 80% to 110% of nominal voltage,
- DC equipment: From 80% to 120% of nominal voltage for general loads. For closing and opening releases required DC voltage range is specified in Particular Technical Specifications.

## 7.38 Energy Meters Specifications (Not applicable)

### 1.1 Applicable Standards & Approvals

Energy meters are to be compliant with all related IEC standards.

The specific requirements for compliance with international standards shall include:

- IEC 62053-22 – Alternating current static meters for active energy (Class 0.2S and 0.5S)
- IEC 62053-23 – Alternating current static meters for reactive energy (Class 2 and 3)
- IEC 62056-21 – Data exchange for meter reading – Direct local data exchange
- IEC 62052-11 – General requirements, tests and test conditions
- ISO 17025 – General requirements for the competence of testing and calibration laboratories
- IEC 62053-31 – Pulse output devices for electromechanical and electronic meters (two wires only)
- ISO 9001 – Quality management systems
- ISO 14001 – Environmental management systems
- IEC 60068-2-1 – Environmental testing
- IEC 60068-2-2 – Basic environmental testing procedures
- IEC 60068-2-5 – Basic environmental testing procedures
- IEC 60068-2-6 – Environmental testing
- IEC 60068-2-11 – Basic environmental testing procedures
- IEC 60068-2-27 – Basic environmental testing procedures
- IEC 60068-2-30 – Basic environmental testing procedures
- IEC 60068-2-75 – Environmental testing
- IEC 60085 – Thermal evaluation and classification of electrical insulation
- IEC 60359 – Electrical and electronic measurement equipment – Expression of performance
- IEC 62053-52:2005 Symbols for alternating-current electricity meters
- IEC 60417:2002 DB Graphical symbols for use on equipment
- IEC 60529 – Degrees of protection provided by enclosures (IP Code)
- IEC 60695-2-11 – Fire hazard testing
- IEC 60721-3-3 – Classification of environmental conditions – Part 3: Classification of groups of environmental parameters and their severities – Section 3: Stationary use at weather protected locations
- IEC 61000-4-2 – Electromagnetic compatibility (EMC) – Part 4: Testing and measurement techniques – Section 2: Electrostatic discharge immunity test Basic EMC publication
- IEC 61000-4-3 – Electromagnetic compatibility (EMC) – Part 4-3: Testing and measurement techniques – Radiated, radio-frequency, electromagnetic field immunity test
- IEC 60038 – IEC standard voltages
- IEC 61869-2 – Instrument transformers – Part 2: Current transformers.
- IEC 61869-3 – Instrument transformers – Part 3: Inductive voltage transformers

- IEC 60050-300 – International Electro technical Vocabulary – Electrical and electronic measurements and measuring instruments – Part 311: General terms relating to measurements – Part 312: General terms relating to electrical measurements – Part 313: Types of electrical measuring instruments – Part 314: Specific terms according to the type of instrument
- IEC 60060-1 – High-voltage test techniques – Part 1: General definitions and test requirements

Meter approvals and certifications shall be from internationally recognized and accredited laboratories only. A copy of each certificate relating to meter approval/compliance shall be included.

### 1.2 Accuracy

For the purposes of this tender, the required accuracy class for all active energy measurement is specified as Class 0.2S, and for reactive energy measurement is specified as Class 0.5S.

### 1.3 Environmental

Energy meters shall function normally in the following conditions:

- Ambient temperature of -5°C to 50°C
- Storage conditions of between 0 and 30°C
- Humidity of 75%

### 1.4 Electrical

#### Voltage

Nominal Voltage $U_n$:

- Measuring circuitry (from voltage transformer):3 x 100/120 Volts AC
- Auxiliary circuitry: 1 x 85-240 Volts AC and DC (Universal Auxiliary power supply)

Maximum voltage $U_{max}$: 130% $U_n$

#### Current

Nominal current $I_n$ 1Amp

Maximum current $I_{max}$: 120% $I_n$

Starting current: 0.05% $I_n$

#### Frequency

Nominal frequency: 50Hz ±2%

#### Others

If the meter auxiliary supply fails, the meter shall automatically switch to the VT input supply voltage and the recording of data shall not be interrupted.

Primary values for voltage and current shall be programmable using the configuration software.

Immunity from electrical interference shall be as prescribed in the IEC standards above.

Meters required shall be three-phase, four-wire (3ph 4w), and can be connected in delta.

A SuperCap or lithium battery shall provide backup power for RTC and the storage of register values and configuration data for up to one year without mains power applied.

The meters shall have provided with transformer losses compensation, Line losses compensation and energy measurement error factor applied by the user, these compensation shall be activated or de activated depending on the user choice.

### 1.5 Meters Mounting

Energy meters shall be mounted in surface mounted, any accessories to mount the meter on the surface of the panel shall be included.

Drawings stating the dimensions of meter shall be provided either separately or included in brochures or data sheets.

### 1.6 Functionality

#### 1.6.1 Alarms & Events

The following energy meter generated alarms and events are required:

- Internal battery low
- One or more phase failure (programmable threshold level – sampling frequency period to be stated)
- Overvoltage (programmable threshold level – sampling frequency to be stated)
- Meter re-programmed (incl. CT or VT ratio changed and RTC reset)
- Meter last accessed time and date (local and remote)
- Meter error (self test)
- Voltage imbalance (programmable threshold and time delay)

#### 1.6.2 Meter inputs

Energy meters shall have a minimum of two programmable relay inputs in order that externally generated alarms can be reported back to the Head-end, data collection system.

#### 1.6.3 Meter outputs

Energy meters shall have a minimum of three configurable/programmable relay outputs available.

#### 1.6.4 Registers

The following meter registers are required:

- Cumulative energy registers for:
  - Active energy – Import
  - Active energy – Export
  - Reactive energy – Import
  - Reactive energy – Export
- Programmable period (configurable from one minute to 60 minute) Demand registers for:
  - Active power – Import
  - Active power – Export

- Reactive power – Import
- Reactive power – Export

- Five Time of Use registers (Programmable by hour, day, month and season)
- Five Programmable Billing cycle registers (Wh and VArh) (Programmable by hour, day, month and season).

All registers should be programmable to display W, kW, MW, etc.

No multiplication factors shall be allowed.

### 1.6.5 Storage

The meter shall have two separated load profiles and each one of them have the setting for the required integration period (i.e. configurable from one minute to 60 minute) and each of them shall have the ability to store any measured value from the meter including the tariff registers.

Data registers (Load Profiles) shall have adequate capacity to store three months on site data to allow for any interruptions to the automatic data Collection System, including:

- Two load profiles feature.
- Demand log (as per above)
- Time of Use registers (Programmable by hour, day, month and season)
- Programmable Billing cycle registers (Wh and VArh),
- Voltage and current for each phase.
- Total power factor (the total power factor shall be registered in both directions export and import with sign indication).

Also, to facilitate the storage of data, meters shall be fitted with an internal power supply e.g. battery, which should have a typical life under normal operating conditions of ten years.

### 1.6.6 Real Time Clock (RTC)

Start and end periods for Daylight Saving Time shall be programmable in the meter once only i.e. should not require re-programming each year (the setting shall have date and time of switching depending on customer settings and not depending only on choosing the Time Zone).

Adjustment for Daylight Saving shall occur in the meter automatically or as programmed i.e. ability to change automatically every year according to the setting of summer and winter time in the meter. Current Jordanian summer time starts on last Thursday in March at midnight, ending on last Friday in October at 01:00am.

RTC shall not drift beyond second per month.

Energy meters should have local and remote time synchronization capability if the time drifts outside acceptable limits the synchronization will be done through the AMR server(s).

- ### 1.6.7 Meter Auxiliary Supplies

The auxiliary supplies shall normally be taken from the 110V DC battery within each Substation.

The meters auxiliary supply shall be secure and reliable via voltage selection relay between (DC Voltage & AC voltage) in case that the main supply fail (DC) changing automatically to

backup supply (AC) is required if the meters does not have internal voltage change over relays.

### 1.7 Communications

#### 1.7.1 Protocols

Energy meters should use different protocols to connect for both AMR/MDM system and SCADA system to achieve that two communication ports is required. The Meters purchased will be required to integrate to the Current AMR/MDM system type ZFA-F from ITF-Froschl, and it is a condition of this tender that the bidder ensures that this is possible and supplies the required meter driver if it is not in the current NEPCO AMR/MDM system.

The preferred Protocol to connect to the AMR system is DLMS.

To achieve the above mentioned connections the meter shall support the two communication protocols via the two required communication port simultaneously without interruption or affect the other port.

Meters may also be specified as IEC 61850 compatible for future Smart Grid integration.

#### 1.7.2 Remote

The TCP/IP over Ethernet communications can be either built-in type or as an internal module and the physical connectivity shall be via RJ45 socket.

Energy meters shall have an RS-485 output to connect the meters in Multi Drop connection to connect via MODBUS/RTU for SCADA, as well as an RJ45 output from the Ethernet communications module to connect the meters to the AMR/MDM system.

#### 1.7.3 Local

Local communications for meter reading and configuration purposes shall be possible via an optical port located on the front of the meter or by direct connection port.

For calibration purposes, the optical port shall also be capable of providing a suitable output pulse to calibration equipment for both active (W) and reactive (VAr) power.

All accessories to communicate with the meter shall also be supplied.

### 1.8 Configuration Software(s)

Meter configuration software shall be provided to enable local and full remote (via the data network without the necessity to operate any hardware for the meters locally) programming of, but not limited to, the following:

- Measurement transformer ratios
- Measurement transformer compensation
- Time and date
- Demand period duration
- Display sequence
- Time of Use registers
- Billing period

A minimum of four test points from the combined error of the current transformer and voltage transformer should be capable of being programmed in the meter.

The configuration software shall run on a Microsoft Windows environment and be compatible with a laptop computer (to be specified by the bidder – max. 15-inch screen).

The laptop quoted shall be capable of supporting multiple configuration software packages for meters of different models and manufacturers.

NECPO will carry out all energy meter programming related to CT and VT information.

### 1.9 Labelling

Meters shall be marked “The Property of National Electric Power Company” and shall be individually serial numbered according to NEPCO approved format Circuit names shall also be labeled on the front of the meters (NEPCO will provide these labels following contract award).

Primary and secondary values for voltage and current shall also be displayed on the meter nameplate as well as the circuit name (these will be supplied by NEPCO).

### 1.10 Security

Configuration of the meter shall be controlled through appropriate multiple level password protected access – to be defined by the bidder.

Meter cover and terminal cover shall have appropriate facilities for the application of a wire (or similar) security seal.

- Metering Panels Construction

Meter panel carcass shall be constructed from 1.5mm sheet steel and painted with primer then undercoat, and finished in paint code 7035.

Completed panels shall be package to a suitable level of protection for sea freight shipping to ensure no damage occurs in transit.

A minimum of four floor-fixing points shall be pre-drilled and available in the base of the cabinet.

Gland plates suitable for a range of cable sizes shall be included at the base of the cabinet.

Cabinets shall be (80-85 W x 60 D x 200-225 H) cm, and rack type with transparent (shatter proof plastic) single front door hinged on the right hand side. Rear opening shall be by two equally sized sheet steel doors with locking facility incorporated into the handle

Appropriate lifting eyes shall be fitted on the top of the panel and should withstand the additional weight of eight energy meters.

Cabinets shall be fitted with a thermostatically controlled fan for cooling purposes.

Cabinets shall be fitted with an internal light source that is switched on/off when opening and closing the rear doors.

Cabinets shall be fitted with a standard 13 Amp power socket.

Bidders to submit General Arrangements and Wiring Diagrams of cabinet design proposed to be approved by NEPCO.

Meter panels shall be tested to a protection level of IP52.

An earthing bar shall also be included.

The panels should be fully wired and fully equipped with the components as shown in table No.1 and the related accessories .

Wiring

Panels shall be wired for the number of circuits/meters as described in the bill of quantities section.

All panel wiring to be suitable for power and data signals as appropriate.

All panel wiring shall be:

- Multi-stranded
- Colour coded according to phase colour (R,Y,B).
- Minimum cross sectional area of 2.5mm2 for CT, VT and aux supplies circuits Wires shall not be terminated without crimps.

Wires ferrules should be supplied and approved by NEPCO for all panels.

Factory test certificates for all wiring checks e.g. point-to-point and continuity tests, shall be included.

Power and data cables shall be suitably separated inside the cabinet.

Accessories

All Meter Panels shall come fully equipped with the following:

- One 13Amp power socket (UK type 3 square pins)
- One cooling fan with variable setting temperature controlled switch
- Internal lamp suitable for providing adequate light for working conditions, with door activated switch
- DIN Rail and terminal blocks with appropriate isolation features and test point and earthing facilities
- 10% spare terminals to be included
- MCBs for incoming VT and power isolation with alarm contacts
- Document/drawing storage pockets on the inside of the rear doors
- All wiring to be enclosed in trunking with power and data cables separated
- Engraved circuit labelling above each pair of meters (details to be provided by NEPCO)
- Open/close links for VT circuits and open/close shorting links for CT circuits (as Error! Reference source not found.)

**Voltage Selection Scheme General**

In order to prevent the loss of energy measurement due to the failure of a voltage transformer secondary supplying any one or more measuring circuits of an energy meter, a voltage selection scheme shall be employed.

Voltage selection schemes shall be configured to switch from the designated voltage transformer secondary circuit to an alternative voltage transformer secondary (typically of a similar, adjacent circuit) should a single, or multiple phase failure occur.

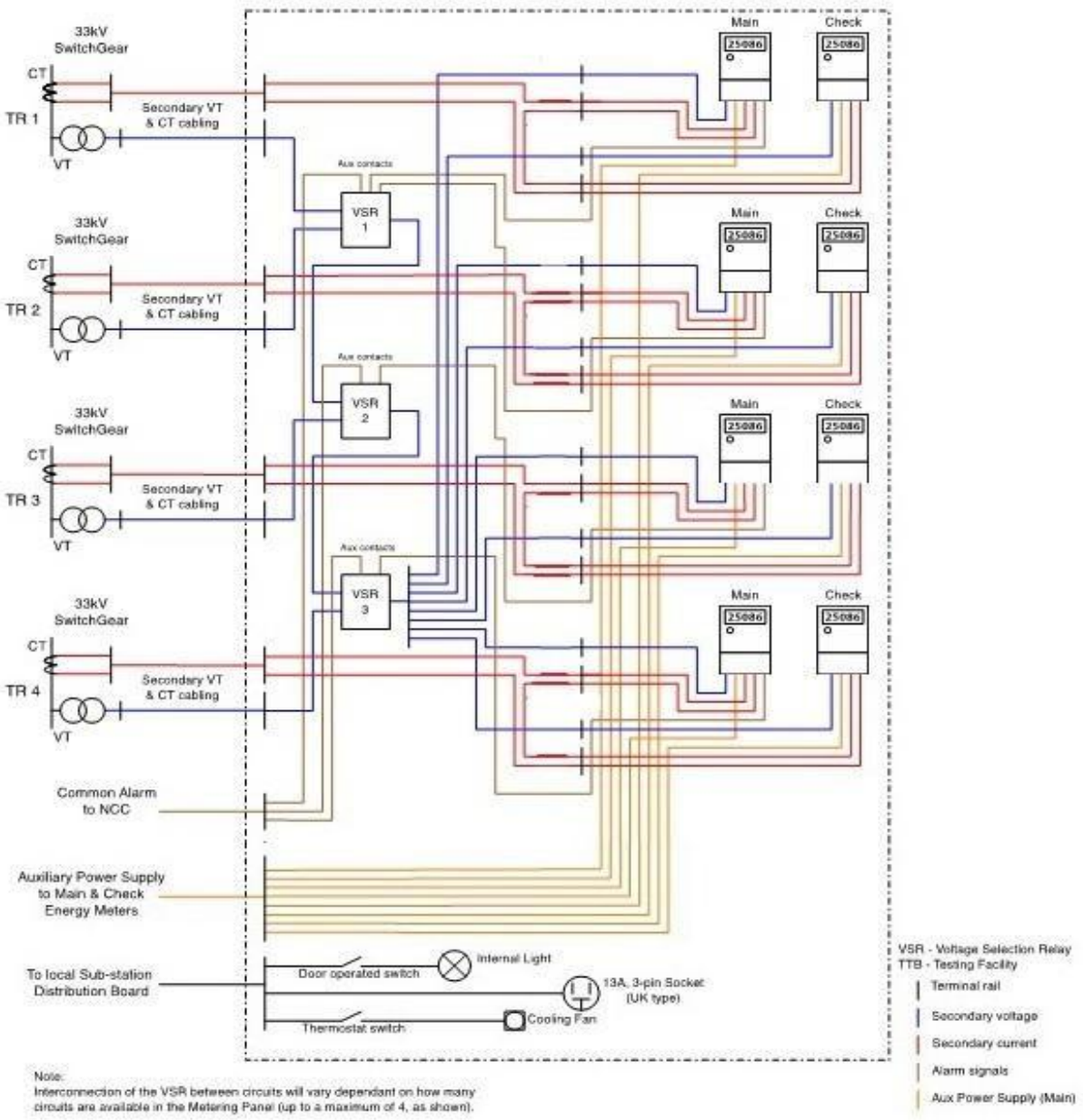
Upon operation of the voltage selection scheme, an auxiliary contact shall be available which can be used as an alarm output and may be used to indicate that a failure has occurred.

Voltage Selection Schemes shall be included within the meter panel and follow the schematic diagram in below.

The Voltage Selection Schemes proposed, in addition to the above, shall suit the specific requirements of each substation and be subject to NEPCO approval.

Discreet auxiliary relays are not deemed an acceptable solution for providing voltage selection, and as such shall not be proposed by the bidder.

Schematic Arrangement



Meter panels shall meet the requirements as shown in Figure 1 below. A maximum of four circuits can be arranged per panel.

Figure 1 - Meter Panel Schematic (4 Circuits)

Detailed descriptions and diagrams for testing facilities are contained later in this document.

Technical Specification Applicable Standards

The specific requirements for compliance with international standards shall include:

- Insulation class:

- IEC 601010-1: 1990/A2: 2001 Class I o EN 61010-1: 2001 Class I

- Insulation Category (Overvoltage): o IEC 601010-1: 1990/A2: 1995 Category III o EN 61010-1: 2001 Category III • Environment:

- IEC 601010-1: 1990/A2: 1995 Pollution degree 2 o EN 61010-1: 2001 Pollution degree 2 • Product Safety: o 72/23/EEC o EN 61010-1: 2001 o EN 60950-1: 2002

Environmental

The Voltage Selection Relay shall function normally in the following conditions:

- Ambient temperature of -5°C to 50°C
- Storage conditions of between 0 and 30°C
- Humidity of 75%

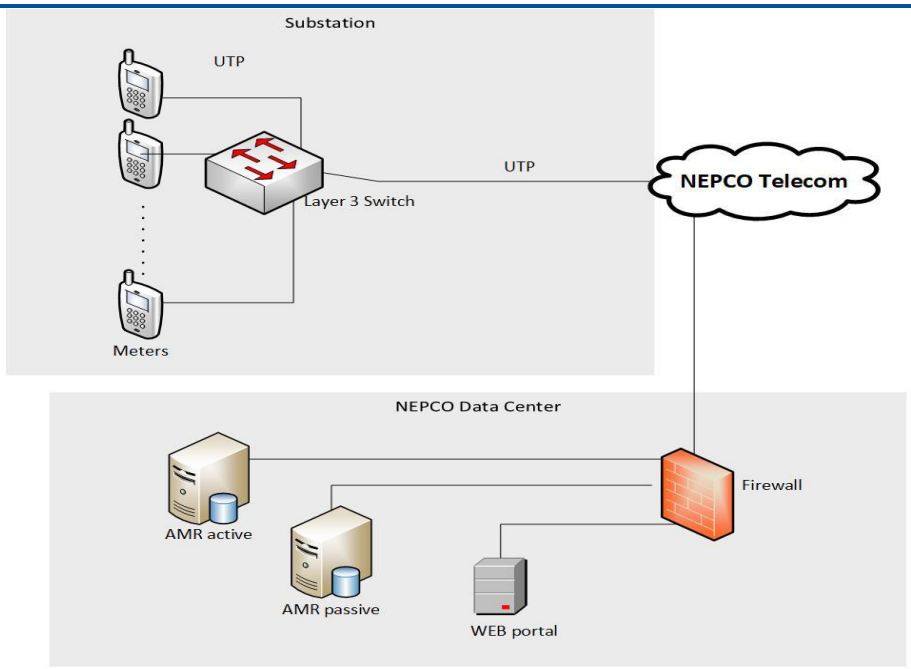
Electrical

- From voltage transformer secondary: 110 Volts ac
- System frequency: 50 Hz

**Metering System Network**

The network is consisted of the following items:

- The Meter itself: each meter should have two communication ports; one of them shall be Fast Ethernet (10/100Mbps) port to be connected to NEPCO AMR network, while the other is to be connected to the billing system of the Facility. The two ports needed for data security and avoid data network interconnection and fully physical separation between the mentioned networks.
- One dedicated high performance Industrial layer 3 switch, the switch will be used to connect meters toward NEPCO AMR network.
- Cisco platforms are preferred to facilitate monitoring and health check tasks.




- In case of the industrial L3 switch is placed in a facility other than NEPCO substation, fibre cabling and termination should be done between NEPCO substation and the facility. At NEPCO side end, the termination should lead to a single RJ45 connector at telecom cabinet.
- The L3 switch should be of a form factor that is either resides in a standard 19" dedicated wall mounted network cabinet or Rail mounted in physically secured cabinet.
- Fiber termination equipment (ODFs, fiber to UTP converters, power converters, etc.) should be industrial grade equipment designed for harsh environment and should also enclosed securely within physically secured cabinet at both side of termination.
- Any fiber transceivers modules (SFPs) or fiber patch cords required to complete the physical connection up to telecom cabinet at NEPCO substation should be also provided.

## 7.39 STAND BY DIESEL GENERATOR SETS

An automatic low voltage, diesel engine driven generating set shall comply with the following provisions of this Specification .
The stand-by diesel generating set shall be rated to continuously feed the substation's loads during the lack of the power supply to the Low Voltage A.C Distribution Board .
In any case the rated capacity of the diesel generator unit shall not be less than mentioned in SCHEDULE A on continuous rating (prime diesel generator).

All electrical and mechanical connections necessary for the installation and operation of the diesel generator shall be provided under this contract, this included but not limited to the connections between the standby diesel generator set, earth, bulk fuel tank, daily fuel tank, LVAC panels and auxiliary circuits ,

### Standards

The equipment shall comply with this Specification and the following Standards:
ISO 8528 Reciprocating Internal Combustion Engine Driven AC Generating Sets
IEC 60034 Rotating Electrical Machines

**General Requirements**

The generator set shall be mounted in a concrete room with enough spaces not less than 6m*6m*5m, the room shall contain the complete installation of the required equipment including daily fuel tank, cooling system, control equipment, control panel, starting battery, charger and generator circuit breaker. However, the diesel generator shall be placed in a ventilated purpose-built containerised housing.

An external bulk fuel storage tank shall be provided under this contract with a concrete tank's bund which shall hold a 120% of the tank capacity.

An automatic fuel refilling system from the bulk tank to the daily tank shall also be supplied.

The engine, generator and cooling radiator shall be mounted on a combined basement of stress relieved fabricated steel.

The fresh and exhaust openings in the diesel generator's room walls shall be controlled by motorized louvers to ensure a fully sealed room when the diesel generator is not running, moreover the diesel generator room shall be fully sealed to avoid any indoor dust inside the room.

The stand-by diesel generating set is to be provided with all equipment necessary to enable it to start automatically on failure of the normal mains supply and to shut down on restoration of supplies. The set shall also be started and shut down automatically on a routine basis for test purposes.

The set is to be capable of a continuous output as specified in the schedules, when operating at site under the specified climatic conditions and is to be capable of operating at an overload of 10% in excess of the continuously rated output, at the rated speed for 1 hour in any period of 12 hours consecutive running.

**Engine**

The diesel engine shall be of the four stroke naturally aspirated or exhaust gas turbo-charged type, designed for industrial operation and with a rated speed not exceeding 1500 revolutions per minute. The engine model must have been in continuous production for at least 2 years without substantial modification.

The engine is to be suitable for operation on light distillate fuel oil, having a net calorific value of not less than 41MJ/KG.

The engine shall be capable of immediate starting and accepting full load following extended inoperative periods. All facilities such as preheating and cycle priming necessary to achieve this requirement shall be provided.

The generating set manufacturer shall be responsible for ensuring that the torsional vibration amplitude and stresses of the diesel engine and generator shaft systems shall be within acceptable limits both at the rated speed and transiently when starting and stopping.

**Governing and Engine Protection**

The diesel engine shall be fitted with a speed governor capable of an accuracy of Class A2 of ISO 3046/IV except that the speed droop shall be adjustable within the range 0% to 6%. The governor shall be fitted with a speeder motor to enable the speed setting to be adjusted over a range of at least ± 4% of the rated speed from the control panel. It shall also be possible to make similar speed adjustments manually at the engine.

The governor shall be fitted with an electrically operated solenoid to enable the engine to be shut down when the solenoid is energized.

The governor shall be fitted with a mechanically operated shut down device which will automatically operate and shut off the fuel supply to the engine on occurrence of engine over speed or low lubricating oil pressure. The devices shall be fitted with a set of normally open contacts and wired to trip the generator circuit breaker when the automatic shutdown device operates. The over speed trip shall be set to operate when the rated speed is exceeded by 15%.

The following protection devices shall be provided with the engine and the Contractor shall provide and install all the necessary alarm initiating devices:

- High Lubricating Oil Temperature
- Low Lubricating Oil Pressure
- High Engine Jacket Cooling Water/Air Temperature
- Engine Overspeed
- Battery charger failure.

- o Low battery voltage.
- o High Battery Voltage.
- o Generator Power
- o Line Power .
- o System Ready.
- o Comms ok.
- o Low water level .
- o Over crank.
- o Gen. run.
- o Low fuel.

Item (a) may be omitted if lubricating oil cooling is carried out by the jacket water. In the case of air-cooling engines, the Contractor shall propose an alternative to item (c).
The alarm initiating devices shall be of high quality and of robust construction to withstand operation in high temperature and vibration conditions entailed with the diesel engine.
With the exception of the over speed trip, the protection shall be of 2 stage, the first stage initiating visual indication and the second stage engine shut-down. Initiation of the second stage shall be arranged to trip the alternator circuit-breaker automatically.
Visual indication of the cause of an alarm signal or shut-down shall be given on the alternator control panel. These alarms shall be individually communicated to the National Control Centre (NCC). An inhibit system to cater for normal shut-down and initial start-up shall be provided.

### Fabricated Steel basement

The diesel engine and direct coupled generator shall be combined, mounted on a robust stress relieved fabricated steel basement. The diesel engine and generator shall be accurately aligned on the basement before workshop tests and dispatch to site. The generator shall be dowelled in position after alignment with the engine.

### Anti-Vibration Mountings

Anti-vibration mountings shall be provided on the fabricated steel basement and shall be designed to minimize the transmission of vibrations to the foundation slab but without resulting in excessive amplitudes of movements of any part of the generating set.

Mountings containing rubber shall be fully protected against contamination by oil leakage from the engine.

### Flexible Connections

Flexible connections shall be provided to exhaust and fuel piping that leaves the engine enclosure to prevent the transmission of vibration and the fracture of the piping due to movement of the set. The choice of connections and their installation is to be such as to give long life under normal operating conditions of the set.

### Engine Lubrication

Lubrication to the engine shall be by means of an engine driven integral pump. The pump shall have on the suction side a coarse strainer and on the delivery side a duplex 'full flow' fine filter complete with changeover cock incorporating pressure by-passes to facilitate oil flow to the engine should the filter become blocked.

The Contractor shall ensure that the lubricating oil system capacity shall be sufficient to enable the engine to run continuously for 12 hours at any load without replenishment.

If priming of the lubrication system is an essential part of the starting sequence of the set, a suitable priming pump shall be provided and its control shall be linked into the automatic and "push-button" starting systems to ensure that the set cannot be started without first being correctly primed.

### Engine Cooling

The engine cooling arrangements are to be such as to provide efficient cooling under all climatic conditions specified.

The engine shall be water cooled. A sectional radiator shall be provided and mounted on the combined basement and arranged to cool the engine jacket water, lubricating oil, and change air as appropriate. Thermostatic control of the jacket water shall be provided and also, preferably of the lubricating oil. Circulation of cooling water through

the engine and radiator shall be by means of an engine-driven pump. Hose connections shall be provided on all water circuits to enable the systems to be drained down for maintenance.

The cooling fans shall be arranged to be driven directly by the engine and the hot air is to be ducted to suitable openings in the generator enclosure. The duct is to incorporate a suitable flexible section to prevent the transmission of vibration from the engine.

### Starting System

Electric starting equipment shall be provided and so designed that the engine will start automatically upon a signal initiating from the main LVAC panel on failure of the normal electricity supply to the substation services board. Provision shall also be made for local manual starting to the set.

The starter motor shall be of a design in which the starter pinion is brought into engagement with the teeth on the engine flywheel before current is applied to accelerate the motor. Failure of the pinion to engage shall inhibit the application of this current.

The equipment shall include an adequately rated lead/acid starter battery together with a charger of the metal rectifier type. The battery charger will be supplied from the mains and an engine driven dynamo is not required. The battery shall be located in a suitable stand or supports in a position where access to the engine is not impaired and be protected against accidental mechanical or electrical damage.

The battery charger shall have a continuous output rating sufficient to recharge the battery from 1.8 V/cell to a fully charged condition in a period of 8 hours. The characteristics shall be such as to ensure an automatic voltage charge at 2.3V/cell provided the input voltage and frequency shall remain within ± 6% and ±2% respectively of normal value. The charger shall include a battery charge fail alarm. This alarm shall be communicated to the Control System.

Without power supply to the charger, the battery shall be capable of providing not less than 4 starting cycles within a period of 5 minutes. Upon restoring power supply to the charger immediately thereafter, the charger shall be capable of restoring the battery, within 30 minutes, to a condition in which one more starting cycle can be completed.

Not more than 3 consecutive attempts to start may be made in any period of 1 minute, each starting period and the period between such consecutive attempts being automatically time controlled by the equipment. At the failure of the third attempt the starter circuit shall be locked out pending manual re-setting. It shall be impossible to complete the starting circuit at engine speeds in excess of the minimum firing speed.

A suitable battery isolating switch, capable of being locked in both the open and closed positions, shall be provided on the engine to prevent starting while the engine is under maintenance.

### Air Intake and Exhaust System

The engine combustion air intake shall be directly from the generator enclosure. Cleanable air filters, selected for their suitability for the site environment are to be fitted to the intakes.

The provision of air to the enclosure will be by means of openings left in the wall(s) and covered with louvers and insect screens. If this provision is considered inadequate by the Contractor, alternative arrangements may be proposed.

The engine shall be efficiently silenced with exhaust silencers complete with interconnecting pipe and fittings. The design of the silencers shall be such that exhaust noise will not exceed 60dBA at a distance of 50 meters from the enclosure. Supports for each complete system shall be of the anti-vibration type. Allowance for expansion of the exhaust system shall be made by the inclusion of expansion bellows. The complete system including brackets shall be supplied galvanized and shall be insulated within the enclosure. The standard of insulation shall be such as to limit the cold surface temperature to a maximum of 60°C and the lagging shall be protected by aluminum sheet cladding.

### Bulk Fuel Storage

A bulk fuel tank of sufficient capacity to provide the engine requirements for 5 days' operation at rated output shall be provided and installed in the position shown on the layout drawings accompanying this Specification. The

tank shall be of horizontal cylindrical type, fabricated from steel plate and supplied complete with mounting saddles, inspection manhole, access ladder, fill pipe and cap, level indicator, delivery, overflow, vent and drain pipes. Suitable foundations will be provided under this contract.
The bulk fuel tank thickness shall not be less than 6mm. The bulk fuel oil tank shall be protected against corrosion by a cathodic protection system.
An appropriate sunshade shall be furnished to protect the bulk fuel tank from the sun light.
In order to provides a barrier to retain fuel spillage an adequate tank's bund shall be constructed from concrete with a holding capacity of 120% of the tank size, a proper ladder or steps shall be furnished to allow inspection of the bund and to allow access to the bulk tank itself.
Piping and pumping facilities should be arranged so that no leaks can escape the confines of the bund. All pipework should go over the bund walls, not through them .
All external fuel oil pipes shall be insulated with sufficient thickness of insulation not less than 25 mm and covered with aluminium cladding.

### Daily Service Tank

A daily service tank having a capacity sufficient for 9 hours' engine operation at rated load shall be provided. The tank shall be totally enclosed and of welded steel construction with suitable supports and shall be installed in a position where any fuel leakage cannot impinge on exhaust pipes or other hot engine surfaces.
The tank shall be provided with all necessary fittings including fill, vent, drain and overflow lines, level indication and access for inspection and maintenance. Level switches shall be provided for the following services- :

(a) Low level alarm
(b) High level alarm
(c) Low level start of transfer pump
(d) High level start of transfer pump

These alarms shall be individually communicated to the National Control Centre (NCC).
Safety distance between fuel tank and diesel generator must be taken into consideration.

### Fuel Transfer Pump

An electric motor-driven fuel transfer pump shall be provided to enable the service tank to be filled from the bulk storage tank. The capacity of the pump shall be such that the service tank can be completely filled in not more than 30 minutes. The pump motor starter control panel shall contain a selector so that the pump may be either started or stopped by hand or automatically on receipt of signals from the level switches in the service tank.

For emergency use, a semi-rotary hand pump shall be supplied and connected in parallel with the motor driven pump. It shall be of sufficient capacity to enable the service tank to be filled in not more than 1 hour. A suitable strainer shall be supplied and fitted at the transfer pump suctions.

### Fuel Boost Pump

If required by the engine manufacturer, a fuel boost pump shall be provided between the service tank and the engine. The pump shall be directly driven by the engine.

### Fuel Filter

A final fuel filter shall be provided at the inlet to the engine fuel rail. This filter shall preferably be of the duplex type enabling an element to be changed without stopping the engine.

### Fuel Piping

The Contractor shall provide and install all required piping to carry the fuel from the bulk storage to the service tank and the engine. The pipe layout shall be such that it does not pass close to hot surfaces, and in no circumstances shall it be permitted to pass over exhaust pipes.

All necessary valves and fittings shall be provided including sufficient isolating valves to enable items in the system to be serviced without draining down the whole system.

The pipeline shall be thermally insulated over its entire length with a thermal insulation material covered by a rigid aluminum cladding.

### Generator

The generator shall comply with IEC 60034 and shall be of the brushless type. It shall be directly coupled to, and share a common high bedplate with, the prime mover. The degree of protection for the generator and exciter shall

be not less than IP 42. The generator shall be complete with all necessary cooling fans, excitation and voltage regulating equipment, generator circuit breaker and electrical protection equipment. The generator rating shall be as specified in the Schedules.

The generator shall be star connected with earthed star point.

The generator shall be capable of maintaining its continuous maximum rated output when operating within ± 5% of rated voltage and at rated power factor of 0.8.

The critical speed shall exceed twice the overspeed test value.

All windings shall be suitably impregnated to withstand the site ambient conditions.

Unless the generator has only a single sleeve type bearing, a flexible coupling selected for appropriate torsional vibration and misalignment characteristics shall be provided between the engine flywheel and the alternator shaft.

### Generator stator

The stator core shall consist of high permeability, low loss steel stampings, tightly clamped and securely located within the machine casing.

The windings shall consist of electrolytic copper conductors insulated throughout with Class F materials but with operating temperatures of class B as defined in IEC 60085.

The windings shall be effectively braced to withstand the maximum forces arising from any short circuit that may occur at the stator winding terminals. Any material that is liable to shrink in service shall not be used for bracing, packing or wedging. The ventilating circuit shall be designed to avoid hot-spots and to permit adequate cleaning by a portable centrifugal blower.

Tubular low-temperature heaters of sufficient rating to maintain the windings in dry condition during long periods of standstill shall be fitted in the stator casing and wired out to a terminal box on the bedplate. They shall be suitable for operation from a 230 volt single phase ac supply.

The leads from the heaters shall be brought to an isolator which shall be mounted on the common bedplate or the stator frame.

Both ends of each stator winding shall be brought out to terminal positions on the stator casing, the phase and terminal box being arranged for 3-phase and neutral connection.

All current transformers, including the associated primary connections and secondary circuit terminal blocks, required for the metering, instrumentation and protection specified, or for excitation circuit compounding or compensation, together with the generator neutral earthing connection shall be supplied and accommodated within a substantial dust-proof sheet steel enclosure.

The generator star point shall be solidly earthed to the main earth system, and provision shall be made for the mounting and connection of a neutral current transformer for protection of the generator windings.

The phase connections shall terminate in a circuit breaker cubicle which shall be free from vibration from the generator. The connection from the generator to the circuit breaker cubicle shall allow for the mounting and connection of the necessary current transformers.

### Generator rotor

The rotor shaft and hub shall be forged steel preferably in one piece. The rotor poles shall be constructed of steel laminations, keyed and securely fixed to the rotor hub and fitted with interconnected damper windings.

The field winding shall consist of electrolytic copper conductors insulated throughout with Class F materials. They shall be fully insulated at all positions of support and shall be securely located against movement due to thermal and rotational cycling and the forces arising during over-speed testing, transient over-speeds in service and normal operation.

Where a separate exciter is provided, the exciter rotor shall be mounted on the extended main shaft at the free end of the generator.

The minimum factor of safety of the rotating system shall be not less than 1.5, based upon the yield point of the part most highly stressed at the stated over-speed or during a stator 3-phase terminal short-circuit at normal voltage whichever is the greater.

### Generator exciter

The core and poles of the exciter shall be made of high permeability low loss steel stampings tightly clamped and secured to minimize magnetic noise. The characteristics of the exciter shall comply fully with the operational requirements of the alternator in matching the required loading conditions.

### Ventilation

The generator and exciter shall incorporate shaft mounted fans of sufficient capacity to provide the machine cooling effect necessary to comply with the temperature requirements of the Specification when operating in the site ambient conditions. Fans with spot welded blades shall not be used.

The hot air from the machines shall be discharged from the top with suitable covers to prevent debris falling into the machine and to avoid recirculation. All openings for inlet and outlet air shall be suitably screen protected.

### Voltage Regulation

Continuously active, quick acting electronic automatic excitation control equipment, responsive to the generator line to line voltage and loading conditions shall be provided to maintain the alternator voltage within the prescribed limits.

The equipment shall include all selector switches, indicating instruments, rectifiers, resistors and any other auxiliary components necessary for the satisfactory operation of the plant.

A voltage setting device capable of adjusting the required voltage in steps of 1% between the limits of 95% and 105% of normal voltage at any load within the rating of the machine shall be mounted on the control panel.

When the generator maximum continuous load at rated power factor is rejected, the regulator equipment shall be capable of limiting the generator momentary over-voltage to a value not exceeding 120% rated voltage and shall restore the voltage to within 2% of the nominal pre-set value within 3 seconds.

Over-voltage protection shall be provided, the voltage setting range being 105% to 125% in steps of 5%, the time setting range being adjustable within the range 1 second to 5 seconds in steps of 1 second.

### Control Cubicle

Sheet steel cubicle of robust construction shall be provided and shall contain the following:

a) All the control, alarm, indicating, metering and protection equipment.
b) All multifunction digital transducer (power) meters and connections necessary for the functioning of the instrumentation.
c) An alarm panel with lamps having facilities for alarm accept, reset and lamp test facilities. Initiation of any of the alarms shall be arranged to transmit a signal to the control system.
d) Battery charger for starter battery.
e) The stand-by diesel generator signals (such as on/off, common alarm, low fuel level, etc.) shall be communicated to the National Control Centre.

Readily removable panels in the side or a hinged front panel shall provide access to the interior of the control cubicle. All equipment shall be installed and wired complete in the factory.

Instruments shall be rectangular type with flush or semi-flush mounting with white scales and black markings.

### Generator Circuit Breaker

The generator circuit breaker normally will be molded case type (MCCB), incorporating a combined thermal and instantaneous magnetic release or electronic device that shall be adjustable to suit the characteristics of the generator. When an MCCB is used, it shall be fitted with a shunt release operated from a CT connected earth fault device.

### Tools

A complete set of tools and devices required to carry out all maintenance and normal overhaul on the diesel engine and associated auxiliaries shall be provided.

### Spare Parts

A complete set of spare parts shall be supplied for the diesel engine, alternator, voltage regulator, and associated auxiliaries sufficient in quantity to enable the generating set to operate for a period of 1000 hours.

## 8. Inspection and Tests

The Contractor shall carry out the tests stated in this Technical Specification and, without extra charge, such additional tests as in the opinion of the Client are necessary to determine that the Contract Works comply with this Technical Specification under all possible working conditions.

All testing laboratories shall be accredited according to ISO/IEC 17025 by ILAC (The International Laboratory Accreditation Cooperation).

The Certificates of performed type tests shall be submitted along with the Tender. For 132kv and 33 kV equipment's submitted Type Test Certificates shall be as required in ITT.

All materials used, shall be subjected to and shall withstand satisfactorily such routine tests as are customary in the manufacture of the types of equipment included in the Contract.

All tests shall be carried out to the satisfaction of the Client and in his presence, at such reasonable times as he may require, unless agreed otherwise.

Not less than 28 calendar days, notice of all tests shall be given to the Client in order that he may be represented if he so desires. Failure of the Contractor to give such notice which results in a delay in the completion of the tests cannot be used by the Contractor as a reason for failure to meet the overall completion date and any extra costs incurred by the Contractor shall not be recoverable. As many tests as possible shall be arranged together. Three (3) copies of the Contractor's Test Reports shall be submitted to the Client.

Measuring apparatus shall be approved by the Client and if required shall be calibrated at the expense of the contractor at an approved laboratory.

All the adjustable devices shall be calibrated and adjusted for the anticipated operating conditions and shall be interlocked in order to prevent readjustment on the Site.

The Contractor shall be responsible for the proper testing of the work completed or equipment or materials supplied by a sub-contractor to the same extent as if the work, equipment or materials were completed or supplied by the Contractor himself.

All apparatus, instruments and connections required for the above tests shall be provided by the Contractor.

The Client shall be responsible to provide on-site electrical energy for the purpose of Site tests.

The Contractor shall supply suitable test pieces of all materials as required by the Client at the Site.

The cost of all inspection and tests and/or analyses shall be borne by the Contractor. Furthermore, all expenses including economy class air fares, hotel accommodation, local transportation, visa fees, medical insurance, etc. of the Client's personnel during Factory Acceptance Tests (FATs) shall be borne by the Contractor. Any costs incurred regarding the re-inspection and re-testing as a result of a failure of the equipment under test, shall be borne by the Contractor.

No inspection or lack of inspection, or passing by the Client of work, equipment or materials, whether carried out or supplied by the Contractor or sub-contractor, shall relieve the Contractor from his liability to complete the Contract Works in accordance with the Contract or exonerate him from any of his guarantees.

After successfully completed tests, all the sensitive equipment within the cubicle, panel or any other device, shall be disassembled and transported specially packed and protected. Also, each detachable part shall be adequately marked to insure proper reassembly on the Site.

## 8.1. Factory Acceptance Tests (FAT)

Prior to delivery, all 400KV, 132kV and 33 KV equipment and ancillary equipment shall be factory tested.

Cubicles and panels shall be completely assembled in the factory and wired.

Factory Acceptance Tests (FAT) for the following equipment shall be performed at the Manufacturer's factory, in presence of the Client, according to the latest edition of the relevant IEC, BS, and IEEE Standards, unless specified otherwise:

| Description | Period of FAT (days) | Price |
|---|---|---|
| 400 KV GIS switchgear and LCC panels for three (3) persons | To be filled by bidder | To be filled in schedule G |
| 400 kV control & protection systems for two (2) persons | To be filled by bidder | To be filled in schedule G |
| 132 KV GIS switchgear and LCC panels for three (3) persons | To be filled by bidder | To be filled in schedule G |
| 132 kV control & protection systems for two (2) persons | To be filled by bidder | To be filled in schedule G |
| 400KV, 132kV CTs and VTs for two (2) persons | To be filled by bidder | To be filled in schedule G |
| 33 KV control & protection systems for two (2) persons | To be filled by bidder | To be filled in schedule G |
| 33KV switchgear for two (2) persons | To be filled by bidder | To be filled in schedule G |
| 400/132/33KV Autotransformers for three (3) persons | To be filled by bidder | To be filled in schedule G |
| Power and earthing/auxiliary transformers for three (3) persons. | To be filled by bidder | To be filled in schedule G |
| 33KV reactors for two (2) persons | To be filled by bidder | To be filled in schedule G |
| 33KV Power Cables for two (2) persons | To be filled by bidder | To be filled in schedule G |
| 110VDC chargers for two (2) persons | To be filled by bidder | To be filled in schedule G |
| Capacitor Banks for two (2) persons | To be filled by bidder | To be filled in schedule G |

**Notes:**

- **The offered FAT period shall be specified in days, excluding travel days, and must be sufficient to conduct all required tests as per IEC and Particular technical specifications. The contractor shall adhere to the offered FAT schedule and any change in the offered schedule will not be accepted after awarding.**
- **NEPCO has the right to accept or reject merging the periods of separate FAT.**

Factory Acceptance Tests (FAT) for the remaining equipment shall be also performed and all results shall be submitted to the Client for approval.

The scope of tests shall be in accordance with the Detailed Test Program approved by the Client, but any of the tests performed during manufacturing can be repeated. Reports from tests performed during production shall be available to the Client during the FAT.

For the purpose of FAT tests, the Contractor shall provide all necessary works and conditions needed to conduct all tests, sufficient number of copies of detail Design documentation, Test reports from previously conducted tests, testing protocols and procedures, as well as other required by these Technical Specifications.

The Contractor is obliged, after the conducted tests, to prepare Test Report from FAT tests. Test results shall be submitted to the Client for approval for all equipment specified above. The Test Report shall be signed by all parties involved.

All expenses including economy class air fares, hotel accommodation with meals, local transportation, visa fees, medical insurance, etc. of the Client's personnel during FAT shall be borne by the Contractor. Any costs incurred regarding the re-inspection and retesting as a result of a failure of the equipment under test, shall be borne by the Contractor.

The Contractor shall also give priority to the Royal Jordanian Airlines for airfreights shipment and transport of personnel.

It is anticipated that the Client will have continuous presence during execution of the Factory Acceptance Tests.

**In line with Schedule G and its notes, the Contractor shall include the expenses for the representatives attending the test in the Price Schedule (G).**

Test plans must be submitted before three weeks from starting the FAT