REPUBLIC OF THE PHILIPPINES

NATIONAL POWER CORPORATION

(Pambansang Korporasyon sa Elektrisidad)

BID DOCUMENTS

Name of Project : **SUPPLY, DELIVERY, CONSTRUCTION, INSTALLATION, TESTING AND COMMISSIONING OF 10MVA MASBATE (MALINTA) SUBSTATION**

Project Location : **Malinta, Masbate**

Specs No. : **LuzP23Z1636Sce**

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EW-1.0 GENERAL TECHNICAL REQUIREMENTS

EW-1.1 SCOPE

EW-1.1.1 General

This Section specifies the minimum set of requirements applicable to the materials and equipment included in the scope of works under this Project. Supplementary requirements of a special nature are contained in subsequent sections.

EW-1.1.2 Scope of Works

The scope of work shall cover but not limited to the following:

1. Design, manufacture, supply, delivery, installation, test and commissioning of the following substation equipment:

    a. Power Circuit Breakers;
    b. Disconnect Switches (w/ ES and w/o ES);
    c. Main Control Switchboards;
    d. Metalclad Switchgears;
    e. Lightning Arresters;
    f. Current Transformers;
    g. Voltage Transformers;
    h. Power, Control and Instrumentation Cables;
    i. Switching station Steel Structures;
    j. Installation Materials including High voltage buswork, insulator assemblies, conductors, hardwares, connectors, overhead ground wires, etc.;
    k. Grounding System;
    l. AC & DC Station Auxiliary Switchboard;
    m. Storage Batteries;
    n. Station Service Transformer;

2. Assessment Test including Frequency Response Analysis (FRA), Oil test / Winding Resistance Test, Dielectric Breakdown and Power Factor (Perform Electrical Test) of the existing/spare 10/10/10MVA Power Transformer in Mobo S/S;

3. Dismantling and undressing of 10/10/10MVA Power Transformer accessories and de-tanking and transfer the existing transformer insulation oil in a clean drum container;

4. Crating and hauling of Power Transformer 10/10/10MVA, 3-winding, 69/13.8/13.8 kV, ONAN, 3-Phase, 60Hz and its accessories from Mobo S/S to Masbate S/S;

5. Supply of Transformer Insulating Oil in accordance with ASTM D3487, specifications and technical data sheet;

6. Replace gaskets of the secondary housing of the current transformer, radiator valve and oil piping flanges;

7. Replace rubber bushing for secondary terminal bushing;

8. Calibration of the mechanical protection of the transformer (winding temperature, oil temperature, oil level indicator, rapid pressure, pressure relay, and buchholz relay);

9. Re-Installation/Erection, Testing and Commissioning of 10/10/10 MVA Power Transformer and its accessories to Masbate Substation including filling and testing of new transformer insulating oil;

10. Re-wiring, Testing and Commissioning of new transformer protection panel to 10/10/10MVA Power transformer and instrument transformers;

11. Supply, delivery, installation, test and commissioning of Line Protection Panel, Transformer Protection Panels and Transformer OLTC Control Panel;

12. Supply, delivery, installation, test and commissioning of Telephone System;

13. Supply, delivery, installation, test and commissioning of Intercom System;

14. Supply, delivery, installation, test and commissioning of CCTV Surveillance System;

15. Supply, delivery, installation, test and commissioning of VSAT System;

16. Supply, Installation and Test of Lighting & Power System and its Accessories;

17. Supply and installation of cable trays, including supports and accessories;

18. Supply, laying, tagging, bundling, termination and test of power, control and instrumentation cables;

19. Supply and installation of embedded and/or exposed electrical metallic/non-metallic conduits, boxes, fittings and accessories for power and control cables;

20. All other works and services including those not specifically detailed herein but are required to fully complete the project.

EW-1.2 WORKMANSHIP

Workmanship shall be of first-class quality and in accordance with the best modern practice for the manufacture, installation/erection, testing and commissioning of high-grade equipment, notwithstanding any omissions from these specification and drawings.

All materials supplied under this specification shall be unused, of recent manufacture, free of defects or irregularities and the best available considering durability, strength and intended service suitability and best engineering practice.

All parts shall conform to the dimensions shown on, and shall be built in accordance with approved drawings. The surface finish of all parts and components shall be in conformity with the respective strength, fit and service requirements

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Like parts and spare parts shall be interchangeable whenever possible.

Machining of renewable parts shall be accurate and to specified dimensions so that replacement of those parts fabricated or made according to dimensions so indicated in the drawings could be readily installed.

EW-1.3 MATERIALS

EW-1.3.1 Requirements to Materials

All materials to be used under this Contract shall be new, the best of their respective kinds and free from defects and imperfections. All materials shall comply with the latest revisions or edition of the specified standards for each equipment specification unless otherwise specified or permitted by the NPC.

When other standards are used, Contractor shall indicate the equivalence between the materials used and the corresponding materials following the specified standards in the equipment specification and shall obtain the approval of the NPC before starting the manufacture of the equipment and materials.

Materials and finishes selected for equipment shall be suitable for the purpose intended and for the humid tropical conditions under which the equipment is to operate. The use of other materials maybe permitted where the equipment is hermetically sealed.

Iron and steel where possible, shall be avoided in instruments and in electrical relays. Instrument screws (except those forming part of magnetic circuit) shall also be brass or bronze. Steel screws, when used, shall be zinc or chromium plated, or when plating is not possible owing to tolerance limitations, shall be of corrosion-resisting steel. Springs shall be of a non-rusting material, such as phosphor-bronze or nickel silver.

The names of manufacturers of equipment and articles contemplated for incorporation in the work together with performance capacities and other significant information pertaining to the equipment shall be furnished for approval. Equipment and articles installed or used without such approval shall be at the risk of subsequent rejections.

EW-1.3.2 Test of Material

Materials, parts and assemblies thereof entering into the work shall be tested, unless otherwise directed, according to the best commercial method for particular type and class of work. When the Contractor desires to stock material not manufactured specifically for the equipment furnished, satisfactory evidence that such material conforms to the requirements herein stated shall be furnished, in which case tests on these materials may be waived. Certified mill test reports of materials will be acceptable.

Certified copies of test reports shall be furnished in triplicate as soon as possible after the tests are made and shall be in the manufacturer's possession prior to incorporating that material in the work. The reports shall be in such form as to enable determining compliance with the applicable specification for the material tested. When requested, tests shall be made in the presence of a duly authorized inspector.

EW-1.4 CODES AND STANDARDS

EW-1.4.1 Prescribed Standards

Unless specified otherwise in the various sections of this technical specifications for equipment, the design, materials, manufacture and testing of all works under this Contract shall comply with the latest revision or edition of the various standards specified for each equipment section of the specification.

The latest edition of each standard shall mean the latest edition available at the date of Contract signing.

In addition to the codes and standards mentioned in the technical specification for each equipment, the Contractor shall comply with all National and local laws, codes, regulations, statutes and ordinances.

Equipment or materials meeting other internationally accepted standards, which ensure an equal or higher quality than the standards mentioned, will also be accepted.

In the event of any apparent conflict among standards, codes or this specification, the Contractor shall refer the conflict to NPC for written resolution before start of fabrication. Final decision regarding the acceptance of proposed standards is the prerogative of the NPC.

No deviation from the accepted standards shall be made subsequent to the Contract without the written approval of the NPC.

Standards listed in individual technical specification are used mainly for NPC's references. Other internationally known standards however, shall also apply, provided such standards are equivalent in all respect to the standard prescribed and to the specific requirements described in the individual equipment specification. Contractor shall submit copies of such standards for NPC's review and approval.

EW-1.4.2 Designation of Trade Name or Catalog Name and Number

For convenience in designation in the Specifications, certain equipment, articles, materials, or processes are designated by trade name or catalog name and number. Such designations shall be deemed to be followed by the words "or equivalent' whether such words are shown or not, and the Contractor may offer any material or process which shall be equal in every respect to that so indicated or specified. The burden of proof of acceptability to the NPC, as to the comparative quality and suitability of alternative shall be upon the Contractor. If the Contractor's request is not approved, the Contractor shall not ask or be permitted to use the same alternative materials or equipment in modified form.

EW-1.5 INTERCHANGEABILITY AND STANDARDIZATION OF SMALL EQUIPMENT

All like parts shall be fully interchangeable with no requirement for alteration or adjustment.

The Contractor shall be responsible for the standardization of all small equipment, materials and devices he would supply. He shall arrange and perform the necessary coordination work with his manufacturers for the purposes of such standardization.

All equipment, parts and elements of mass production shall be standardized. Such items of equipment, parts and elements shall include, but shall not be limited to, the following;

- Motors
- Pumps
- Flanges
- Valves
- Bolts
- Gauges and detectors
- Electrical instruments and measuring devices
- Terminals and terminal boxes
- Primary, secondary and auxiliary relays
- Contactors, fuses and switches
- Lamps, bulbs, sockets, plugs, push button, etc.
- Lubricants
- etc.

EW-1.6 TESTS AND INSPECTION

EW-1.6.1 General

The Contractor shall provide a test specification covering all tests on Contractor's premises. Successful completion, as deemed by the NPC, of Inspection and Tests on Contractor's premises shall be a prerequisite to shipment of all materials, equipment, software or system(s). Following successful completion of inspection and tests on his premises, the Contractor shall obtain the approval to proceed with the delivery of the equipment, materials, software or system(s) from the NPC in accordance with the Technical Specification for the equipment.

The objective of the test specification shall be to set forth the means, manner and circumstances in which to verify compliance with the Contract requirements including all functional and operation performance claims for the material, components, equipment, software or system made by the Contractor and/or the original equipment manufacturer.

The test specification shall include a program for Factory Acceptance Test (FAT) and detail the following:

a. Requirements to be tested;
b. Step-by-step method of testing;
c. Expected results of tests

Approval of the test specification/procedure will not prejudice the NPC's right to order additional tests, should the NPC deem, following approval but before his acceptance of the material, equipment, software of system(s) for shipment, that certain conditions or combination of conditions were not foreseen in the test specification, in order to demonstrate that performance requirements of this Specification have been met.

Tests shall only be conducted with the aid and in accordance with test specification(s) and standards clearly identified as approved for use by the NPC, and, where applicable, employ test instruments of suitable quality calibrated to manufacturer's recommendations by a reputable agency within the previous six (6) months.

The Contractor shall provide for the expenses of unrestricted return airfare, hotel accommodation including inland transportation at the Contractor's country of origin for NPC's staff on factory acceptance tests. The trip for the factory acceptance tests will be carried out by at least two (2) of NPC's staff unless otherwise indicated in the Technical Data Sheets of the equipment for a minimum duration of seven (7) days test period or the duration of the tests as indicated in the Schedule of Timings submitted by the Contractor. Costs for these expenses shall be included in the price for the particular equipment to be witnessed by the NPC or his authorized representative(s).

EW-1.6.2 Inspection on Contractor's Premises

The NPC reserves the right to inspect all shop and assembly work associated with the Works, verify quantities consigned to stores and inspect quality control and assurance records as well as shop and purchase order records. When scheduled, and as often as the NPC deems appropriate, progress will be monitored with respect to Key Dates in the Contract Schedule and the sequence of events and activities on the Contractor's Detail Contract Schedule.

The Contractor shall demonstrate and furnish evidence that general progress is being maintained so that no activities are in danger of becoming the critical path and that specific progress of those activities on the critical path meet all target dates set by the Contractor as well as Key Dates in the Detail Contract Schedule.

The Contractor shall furnish the NPC, a list of Contractors and the components, materials, equipment or software to be furnished by them for use in the Works, in sufficient time to permit inspection and testing of all components, materials, equipment and software. Purchase Orders shall clearly indicate level of inspection to which purchased items will be subject.

All shop orders or instructions to production and manufacturing departments shall quote the pertinent requirements of the Specification and shall bear a suitable notation advising quality control inspection requirements. A system for advising the quality control department of same shall exist. If so requested by the NPC, the Contractor shall furnish triplicate copies of the designated internal orders and instructions.

EW-1.6.3 Tests on Contractor's Premises

EW-1.6.3.1 Routine Tests

The Contractor shall perform routine tests in accordance with requirements of the Specification and the Contractor's test specification approved by the NPC. The Contractor shall give the NPC access to Works to determine or assess compliance with the provisions of this Specification or to witness Contractor's routine shop tests. The Contractor shall submit results of routine tests within fifteen (15) days after performance of the tests.

EW-1.6.3.2 Type Tests

The Contractor shall carry out all type tests called for in this Specification and such tests in the Standard in accordance with criteria and to the extent specified in the Specification and on custom manufactured items as called for by the NPC to obtain required performance data.

Upon submission of relevant test certificates from an independent testing agency approved by the NPC, and proof that the equipment to be tested is identical to that covered by the test certificates, the NPC will waive the requirements for corresponding type tests called for in this Specification and/or specified in the Standards.

EW-1.6.3.3 Factory Acceptance Tests

Prior to shipping and final inspection, tests hereinafter referred to as Factory Acceptance Tests (FAT) shall be conducted by the Contractor at his plant and will be witnessed by the NPC.

All expenses to be incurred of for the Factory Acceptance Test shall be borne by the Contractor such as unrestricted airfare, inland transportation and accommodation based on the latest Prescribing Rules and Regulations and Rates of Expenses and Allowances for Official Local and Foreign Travels of Government Personnel and/or the daily rates established by the UNDP International Civil Service Commission Daily Subsistence Allowance (DSA) for a minimum duration of seven (7) days test period or the duration of the test inclusive of travel time to and from manufacturer's premises as indicated in the Schedule of Timings submitted by the Contractor.

Materials/Equipment subject for Factory Acceptance Test (FAT) are described in Section VI – Technical Specifications, Part II – Technical Data Sheets and to be witness by three (3) NPC personnel for each equipment.

The Contractor shall carry out tests, as may be required by the specified Standards and the Quality Control and Assurance Program, as well as the entire test program, approved by the NPC, prior to the witnessed FAT, remove all faults found and correct all failures so that to the best of his knowledge, no functional or procedural errors will occur during the witness FAT.

At the commencement of the witness FAT, all equipment shall be brought together in one place, integrated and the configuration/set-up at the factory site shall be identical to that to be installed at the site and any equipment and software necessary for the proper operation of the equipment shall have reached its final form, not to be changed during the FAT and until commencement of commissioning at site.

The Contractor shall immediately advise the NPC should failures occur, take remedial action subject to the NPC's approval and proceed with the FAT as and when directed by the NPC. It shall be the NPC's prerogative to order a repeat of all such tests that he deems may have been affected by the failure.

The Contractor shall ensure that during the test, all hard copy from output devices is retained and that no outside parties interfere in any way with testing, equipment or test instruments, fixtures and jigs for the entire duration of the FAT. Only Contractor's personnel who are needed on the testing of the equipment shall be allowed in the test area. The Contractor shall appoint a chief-tester who shall be responsible for conducting the test, ensuring at all times that the test instruments, fixtures, jigs and extender cards, and those of the Contractor's personnel who in any way may contribute to the test, including testers, specialists and maintenance personnel are available prior to scheduled commencement of each test or as and when instructed by the NPC.

The chief-tester shall also be responsible that an accurate record of tests is kept and each individual test is duly initialed and dated by the tester and marked either passed or failed with annotations of antecedents and observations concerning the test. For each day of testing, the chief-tester shall submit to the NPC the proposed disposition of each criterion that failed during the previous day of testing, prior to commencement of the tests scheduled for that day. Tests witnessed by the NPC will be initialed accordingly by him on the test record. The test record and dispositions, and any other pertinent supporting data and documents shall form part of a test report to be submitted in accordance with the specification.

Material, equipment, software or system(s) shall be required to pass one complete run of functional tests with satisfactory results and shall have all faults and failures corrected, if any. At completion of all tests, as well as at any time during the test at the NPC's discretion, test results, except for the parts comprising dynamic data, shall be compared with the reference copy. If no differences are detected and all tests have demonstrated compliance with the requirements of this Specification, then the FAT will be deemed successful.

EW-1.6.3.4 Tests Failures

If any equipment fails to pass any test, the NPC may, at his own judgment, direct the Contractor to make any necessary corrections or alterations to it for minor defects or to replace it forthwith for major defects. Any and all expenses that might result by the supply and installations of new parts or by modification of existing parts and any and all expenses resulting in additional tests made necessary by failure of equipment to meet the guarantees and other requirements of the specification shall be borne by the Contractor. The costs of witnessing the Factory Acceptance Tests by the NPC or his representative(s) as a result of re-test to be conducted on the equipment shall also be borne by the Contractor.

EW-1.6.4 Field Test

Field tests and acceptance tests shall be performed by the Contractor and witnessed by NPC's representative to determine whether requirements of the specification have been fulfilled. The Contractor shall provide instructions and acceptance criteria for field testing for NPC's review and approval prior to conduct of such tests and commissioning the equipment. No field tests shall be performed unless approved by the NPC.

EW-1.6.5 Test Reports/Certificates

Six (6) certified copies of the reports of all NPC's specified tests and other manufacturer standard tests shall be furnished to the NPC immediately within a maximum of fifteen (15) days following the completion of the tests. For equipment which had the required type test already, the type test certificates shall be submitted by the Contractor together with his proposal.

For the routine tests, acceptance tests and field tests, the test certificates shall include, in addition to the test results, the following information:

a. Date for the test certificate
b. Equipment data
c. NPC's reference number
d. The equipment serial number

Certified test data submitted to NPC shall also include copies of oscillographic records made in conjunction with the tests, and certification that all equipment furnished are suitable, when energized at continuous voltage, and for manual washing using a single-stream high pressure nozzle.

The Contractor shall bear the cost of furnishing these records and reports.

EW-1.6.6 Waiver of Factory Acceptance Tests Witnessing / Inspection by NPC

Where Factory Acceptance Tests (FAT) to be witnessed by NPC's representative(s) have been required in the Technical Data Sheets of a particular equipment, costs of these tests witnessing shall be deemed included in the price for the equipment.

However, if the NPC opted not to witness the Factory Acceptance Tests, NPC will issue a Certificate of Waiver of Tests Witnessing/Inspection for the equipment and materials. In such case, the Contractor shall proceed with the Factory Tests in accordance with the requirement of the specification and the manufacturer's test specification as approved by the NPC.

Where Factory Tests are not required to be witnessed by NPC's representative(s) as indicated in the Technical Data Sheets of the equipment, a Certificate of Waiver of Tests Witnessing/Inspection will be issued also by the NPC. In this case, no claim whatsoever can be made by the NPC on the Contractor as a result of waiving the Factory Acceptance Tests.

EW-1.7 ELECTRIC WELDING

EW-1.7.1 Welding Procedure

All welding shall be performed in accordance with a procedure which shall be in accordance with standards equal to those required by the "Standard Qualification Procedure" of the American Welding Society.

EW-1.7.2 Acceptance of Welded Structures

The acceptance of the welded work shall depend upon correct dimensions and alignment and absence of distortion in the structure, upon satisfactory results from the examination and testing of the joints in accordance with the instructions given on the drawings and the soundness of the welds and upon general good workmanship.

EW-1.7.3 Cleaning

All excess weld materials, slag, splatter and flux residues shall be removed from the steel work.

EW-1.8 TROPICAL SERVICEABILITY

EW-1.8.1 General

In choosing materials and their finishes, due regard is to be given to the humid tropical conditions under which equipment is to work. Some relaxation of the following provisions may be permitted only when equipment is hermetically sealed but it is preferred that tropical grade materials should be used wherever possible.

Cubicles used for switchgear and control cabinets in outdoor plant shall be vermin-proof and fungus-proof.

Totally enclosed motors and enclosures containing electrical control and switching equipment and instrument for outdoor installations shall be equipped with temperature controlled electrical heaters. The construction of the enclosures and installation of heaters shall be as to ensure effective circulation of air while ensuring that no damage to equipment occurs due to overheating.

The Contractor shall supply the NPC with detailed descriptions of all design characteristics necessary to fulfill the requirements in connection with the tropical conditions under which the equipment will be operated.

EW-1.8.2 Metals

Iron and steel are in general to be galvanized or painted as appropriate. Small iron and steel plate (other than SUS 316 stainless steel) of all instruments and electrical equipment, the cores of electromagnets and the metal parts or relays and mechanisms are to be treated in an approved manner to prevent rusting. Cores or other components which are laminated, or which cannot be rustproofed, shall have all the expected parts thoroughly cleaned and heavily enameled, lacquered or compounded. Where it is necessary to use dissimilar metals in contact, these should, if possible, be so selected that the potential difference between them in the electrochemical series is not greater than 0.5 volt. If this is not possible, the contact surfaces of one or both of the metals are to be electroplated or otherwise finished in such a manner that the potential difference from each other by an approved insulating material or a coating of approved insulating varnish.

EW-1.8.3 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, are to be zinc or chromium plated or, when plating is not possible owing to tolerance limitations, are to be of corrosion-resisting steel. All wood screws are to be of dull nickel plate brass or other approved finish. Instrument screws (except those forming part of a magnetic circuit) are to be brass or bronze. Springs are to be of non-rusting materials, e.g., phosphor bronze or nickel silver, as far as possible. Pivots and other part for which non-ferrous material is unsuitable are to be of an approved rustproof steel where possible.

EW-1.8.4 Fabric, Cork, Paper, etc.

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

EW-1.8.5 Wood

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

EW-1.8.6 Adhesives

Adhesives are to be specially selected to ensure the use of types which are impervious and resistant to attack of mildew and insects. Synthetic resin cement only shall be used for joining wood. Case-in cement shall not be used.

EW-1.9 ENVIRONMENTAL REQUIREMENT AND OPERATING ENVIRONMENTAL CONDITIONS

EW-1.9.1 General

All equipment shall conform with the environmental requirements and conditions applying to the location where it is to be used. Additional heating by equipment inside buildings must be taken into account.

All equipment and materials to be furnished shall meet the performance and rating requirements of this specification and all Contractor's guarantees shall be based on operation within the environment specified in the Technical Data Sheets of the equipment. This also applies during storage and if susceptible to moisture absorption or fungus attack, the equipment and materials shall be treated with fungicidal varnish and otherwise be adequately tropicalized as specified in Section EW-1.8.

Special measures shall be taken such as the use of chemically inert parts and proper surface preparation and paint application in accordance with this Specification for equipment installed at Site(s) with a corrosive atmosphere, to protect exposed metal parts and other materials susceptible to chemical reaction.

Materials susceptible to deterioration from climatic conditions or subject to the formation of fungus or any other form of parasitic life shall preferably not be used, but if used and cannot be avoided, these must be permanently protected.

For all outdoor equipment, the operation of the equipment must not be influenced by dew, fog, rain, wind, sun radiation, quick changes of temperature, dust, smoke, salts, aggressive gases, and steams. Outdoor installations shall be protected against solar radiation by means of adequate covers, where required, with non- deteriorating material to be provided by the Contractor.

EW-1.10 SEISMIC REQUIREMENTS

Equipment and equipment support shall be designed to withstand and maintain their structural integrity when exposed to seismic loading/seismic factor specified in the Technical Data Sheets. It shall be designed to resist a lateral seismic force and remain in place in accordance with the requirements of the latest issue of Uniform Building Code (UBC), Section 2312g or NSCP.

The Contractor shall demonstrate the equipment's ability to withstand and maintain its structural integrity when subjected to the forces resulting from the seismic conditions specified herein. This can be accomplished in one or a combination of the following methods:

a. Predict the equipment's performance and response to a seismic force by mathematical static analysis;
b. Test the equipment under simulated seismic conditions (static or dynamic testing); or
c. Utilize previous seismic qualification of the equipment and demonstrate applicability under the seismic conditions specified herein.

The seismic loading on the equipment and its supports shall be obtained by multiplying the weight of components by the horizontal seismic acceleration coefficient (H). The force shall be assumed to act in any lateral direction.

Where: H = 0.5 x Z x I
Z = Uniform Building Code coefficient corresponding to the zone where the equipment is located
I = Importance Factor

Equipment and supports shall be designed for lateral forces in accordance with the following formula derived from the UBC:

Fp = HWp

Where:
Fp = lateral force on the equipment
Wp = the total weight of the equipment supplied by the Supplier
H = Horizontal seismic acceleration coefficient given in the above formula

Support design shall not include friction in resisting the lateral shear load.

The maximum stresses, under seismic loading combined with all other load effects, shall be within the normal allowable material working stress limits as set forth in the appropriate design standards and codes listed in this specification.

Deformations resulting from the combined influence of normal operating loads and seismic loads shall be investigated to verify that they will not impair structural integrity.

The Contractor shall submit a certification stating that the equipment can resist the forces resulting from the seismic conditions specified herein and remain in place. The Contractor shall submit the following data and documents for NPC's information:

a. Outline arrangement drawing showing all pertinent dimensions and support locations

b. Analytical method and procedures in a step-by-step form which is readily auditable by persons knowledgeable in such analysis

c. Results of analysis and conclusions

EW-1.11 CLEANLINESS

At time of shipment, the equipment shall be clean inside and outside.

All waste such as metal chips or filings, welding stubs, dirt, rags, debris and any other foreign material shall be removed from the interior of each component. All mill scale, rust, oil, grease, chalk, crayon or paint marks and other deleterious materials shall be removed from all interior or exterior surfaces.

Solvent cleaning, if required, shall be performed in accordance with SSPC-SP1.

Heavy cleaning, if required, shall be performed in accordance with SSPC-SP3.

Cleaning of stainless-steel surfaces shall be performed with solvents, cloths and abrasive that do not contain halide. Only stainless steel, clean, iron-free, hand or power tools and aluminum oxide abrasive shall be used on stainless steel components. Materials used to clean carbon steel or cast iron shall not be used to clean stainless steel surfaces.

EW-1.12 SURFACE TREATMENT AND CORROSION PROTECTION

EW-1.12.1 General

Equipment and all steel parts shall be painted, hot-dip galvanized or treated with protective coatings to prevent corrosion and provide a smart and pleasing appearance. This work shall comprise the surface treatment, priming and application of paint or metallic coatings in the workshop and at the site, including all paint repair works that may be necessary. Corrosion protection shall include the steel surfaces of structures cast into concrete.

The works of corrosion protection shall include all equipment and installations for sand blasting and paintings.

The Contractor shall furnish, with his proposal, a complete description of the corrosion protection he intends to provide. After purchase order, the Contractor shall submit applicable cleaning and coating procedures and specific description of coating material to be used.

Where possible, equipment shall be designed such that all surfaces can be finish-coated or recoated after erection at the site.

EW-1.12.2 Requirements to the Finished Coating

All finished surfaces shall be level and free of tears, burrs, clots and impurities. The coat of paint shall be of even thickness, also in corners and on edges. Moreover, all finished surfaces shall be uniform in respect of color and gloss.

The paint film, under visual examination, must in any case present the appearance of an accurate application and be free of lesions, porosity, cracks or bubbles.

Any damage during transport, mounting, welding, etc. shall be repaired by Contractor. Repair methods shall be submitted for approval of the NPC. This also applies to damages to components supplied by a sub-contractor.

EW-1.12.3 Guarantees

The guarantee period of the paint work shall be two (2) years. During this period, it will be the responsibility of the Contractor to repair or replace without charge all paintwork showing defects (such as discoloration, peeling, wrinkles, bubbles, flakes or rust, etc.) where it may be proven that the deterioration arises from:

a. Poor quality paint;
b. Insufficient cleaning of the surface before painting;
c. Incorrect choice of paint for the service required; and
d. Incorrect application of paint itself to the surface.

In such cases, the Contractor shall take charge of restoration of all parts which have shown defects.

For the guarantee against corrosion penetration, the NPC requires a ten-year guarantee period. The rust penetration shall be measured according to ISO 4628/3-1982. After ten years, the rust penetration shall not exceed Ri 2. Ri 3 penetration shall entitle the NPC to repair the surface at the expense of the Contractor.

The guarantee shall commence on the day of the issuance of the Certificate of Provisional Acceptance.

EW-1.12.4 Reference Standard

Except otherwise specified elsewhere in the specification, the surface treatment and corrosion protection for all metal parts shall be in conformity with the latest revision of the standards listed below:

ASTM 123	Zinc (hot-dip galvanized) coating on Iron and Steel products
DIN 55928	Protective painting of steel structure instructions
DIN 55945	Painting Materials – Notions
DIN 18363	Paint work – Buildings
DIN 18364	Surface Protection Work for Steel
DIN 53210	Determination of Rust Degree
DIN 55151	Determination of Adhesion
ISO 4628/3	Determination of Rust Penetration

Other internationally known standards however, shall also apply provided such standards are equivalent in all respect with the reference standards prescribed above. The Contractor shall submit copies of such standards for NPC's review and approval.

EW-1.13 EQUIPMENT DESIGNATION (EQUIPMENT MARKING)

EW-1.13.1 Identification System

All equipment and all component parts including cables, control wiring and terminals shall be designated with an alphanumeric code allowing clear identification of the equipment and components during design, installation and operation of the plant/substation. Equipment, cables, control wiring and terminals shall be systematically marked, both on the drawings and documents and on the equipment, cables, wires and terminals themselves.

Equipment designation codes shall be indicated on all planning documents including bills of materials, lists of spare parts, etc. The codes will later be used for easy identification of stored equipment parts and materials and shall be suitable for use with a computer-supported registration system.

Tender drawings are in some cases already marked with designated codes; the system shall be expanded to include detailed diagrams, cable lists, spare parts list, etc. approved by the NPC.

Wherever applicable, labels/plates bearing the E.D.S. code shall be attached to equipment in the Contractor's works.
The material and fastening methods proposed for E.D.S. labels/plates are subject to the approval of the NPC.

EW-1.13.2 Labels and Plates

A stainless-steel nameplate or equivalent anti corrosive nameplate with clearly legible writing shall be permanently attached to each assembled piece of equipment at an easily visible place. It shall provide all necessary information pertaining to the equipment, but as a minimum, the following must be included: Manufacturer's name, type of equipment, serial number, year of manufacture, project identification number, weight, E.D.S. code and other relevant information in compliance with applicable standards. Any special maintenance instructions shall also be shown at this or other suitable location.

For other major components i.e., pumps, motors, etc., the following shall be added: Rated HP, speed, total head, capacity, direction of rotation, and any other pertinent information.

If it is not practical to include NPC's equipment identification, or tag number on the equipment nameplate, then a separate durable stainless-steel tag with NPC's identification number shall be provided and securely attached to the equipment.

Labels shall also be provided for equipment and devices mounted on control boards, relay cabinets, desks and other places as required for proper identification, as well as for operational, functional and safety reasons. The labeling, size of label-plates and their location shall be subject to approval by the NPC. A sample label-plate (with indication of material used) with lettering shall be submitted for this purpose.

Each equipment wherever necessary, shall be provided with cautionary and warning plates and signs in accordance with the prescribed ANSI/IEEE or equivalent IEC Standards for the particular equipment. Nameplates, labels and warning plates shall be in English.

EW-1.14 SPARE PARTS AND SPECIAL TOOLS

A list of mandatory spare parts and special tools to be supplied by the Contractor is specified in the Technical Data Sheets for each of the equipment under this specification. If in case any of the mandatory spare parts or tools are not applicable to his supplied equipment, the Contractor is required to provide an alternative spare parts and tools that are applicable to his supplied equipment with the same quantities as required. The NPC has the option to choose in the list of the recommended spare parts and tools given by the Contractor the replacement for the mandatory spare parts and tools, which the Contractor failed to offer or provide an alternative replacement.

In addition to the above, the Contractor shall also include with his Proposal, a list of recommended spare parts and special tools which he considers necessary for the safe and reliable operation and maintenance of the equipment. The Contractor shall indicate the expected life of the parts requiring replacements and the minimum recommended inventory of the spare parts for installation, start-up, continuous operation and maintenance.

Contractor shall state whether the recommended spare parts is a stock item or a special item, and shall furnish name and location of the nearest Contractor, and approximate lead time required for delivery. The NPC has the option to consider or not to consider the recommended spare parts and tools as given by the Contractor with the corresponding price.

All spare parts shall be readily interchangeable with the ones which they are to replace. They shall be of the same material, of identical size and manufacture and shall have the same properties as the corresponding parts of the installed equipment. Specified conditions relating to tests, treatment of surfaces and painting, etc. of the installed equipment shall also apply to spare parts.

All spare parts shall be properly packed (and where necessary treated) in such a manner as to allow prolonged storage at the Site, considering the ambient conditions prevailing there. In due time, the Contractor shall inform the NPC of the eventual precautions to be taken for the proper storage of the spare parts.

The Contractor shall provide a spare parts list containing at least the following information:

- Name and address of manufacturer and other identification no.
- Item description including EDS-code, drawing no., material designation, units to be ordered.
- List of items (designated by EDS-code) for which the respective spare parts can be used.
- Item price.

EW-1.15 GENERAL ELECTRICAL REQUIREMENTS

EW-1.15.1 General

The supply of the electrical equipment for high and low voltage installation shall be complete to the extent required to put the substation(s)/power plant(s) in satisfactory operating conditions, with all the requirement completely connected and interconnected with operating switches, interlocks, signalization, alarms and metering instruments.

The Contractor must supply all minor items (such as auxiliary relays, terminal blocks, accessories, etc.) which are necessary although not expressly described in the Technical Specifications, in order to guarantee the trouble-free operation and ease in the maintenance of the supplied substations/switchyard (or parts of substations/switchyard) with particular reference to the provisions to be taken in order to avoid dangerous or wrong operations.

The electrical equipment shall be designed in such a way as to bear without damage and permanent deformation the consequences of over-voltage of internal or atmospheric origin and short circuit calculations shall be provided, giving full evidence, that each electrical component can withstand the maximum stresses under fault conditions, e.g., upon failure of the corresponding main protection device and time-delayed fault clearing by the back-up protection device.

Outdoor installations shall be protected against solar radiation by means of adequate covers, where required, with non-deteriorating material to be supplied by the Contractor.

The Contractor shall ensure, that all equipment supplied is insensitive to any signals emitted by wireless communication equipment.

All the metallic frames of the electrical equipment shall be securely connected to the general earthing system in compliance with accepted Standards.

EW-1.15.2 Insulation Levels

The insulation levels for different system voltages shall be as indicated on the particular Technical Data Sheets of the equipment.

EW-1.15.3 Minimum Clearances

The center-line spacing and clearances above ground level of the conductors shall be as shown on the bid drawings, or in the absence of such information, shall match the ANSI Standards.

Clearances of energized metal parts are summarized in the following table for the different systems:

Nominal System Voltage	*d1 (mm)*	*d2 (mm)*	*D (mm)*	*H (mm)*
13.8	300	350	900	3500
34.5	500	610	1500	3600
69	800	900	2000	3750
115	1100	1360	2500	4000
138	1300	1800	3000	4000
230	1850	3200	4000	5000
500	3250	5200	8000	9000

where:

d_1 = minimum clearance between live metal parts and ground
d_2 = minimum clearance between live metal parts of two phases
D = practical distance between phase center lines
H = minimum height of live conductors above ground.

However, the upper edge of an earthed insulator support must, for all voltage series, beat a height of at least 2300 mm above the ground level.

EW-1.15.4 Creepage Distances

Creepage distance of bushing of equipment, string of insulators, station post insulators and rigid support insulators shall comply with the requirements stipulated in the Technical Data Sheets of the equipment.

EW-1.15.5 Levels of Equivalent Salt Deposit Density (mg/cm^2)

The level of equivalent salt deposit density shall be as stated in the Technical Data Sheets of the equipment.

EW-1.15.6 Auxiliary Services Voltages

The auxiliary equipment shall be designed for the conditions of voltage and frequency mentioned in the Technical Data Sheets of the equipment.

EW-1.15.7 Color Standard

Each equipment shall be painted in accordance with the Standard specified below.

Equipment	*Color*
Outdoor equipment	RAL 7035
Indoor Equipment (including Inside cubicle)	RAL 7032

EW-1.15.8 Color and Code of Phase Indication

Color and code of phase indication shall be as follows:

Phase	Color	Code
First phase	Red	A
Second phase	Yellow	B
Third phase	Blue	C

EW-1.15.9 Equipment Number Plates

The Contractor shall furnish outdoor equipment number plates as required by the NPC. Equipment numbers are shown in the Bid Drawings "ONE LINE DIAGRAM" of each substation/switchyard. The equipment number plates shall be clearly visible to a man standing on the ground even at a distance and shall be made of weather resistant materials. This is in addition to the equipment marking to be supplied by the Contractor as mentioned in Section EW-1.13.2.

EW-1.15.10 Phase Indication Plates

Phase indication plates shall be provided on the substation steel structures to indicate the phases of bus, incoming lines and transformer feeders.

Color and codes of phase indication plates shall be as follows:

Phase	Color	Code
A - Phase	Red	A
B - Phase	Yellow	B
C - Phase	Blue	C

The color and code letters shall be luminous and shall be placed at easily recognizable position. The plates shall be made of weather resistant materials.

EW-1.16 PROTECTION SYSTEM REQUIREMENTS

EW-1.16.1 General

The supply of the electrical equipment for high and low voltage installation shall be complete to the extent required to put the substation(s)/power plant(s) in satisfactory operating conditions, with all the requirement completely connected and interconnected with operating switches, interlocks, signalization, alarms and metering instruments.

The Contractor must supply all minor items (such as auxiliary relays, terminal blocks, accessories, etc.) which are necessary although not expressly described in the Technical Specification, in order to guarantee the trouble-free operation and ease in the maintenance of the supplied substations/switchyard (or parts of substations/switchyard) with particular reference to the provisions to be taken in order to avoid dangerous or wrong operations.

The electrical equipment shall be designed in such a way as to bear without damage and permanent deformation the consequences of over-voltage of internal or atmospheric origin and of the short circuit currents within the limits stated in the Technical Specification.

All the metallic frames of the electrical equipment shall be securely connected to the general earthing system in compliance with accepted Standards.

EW-1.16.2 Protection Design Criteria

The functional requirements of this specification relating to protective relaying shall apply to all equipment on which the protective function is dependent. They shall thus also apply to parts which are not directly related to the protective relays, such as functions in the auxiliary power distribution, interface cubicles, etc., included in the relay protection function.

Strict demands shall be made on selectivity in isolation. To improve security, protection systems should be designed to isolate only the faulted portion of the network. For faults external to the protection zone, the protection system should be designed either not to operate, or to operate selectively with other systems, including breaker failure.

All primary faults which are of such magnitude that they jeopardize operation of the grid, which represent a risk to personnel, or which could cause appreciable material damage to plant or to the whole system, shall be isolated or relieved of stresses in a controlled way even in the event of a single failure in the relay protection equipment, its supply of measuring quantities, auxiliary voltage, etc., or primary breakers.

When required, every fault condition shall be detected by at least two fast primary protection systems with different measuring principle.

Primary and back-up protection, including the auxiliary supply, shall be physically and electrically separated to allow maintenance on one protection without affecting the function of the other.

To improve dependability, the two protection sets shall be divided into two electrically and mechanically separated parts by means of:

- separated DC power supply
- separated boards
- separate current transformer cores
- separate voltage circuits
- separated tripping devices
- separated cables
- separated relay protection channels (only for lines)

To improve dependability, each primary protection shall have separate tripping paths to the circuit breaker, that is one primary protection set to actuate trip coil number 1 only and the other protection set to actuate trip coil number 2 only. Cross-tripping is not allowed.

Each protective relay shall be equipped to indicate the trip on the respective alarm relay rack.

The protection system shall be arranged for complete subdivision in two parts (relay set 1 and 2). Protective relays belonging to relay set 1 and 2 must not be fitted in a common panel unless otherwise indicated in the Technical Data Sheets of the respective Sections. Communication between the two subdivisions shall be transferred via barrier relays.

Each feeder shall have a separate protective zone. Each feeder protective relay shall trip only the breaker or breakers associated with that feeder. Selective tripping of all circuit breakers within the protected zone shall be guaranteed.

All protective relays shall be microprocessor based, numerical design if required, modularized plug-in type and placed in standard 19-inch racks (Other relays, where instructed, shall be mounted on the rear panel of a duplex control switchboard. All accessories necessary for this type of mounting shall be provided with the relays). If required to be coupled to substation control system through a microprocessor-based substation control and protection system, all relays shall be numerical in nature with serial communication facilities.

The fault detection and maintenance shall be easy. Suitable facilities shall be provided on each measuring relay or system to disconnect the trip outputs, and to subsequently short and disconnect the current transformers. These shall also disconnect any voltage transformer, alarm or critical DC circuit, without affecting any other devices. Removal of any relay or system component directly connected to any CT circuit shall short out the relevant CT connection.

All relays shall be wired and preferably automatically tested at the factory. Plug-in elements shall have reliable devices for fixing them in the service position.

Breaker failure protection, if required, should be provided to detect stuck breaker condition and initiate tripping of breakers adjacent to stuck breaker, including line remote breaker to improve dependability. DC supplies to the breaker failure protection should be separate from the breaker trip coils dc supplies and from other protection system dc supplies. Generally, only one breaker failure protection system is provided.

Protection systems should not operate for stable power swings. Also, protection systems should not impose limitations under normal or short-time contingency circumstances.

To shorten overall operating times, protection schemes should utilize, where required, differential relaying, communication based relaying and instantaneous overcurrent relaying to the maximum possible extent, with due regard to selectivity.

To improve dependability and security, critical features associated with protection systems and circuit breaker operation should be monitored and annunciated. These features include integrity of power supplies, signal levels, integrity of trip circuits and relay operations.

If required, sequence of event recorders and oscillographs should be provided to permit analysis of protection system performance during network disturbances.

EW-1.16.3 Relay-Setting

Recommended relay settings shall be issued by the Contractor after being supplied with needed basic data from the NPC.

EW-1.16.4 Inter-Tripping

Breakers in adjacent stations have to be opened when the breaker fails to isolate a primary fault. This tripping of breakers in adjacent stations shall be achieved by direct inter-tripping activated from the breaker failure protection.

EW-1.16.5 Relay Indications

All relay protection shall be provided with resettable visual indicating devices for trip functions in the individual protective relay or group of relays for all protection belonging to a primary object. These indications shall be clearly visible without the need for opening doors, or the like, on the relay cubicles or other enclosures. Indication devices shall be provided for every relay protection. Start indications from time delayed protective relays are required. The faulty phases shall be indicated when the measuring principle in the protection makes this possible. Multi-stage protection shall be designed so that the indications will clearly show the stage which has initiated tripping.

Tripping indication shall always be provided, regardless of the duration of the tripping signal.

The following colors shall be made available for visual indications:

- yellow : start indication
- red : trip indication
- green : auxiliary power

In addition to the above visual tripping indications, corresponding potential-free contacts shall be available for Sequence of Events (SOE) and alarm panel, and these contacts shall close when visual indication is obtained.

EW-1.16.6 Tripping Circuit

The tripping circuit for the relay protection belonging to relay set 1 and 2 shall be separated both electrically and mechanically. This implies that they must not include common switching devices, connectors, terminal blocks, cables, auxiliary relays, etc. Breakers shall have electrically and mechanically separate tripping coils for relay set 1 and 2. The function must not be jeopardized if both coils receive a trip impulse simultaneously, or if one coil is short-circuited.

The design in relay set 1 and 2 shall conform with the following stipulations:

- High functional security and speed are necessary in the tripping circuit, and the system design shall thus be such that a minimum of series-coupled elements will be required.

- The tripping circuits shall be supervised both when the breaker is open and closed. The supervision shall include the DC supply, tripping coil, cables (DC supply cable and tripping cable to the breaker). The auxiliary contact for the coil shall also be included in the supervision when the circuit breaker is closed. The alarm shall be time-delayed to prevent it operating during momentary dips in the DC supply. The alarm shall also be inhibited when the circuit breaker auxiliary switch interrupts the trip coil circuit, on circuit breaker opening.

- Each protection dedicated to one unique object shall have its own tripping equipment. Furthermore, each breaker shall have its own tripping circuit for those protection that are common for more than one object, i.e. Breaker Failure Protection.

- There shall be separate equipment for set 1 and set 2.

- The tripping equipment shall have auxiliary relays, which must have an operating time not in excess of 5 ms. These tripping relays shall also be capable of breaking the circuit to the solenoid, even if the auxiliary contact in the breaker should fail to open.

- Trip relays must be immune to operation with wiring capacitive discharge currents in the event of a DC system earth fault.

- Specified lockout relays shall be of mechanically latched type with manual reset.

- The DC circuit used to actuate the tripping relays shall be separate from the DC circuit for the tripping coils.

EW-1.16.7 Auxiliary Relays

General

Auxiliary relays shall be vibration proof and shock-proof. They shall be rated for operation at 125 V dc unless otherwise noted. Both the moving and stationary contacts shall be of silver plated. Each one will close and carry 5 A continuously, or will carry 30 A for one minute.

Manual Reset Auxiliary Relay

Manual reset auxiliary relay shall be electrically and manually reset, high speed, multi-contact type. The voltage rating of the relay coil shall be such that, with the suitable series cut-off contact furnished, the operating time shall be approximately one cycle. The relays shall have interlocking contacts in the closing circuit of circuit breakers they operate.

Self-Reset Auxiliary Relay

Self-reset auxiliary relays shall have a dc operating coils corresponding to the DC source specified in the Technical Data Sheets of the equipment and at least three (3) electrically independent, potential-free, normally open contacts.

They shall be suitable for continuous duty and shall have an operating time of about two (2) cycles. The Contractor shall provide at least two (2) spare "a" and/or "b" contacts.

EW-1.16.8 Operating and Service Conditions

The protective and auxiliary relays shall be installed and operated under the following conditions and ratings unless otherwise indicated in the Technical Data Sheets of each protective relay equipment:

Momentary current	:	40 times rated current coil (2 sec)current (5A)
Continuous voltage	:	1.2 times of rated potential coil voltage (115V)
Continuous current	:	2.0 times of rated current coil current (5A)
Make and carry ratings	:	30 amperes for tripping contacts for at least 2000 operation in a prescribed duty (ANSI C37.90-1978)
Insulation	:	2 kV, 60 Hz for 1-minute
Surge withstand capability	:	ANSI C37.90/IEC 60255
Rated frequency	:	60 Hz
1 MHz burst disturbance	:	IEC Publication 60255-22-1 with severity Class III
Electrostatic discharge	:	IEC Publication 60255-22-2 with severity Class III

Radiated electromagnetic field disturbance	:	IEC Publication 60255-22-3 with severity Class III

The test shall be carried out by using Test Method A and by sweeping through the entire frequency range 27 MHz to 500 MHz

Fast Transient disturbance	:	IEC Publication 60255-22-4 with severity level IV

The Contractor shall also guarantee that all equipment furnished under the scope of this specification shall meet the performance and rating requirements of this specification while operating within the environmental conditions specified in the Technical Data Sheets.

EW-1.16.9 Enclosure and Environmental Requirements

The protective relays shall be enclosed in a free-standing control cubicle with a front hinged-frame suitable for easy installation of functional units, designed for front access.

The installation dimensions for rack mounted equipment should conform to the 19-inch standard.

The enclosure shall be designed to have proper ventilation preventing the occurrence over-heating. The ventilation shall be such that rodents and insects' entry inside the panel are prevented.

The degree of protection of relay cases or cubicles shall be minimum IP50. Relays shall be tropicalized and shall have enhanced corrosion protection.

The enclosure should be provided with a key-lockable full transparent hard plastic protective door mounted on the front of the hinged frame. Equivalent means to protect the individual relays can be provided.

The enclosure shall be provided with enough space for mounting other ancillary equipment as specified. Unused spaces shall be covered with plates. The rear of the cubicle shall be closed suitable for back to back or back to wall mounting. The inside rear plane shall be provided with a fixed mounting plane for terminal blocks and other accessories.

EW-1.16.10 Panel/Cubicle Wiring

Wires shall be 600V, stranded copper conductor with thermo plastic insulation and shall comply with the requirements of ICEA Standard No. S-61-402. Minimum size shall be 2.0sq.mm. or larger for control circuit except annunciator wire which shall be 1.2sq. mm. or larger. Minimum test voltage shall be 2000V.

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

The wiring between sub-components of a single systems hall be of adequate dimensions. Point to point wiring to fixed terminals shall be used for CT and trip circuits, however, other circuits maybe plug and socket assemblies of adequate design. Wires shall not be spliced or joined between terminal points.

Soldered or wire wrapped connections shall only be inside electronic systems. Any wire wrapping shall be in accordance with IEC Publication 60352.

Where provisions are made for the addition of equipment not required initially, means shall be provided for supporting and terminating wiring during the interim period.

All panel wires shall be identified at both ends with numbered ferrules according to the wiring diagrams. On rack mounted equipment using wrap or soldered connections within the rack and for all telecommunication circuits, color coded details wiring will be acceptable. Include color code details in drawings, where used. Numbered ferrules shall be fitted to all multi-core cable tails.

Ferrules shall be of insulating materials with glossy finish to prevent adhesion of dirt. They shall not be affected by moisture or oil and shall be clearly and permanently marked. Temporary marking shall not be used.

All power circuits, control and protection wiring and low level signal wiring shall be physically separated. Separate raceways shall be provided for power cables and the working voltage of each power circuit shall be marked on the associated terminal boards.

As far as reasonably possible, all outgoing wiring should be grouped by function (CT, VT, Trip, Alarm, etc.) with those going to a common destination allocated to adjacent terminal blocks. Terminal block configuration shall be submitted for approval. Labels shall be provided on the fixed portion of the terminal boards showing the function of the group.

Connections for indicating instruments and for the telecommunication circuits from transducers or modem outputs shall use individually shielded wire pairs. One (1) extra terminal per pair of terminals, shall be provided to connect this shield to ground.

If wiring is provided between swinging panels, bundled conductors shall be used on the hinged doors or panels with extra/flexible wire, so arranged that a twisting rather than a bending motion, is imparted to the moving bundled conductors. Each bundle shall be anchored such that the moving bundled length is the maximum available without loops.

Wiring shall be arranged to give easy access to the terminal or relays and other apparatus.

EW-1.16.11 Cubicle Construction

The cubicle shall be of the type specified in Technical Data Sheets of the individual protection equipment. It shall be of reliable construction, of rugged design and modularized.

The cubicle shall be made of smooth sheet steel panels with angle or channel frame and with edges bent to 6.0 mm radius, seam-welded at corners and ground smooth. The panels shall be bolted at the bottom to suitable steel channel sills to be furnished as part of this supply. Suitable grounding and anchor bolt holes shall be provided in the channel sills. Butt joints on outside surfaces shall not be permitted. Outside panels shall not be drilled or welded for attaching wires, resistors or other devices where such holes or fastening will be visible from the front of the panel. All screws and bolts used for assembling members and panels and for mounting wire cleats and devices shall be provided with lock washers or other locking devices. Vertical edges of panels shall be formed and bolted together in such a manner that no part of edges are exposed to view. The panels shall not deviate more than 1.6 mm from the true plane. To prevent warping of panels, all heavy devices shall be adequately supported by means of rear mounted brackets or straps.

The cubicles shall be constructed from a minimum of 2.0 mm sheet steel with edges formed into a rectangular pattern or welded to steel shapes so that each section is rigid and self-supporting and enclosed.

The panels, trim, doors and frames shall match and shall present a neat appearance when assembled. Electrical clearance shall be provided without cutting away the adjacent steel framework. Vents or louvers shall be provided, where required, to give adequate ventilation. All ventilation openings and all opening in the floor shall be provided with screens to prevent entrance of insects and rodents. Thermostatically controlled heaters with switches shall be furnished for prevention of condensation. Heaters shall be suitable for auxiliary power supply specified in the Technical Data Sheets of the telecommunication equipment.

The design of the cubicle and arrangement of devices shall be such that adequate space is provided for inspection and maintenance of wiring, terminals and equipment. Equipment inside the panels shall be so mounted that the studs of the equipment mounted on the panels will be accessible without removing any device. American Standard device number shall be used and marked on the rear of the panels near the corresponding device. The device numbers shall be marked legibly with permanent marking fluid that will form a contrast with the panel finish.

The dimensions of a cubicle shall be as follows unless otherwise specified in bid drawings and/or the Technical Data Sheets:

a. Depth 700 mm (maximum)
b. Width 750 mm (maximum)
c. Height 2200 mm (maximum)

EW-1.16.12 Facilities for Relay Testing and Maintenance

The design of the protection system shall allow easy maintenance of its functions. It shall be possible to check the operating levels and each of the functions separately. The whole functional unit shall also be able to be tested. All tests shall be performed from the front panel. Provisions for push button functional test of the relay shall also be preferably available.

An independent test facility for each individual protective relay, although several relays may be connected together in a common cubicle, shall be provided. While one relay is being tested the other relays shall remain in operation.

The test facilities shall include a permanently mounted test block and shall be paired with a test plug. Switching and isolation of inputs/outputs by means of electrically-operated auxiliary relays is not acceptable. The test facilities may be supplemented by a manually-operated switch, if necessary to comply with all provisions stated below. Details of the test facilities shall be submitted for approval before being used.

The following shall be accomplished automatically and in a safe sequence, to prevent spurious tripping and ensure safety of personnel, when the test position is selected or when the test plug is inserted into the test block:

a. Isolate the tripping circuits, teleprotection signaling circuits, breaker fail and other circuits which could affect the tripping functions.

b. Isolate the relay under test from the CT circuit while maintaining the CT through connection to other relays or instruments in the series-connected chain without opening the circuit at any instant. This process shall not require the test technician to connect external shorting wires before inserting the plug.
c. Isolate the relay from the VT circuit
d. Isolate DC auxiliary supply (optional)

A separate single-finger test plug which can be inserted into the test block, to connect a test instrument, to allow measurement of current or voltage magnitudes and phase angles shall also be provided.

The test plug shall be designed to provide protection to personnel should an open-circuit develop on the external circuit to the test instrument, by shorting the test finger when the voltage across the open CT circuit exceeds a dangerous level not more than 200V.

Means of allowing secondary injection of test currents and voltages using standard 4-mm banana plugs should be provided on the test facilities.

Provide monitoring points on the test block/plug to monitor status of test points such as relay starts, phase selection, trips for each phase, and other critical functions by means of contacts to be connected to the test equipment.

Provide, for each cubicle, a set of test cables with a length of at least 2.5m, to connect the relay under test to the test equipment. It shall include all the wires to monitor all the circuits and inject currents and voltages.

Provide diagnostic and extender cards as well as suitable test probes to match internal test points of the relays to facilitate testing and trouble-shooting.

It shall also be possible to close the cubicle door, even when a block plug is used for disabling operation or tripping of the relay.

EW-1.16.13 Current Circuit

The relay protection shall be designed for a rated current, which corresponds to the secondary rated current of the current transformers. The relay protection shall be dimensioned on current transformers with data in accordance with the apparatus specifications in this document.

The current circuit shall be earthed in the junction box nearest the current transformer in the switchgear. In the case of summation of currents by direct galvanic connection, the circuit may only be earthed at one point and in the junction box nearest the current transformers.

In the first junction box in the substation yard, provisions shall be made for short-circuiting the current circuit in a simple manner. This can be arranged with a suitable design of the terminal block.

Separate current transformer cores shall be used for relay set 1 and 2.

EW-1.16.14 Voltage Circuit

The relay protection shall be dimensioned on the basis of capacitive voltage transformers with data in accordance with the apparatus specification in this document.

The secondary windings of the voltage transformers in the various phases shall be interconnected and earthed in the junction box nearest the voltage transformers. The interconnecting and earthing shall be carried out in such a manner that a correct reflection of the primary voltage will be obtained. No earthing, in addition to the above, may be employed in the galvanic connection parts of the voltage circuits.

The voltage circuit shall be divided into separate groups for relay set 1 and 2. A group for the protective relays must not be used for any other purpose. All subdivisions into groups shall be carried out in the junction box nearest the voltage transformer, where the various groups shall also be individually protected against short circuits with miniature circuit breakers.

The following general functional requirements shall be fulfilled:

For Miniature circuit breakers:

The miniature circuit breakers shall be placed in the junction box nearest the CVT.

The miniature circuit breaker shall be provided with electromagnetic and thermal protection elements.

The miniature circuit breaker shall have potential free contacts for blocking purpose and signaling.

EW-1.16.15 Relay Panel Accessories

Terminal Blocks

Terminal blocks shall be mounted so as to give easy access to wires terminations and ferrules and shall give a clear view of the arrangement of cable tails. The AC, DC current and voltage transformer inputs shall be separately grouped and adequately protected. Each wire shall be connected to an individual terminal which shall have a clearly lettered marking strip corresponding to the wiring diagram. To allow for extensions and alterations, approximately 25% extra terminals should be provided per terminal block.

Terminal blocks for control wiring shall be rated not less than 30A, 600V with barriers of the type approved by the NPC.

Isolation-type terminal blocks shall be provided for the auto-reclosing scheme isolation for all external alarms on each panel. Isolation-type terminal blocks for the sequence of events and transient fault recorder terminals shall also be provided. Shorting type of terminal blocks for current circuit isolation to transient fault recorder shall be provided.

Terminal blocks shall not have more than twelve positions per block, shall be rated 600 volts, 30 amperes, shall be one-piece type and shall have vinyl marking strips. They shall have terminal screws on both sides; box clamps or saddle clamp terminals are not acceptable. No live metal shall be exposed at the back of the terminal blocks.

Every terminal point shall have individual and complete identification identical to those on the wiring diagrams and shall be acceptable to NPC. Terminals for NPC's external connections shall be arranged for consecutive connections of conductors within one cable. Only one external wire will be connected to each outgoing terminal point. Wires (usually three to five, including ground isolating jumpers) for a given current transformer or voltage transformer circuit shall be connected to a single terminal block; they shall not split between two blocks.

Nameplates

Each piece of equipment mounted on or inside the panels shall be provided with a nameplate. Nameplate shall be made or laminated black surface, white core micarta or sheet plastic with lettering engraved on the black surface exposing the white core. Single phase items shall be identified by nameplates as to the particular phase in which they are connected. Nameplate size shall be approximately 25 by 75 mm or 50 by 150 mm. The nameplates shall be fastened to the panels with black finished round-head screws. Nameplate design shall be submitted for approval to the NPC, together with samples of engraved nameplates.

Ground Bus

A ground bus of copper bar not less than 60 sq. mm. shall be bolted to the frame of each of the panel in such a way as to make a good electrical contact. For the relay panels, a ground bus shall be provided along the front of the panel and shall be connected at each panel end to the next panel in the lineup.

The ground bus shall have drilling at each end to permit interconnections with the ground buses in adjacent units. The necessary copper bar jumpers, bolts, nuts and washers for making interconnection shall be furnished.

The ground buses in the relay panes at the left and right ends of the lineup shall be provided with a solder bus clamp type pressure connector for terminating 60mm^2 of stranded copper ground conductor.

Interior Lighting and Convenience Outlets

A switch controlled fluorescent lamp shall be installed at the top of each panel for internal illumination. The switch shall be located at a convenient height inside the unit. A duplex convenience outlet with a rating specified in the Technical Data Sheets of the equipment shall be furnished and installed in each panel at a convenient location.

The lamp switch and convenience outlet shall be located near the latch side of the door in single door panels and near the hinge side of a door in double door units. The lamp and convenience outlet shall be wired to terminal block points for connection to a power source specified in the Technical Data Sheets for the equipment.

EW-1.17 MISCELLANEOUS

EW-1.17.1 Communication

For each Local Control Panel in the switchyard (control cubicle of circuit breaker, transformer control cubicle, Bay Control Unit (BCU) building (if BCU is required outside of the Control Room) and marshalling kiosk), a telephone connection to the Control Room shall be provided to enable reliable communication with a mobile telephone set at any time.

EW-1.17.2 Provisions for Erection and Installation

All parts of the equipment to be assembled on site must be connected by means of screws and bolts/nuts, welding is not acceptable except for accessories and where expressly stated.

It must be possible, except in particular cases, to introduce and draw out all the indoor equipment through the doors or opposite opening.

EW-2.0: POWER TRANSFORMER INSTALLATION

EW-2.0 SCOPE

EW-2.0.1 General

This specification covers the technical and associated requirements for the installation of outdoor, oil filled, power transformers in an electric substation or power generating station.

It is not NPC's intent to specify all technical requirements for installation nor to set forth those requirements covered by applicable codes and standards. The Contractor's work shall meet the requirements of this specification and industry standards.

The Contractor shall bear full responsibility that the equipment has been installed and erected, tested and commissioned (if required in his services), in accordance with all codes, standards and applicable governmental regulations and performs under the conditions and to the standards specified herein.

This specification shall be used in conjunction with Manufacturer's drawings, instruction books, and drawings provided by NPC. In the event of conflict within these documents, Contractor shall inform NPC of the conflict in writing for written resolution prior to performing the work.

EW-2.0.2 Works to be Provided by the Contractor

The Contractor shall provide the services delineated in Paragraph A.2, Section B-2.0 of the Technical Data Sheets. Any tools, materials, labor and other incidentals necessary in providing these services shall be provided by the Contractor to place the transformer(s) in satisfactory condition for operation.

EW-2.0.3 Works to be Provided by NPC

NPC shall provide the materials and services listed in Paragraph A.2, Section B-2.0 of the Technical Data Sheets.

EW-2.1 CODES AND STANDARDS

EW-2.1.1 General

The work provided by Contractor shall be in accordance with this specification and shall comply with, but not be limited to, the following codes and standards, including all addenda, in effect at date of the Contract unless otherwise stated in this specification:

ANSI/IEEE	-	American National Standards Institute and/or Institute of Electrical and Electronics Engineers
C57.12.80	-	IEEE Standard Terminology for Power and Distribution Transformers

C57.12.90	-	Standard Test Code for Liquid-Immersed Distribution, Power and Regulatory Transformers (Sections 90-2, 90-3, 90-5 and 90-7)
C57.70	-	Terminal Markings and Connections for Distribution and Power Transformers
AWS	-	American Welding Society
D1.1	-	Structural Welding Code

These codes and standards set forth minimum requirements which may be exceeded by Contractor if, in Contractor's judgment and with NPC's acceptance, superior or more economical installation procedures or materials are available for successful and continuous operation of the equipment.

In addition to the above codes and standards, Contractor shall comply with all applicable National and Local laws, codes and regulations.

In the event of any apparent conflict among standards, codes or this specification, Contractor shall refer the conflict to NPC for written resolution.

EW-2.2 GENERAL REQUIREMENTS

EW-2.2.1 Welding

All welding by Contractor shall be performed in accordance with the following:

Welds shall be continuous, using proper rod and welding heat and shall have sufficient penetration and dimension to develop full strength of the attached member(s). Finished welds shall be chipped, ground or power wire brushed to remove welding slag, splatter, or other contaminants, after which surfaces shall be painted with zinc-rich paint. Welding shall be performed in accordance with AWS D1.1.

Inspection of welding shall be the responsibility of Contractor.

EW-2.2.2 Fitting, Alignment and Tolerance

The erection and connection of transformers shall be performed so that the equipment is in alignment with the other components without causing any supplemental stress in joints, supports and connections. The equipment Manufacturer's instructions for alignment shall be followed.

Installed transformers shall be erected plumb and/or level and square and in alignment with other equipment. Individual pieces shall be within the tolerances recommended by Manufacturer or as otherwise specified on the drawings.

NPC shall be informed of any major misalignment and misfits and the work shall be stopped until NPC provides revised instructions. However, correction of minor misfits and a reasonable amount of reaming or punching of blind holes shall be considered a legitimate part of erecting structures. Reamed and field drilled or punched holes shall be deburred, cleaned and touched up with zinc-rich paint before connections are finally made up. Any other raw surfaces, such as from any necessary coping of steel, shall be smoothed by grinding or other suitable means, cleaned and touched up with the aforementioned zinc-rich paint applied in accordance with Manufacturer's recommendations.

EW-2.2.3 Field Fabrication and Assembly

For that equipment and material not completely assembled or fabricated when shipped, Contractor shall fabricate and/or assemble such equipment and material in accordance with detail drawings and instructions furnished by NPC. Contractor shall check his effort against field conditions to avoid conflicts and interference.

EW-2.2.4 Installation

EW-2.2.4.1 General

Transformers shall be checked for contamination in accordance with Paragraph EW-2.3 of technical specifications.

Manufacturer's instructions shall be checked to determine if oil filling to a point above the coils is required prior to opening the transformer. When a transformer is shipped in nitrogen or dry gas, the tank shall be opened or the gas-tight seal broken in dry weather only. Days of high humidity should be avoided if possible. It is required that the temperature of the core-and-coil assembly be a few degrees centigrade higher than the ambient temperature to prevent condensation of moisture on the core-and-coil assembly.

If a temporary shipping cover is used, it shall be replaced with the permanent cover, and the transformer pressure tested. The transformer shall be evacuated and filled with dry air, making certain that oxygen content of the entire gas space is at least 19.5 percent as required by OSHA. During the following internal work, a continuous supply of dry air shall be maintained for the safety of personnel, and to minimize the entrance of moisture. If internal work will take more than one day, the transformer shall be sealed under positive pressure until the work recommences. The transformer shall then be purged with dry air before work is resumed.

A thorough internal inspection of the transformer shall be made in accordance with EW-2.3 technical specifications.

External transformer power, control and instrumentation connections, including equipment ground connections, shall be made in accordance with drawings, Control Wiring Diagrams, applicable installation notes and details and grounding notes and details.

Any temporary equipment grounds used for personnel safety during equipment installation (e.g., Paragraph EW-2.2.4.4) shall be removed prior to transformer testing.

After the transformer has been assembled and oil filled, it shall be tested in accordance with these technical specifications.

EW-2.2.4.2 Assembly of Fittings

After the internal inspection has been completed, the bushings and radiators or unit coolers shall be installed. The radiators, coolers, and bushings will be handled in different ways as prescribed by Manufacturer of the equipment, but in general should be lifted in a vertical position during handling and installation.

Bushings shall be clean and dry when installed. Installation shall be in accordance with Manufacturer's instructions. Gaskets and gasket recesses shall be carefully cleaned. Gaskets shall be carefully placed and uniformly clamped so that tight seals are formed. Current-carrying connections shall be thoroughly cleaned and solidly bolted. Belleville type washers, if used, should be depressed to the extent specified by Manufacturer. Mechanical loading on ends of bushings should not exceed design limits.

Radiators or heat exchangers, oil piping valves, and fittings should be thoroughly cleaned and flushed with clean, warm 25°-34°C (80°-100°F) oil before being fitted to the transformer. All gaskets shall be properly seated on the gasket seats at the time of installation. Where necessary to mount a gasket in a vertical plane, the use of gasket cement to hold the gasket in place during installation may be required. If radiators or heat exchangers are not capable of withstanding full vacuum, they shall be left off until after the tank has been filled with oil under vacuum (refer to Manufacturer's instructions).

The de-energized tap changer, oil-level gauge, temperature gauges and other accessories (including neutral grounding equipment, if provided) shall be assembled and internal connections made in accordance with Manufacturer's instructions and control wiring diagrams. The operation of the tap changer shall be checked to be sure that it operates properly in both directions and that full contact area on all taps and adequate contact pressure is maintained on all contacts. The operation of the oil-level gauge shall be checked before sealing the tank.

Care shall be exercised to assure that the welded-in, threaded studs or bolt hardware are not overstressed when installing parts removed for shipment. The maximum torque applied to the threaded fasteners shall be in accordance with Manufacturer's instructions. A torque wrench shall be utilized.

Because of the different types of transformer expansion tank constructions used by the various manufacturers, Contractor shall follow the detailed instructions supplied by transformer Manufacturer for assembling and mounting the transformer expansion tank.

Caution: Do not apply any power or test voltage to the transformer windings or connections when the transformer is partially filled or completely drained of oil.

EW-2.2.4.3 Transformer Dry Out

The transformer insulation shall be checked for moisture content to determine if transformer dryout is necessary. Dewpoint measurement is generally recommended for gas filled transformers; however, there are several other methods for determining moisture content depending whether the transformer was stored (or shipped) gas filled or oil filled. Manufacturer's instructions shall be followed for the recommended procedure and dryness criteria. If dryout is not necessary, transformer shall be filled with oil immediately.

If dewpoint measurement is utilized for measuring or monitoring transformer moisture content, the following precautions shall be taken:

a. Equilibrium conditions must be reached between the air or gas and the surface of the insulation. This takes a minimum of 24 hours between gas-filling and dew point measurement.

b. Insulation temperature must be known accurately.

c. The measuring equipment must be properly calibrated and be in good working order.

d. It may be necessary to remove the dewpoint probe or other detector after each use to minimize the risk of oil vapor and splashed oil contamination, which will destroy the equipment's calibration.

NPC shall be notified if transformer dryout is required, as determined above. Manufacturer's recommended dryout procedure shall be followed prior to oil filling. The preferred method is the use of high vacuum. If the insulation temperature is below 50°F, drying by high vacuum is accompanied by circulating hot oil (Caution: The oil may become hot enough to cause burns). The use of short-circuited windings or hot air for transformer dry out shall be avoided. Moisture content shall be monitored during the dry out process.

Manufacturer's specific instructions shall be followed regarding transformer sections requiring the simultaneous pulling or breaking of vacuum to prevent overstressing of transformer walls or barriers (i.e., load tap changers).

All removable vacuum and tank braces shall be installed prior to pulling vacuum.

Manufacturer's specified position (open-closed) for all transformer valves shall be checked prior to pulling vacuum.

After the transformer insulation dry out is completed in accordance with Manufacturer's acceptance criteria, the transformer shall be immediately filled with oil.

EW-2.2.4.4 Oil Filling

Caution: Oil passing through pipe, hoses, tanks and filter papers may acquire an electrostatic charge which will be transferred to the transformer windings as the transformer is filled. Under some conditions the electrostatic voltage on the winding may be hazardous to personnel or equipment. To avoid this possibility, all externally accessible transformer terminals, as well as the tank and oil filtering equipment, shall be grounded during filling.

The dielectric strength of the oil shall be tested while still in the tankers or delivery containers in accordance with IEEE 64, Section 3 (Table 2). A certified test report shall accompany each oil shipment.

Manufacturer's piping connections for oil filling under vacuum shall be utilized. In addition, precautions mentioned in Paragraphs EW-2.2.4.3 of technical specifications shall be followed.

Transformer shall be vacuum filled in accordance with Manufacturer's recommended procedures and criteria. (Caution: Do not allow transformer oil to enter the vacuum pump). If, for any reason, a modification or change to the recommended oil filling procedure is required, NPC shall be notified and written concurrence obtained so as to preclude violation of the transformer warranty.

A vacuum shall not be pulled on a transformer tank filled or partially filled with oil. First, existing oil shall be drained while admitting dry air, and then the transformer refilled under vacuum.

After oil filling is accomplished, the vacuum shall be broken in accordance with Manufacturer's recommended procedures.

EW-2.2.5 Marking and Identification

All electrical equipment shall be properly marked to facilitate easy and accurate identification by NPC and others. Electrical equipment if supplied by NPC, will have Manufacturer's nameplates with adequate identification attached. If, for any reason, this nameplate is missing, Contractor shall request a replacement from NPC and reinstall it in accordance with equipment drawings. Missing nameplates due to fault of Contractor, shall be replaced by the Contractor with the same quality and materials as the original one or shall be paid by the Contractor at an amount given by the manufacturer of the equipment to the NPC.

All equipment terminals shall be marked by Contractor to facilitate correct phasing and circuit connections. Such markings shall be made permanent for the use of NPC and others.

Identification markings by Contractor shall be legible and located for easy reading. Any nameplate supplied by Contractor shall be corrosion resistant.

EW-2.2.6 Cleaning, Flushing and Lubrication

At the time of completion of the installation, the equipment shall be clean inside and outside.

All waste such as metal chips or filings, welding stubs, dirt, rags, debris and any other foreign material shall be removed from the interior of each component. All rust, oil, grease, chalk, crayon or paint marks and other deleterious material shall be removed from all interior and exterior surfaces.

After having completed the foregoing, all bearings on fans and pumps shall be thoroughly lubricated in accordance with Manufacturer's instructions to be ready for operation.

EW-2.2.7 Repair of Finished Paint Surfaces

A finish coat of paint shall be applied to the equipment at the factory; however, surfaces shall be cleaned and touched up or refinished where soiled or marred as a result of handling at the site.

EW-2.3 QUALITY ASSURANCE REQUIREMENTS

EW-2.3.1 Testing, Inspection and Examination

EW-2.3.1.1 Receiving - External Inspection

An external inspection of the transformer shall be made upon receipt before the unit is removed from the transporting vehicle. The transformer (and accessories) shall be checked for obvious signs of damage. This inspection shall include the following:

The impact recorder charts shall be checked for accelerations in excess of Manufacturer's recommendations. The impact recorder charts shall be signed by NPC, the Carrier's agent (transporter) and Manufacturer's representative. The chart should be returned to Manufacturer and an impact summary report requested. Where possible damage is indicated, NPC and Manufacturer shall be notified for recommendations before transformer is unloaded.

Guy wire tension, tie rods, blocking, and welds to the transporting vehicle shall be checked to determine whether the transformer has shifted from its original loading position.

Contractor shall visually check for external damage to the transformer case, cover, drain valve, cooler valves, or any other external accessories mounted on the transformer during shipment.

Check shall be made for transformer contamination by atmospheric air or moisture by checking the gas pressure in the tank and supply cylinder (if provided), and by measuring the oxygen content and the dewpoint. If the gas pressure, oxygen content or dewpoint are over Manufacturer's prescribed values, a dryout may be necessary in accordance with Paragraph EW-2.2.4 and Manufacturer and NPC shall be notified. (Note: Do not use a mercury manometer to measure pressure or vacuum. Possible mercury contamination of the transformer must be avoided).

For smaller transformers, shipped with oil, oil leaks and oil moisture content shall be checked. The pressure in the gas space shall be verified in accordance with procedures outlined for gas filled units.

Transformer accessories, separately loaded and shipped for assembly with the transformer on location, shall be inspected for damage or mishandling during shipment.

EW-2.3.1.2 Receiving - Internal Inspection

An internal inspection of the transformer shall be made before the transformer is removed from the transporting vehicle if allowed by the Carrier. If it is not allowed, it shall be noted on the acceptance slip that there are possible internal or hidden damages. The internal inspection shall be made at the place where the unit is initially unloaded (minimum handling). This inspection shall include the following:

NOTE: THE TRANSFORMER SHOULD NOT BE ENTERED UNTIL THE NITROGEN OR OTHER GAS IS COMPLETELY PURGED WITH DRY AIR. OSHA REGULATIONS REQUIRE THAT THE OXYGEN CONTENT OF THE ENTIRE

GAS SPACE BE AT LEAST 19.5 PERCENT FOR THE SAFETY OF PERSONNEL.

Any indications in shifting of the transformer core or blocking and bracing materials used to prevent movement of the transformer and load tap changer internals during shipment shall be noted.

Dirt, broken parts, metal particles, moisture or any other foreign materials shall be noted.

Winding and accessory leads shall be checked for frayed insulation as well as bushing pulls through leads, for bare spots.

Internal current transformers including supports shall be checked for tightness.

All electrical connections shall be checked for clearance and tightness of all studs, nuts, bolts, terminals, etc. (including ground straps).

For smaller transformers, shipped with oil, the above listed visual inspection checks can be made through the liquid using a weighted explosion-proof lamp. A lamp cord having synthetic insulation should be used. Do not use a cord with natural rubber insulation. Lamp should not be energized until fully submerged in the oil to reduce thermal shock.

EW-2.3.1.3 Storage

Transformers stored gas filled shall have pressure and ambient temperature readings taken every day for the first two weeks and then at weekly intervals. Monthly dewpoint measurements shall also be taken.

Transformers stored oil filled shall have the tank pressure (pressurized space above the transformer oil) recorded daily for the first two weeks and then at weekly intervals. Oil levels shall be checked and dielectric tests of the insulating oil shall be made monthly.

EW-2.3.1.4 Inspection before Installation

A thorough internal inspection of the transformer and loose equipment shall be made prior to installation in accordance with Paragraph EW-2.3.1.2 and the following:

Manufacturer's instructions and drawings shall be consulted for location of shipping blocking (major and minor) and removal procedures.

Tap changer (if provided) shall be inspected, including removal of shipping blocking and checking of contact wipe and pressure in accordance with Manufacturer's instructions.

Manufacturer shall be notified if any foreign material is discovered inside the transformer or if any discrepancies are found during inspection.

EW-2.3.1.5 Test after Installation

After the transformer has been assembled and filled with oil, the following tests shall be made to ensure that the transformer is ready for service, and to provide a basis for comparison with future maintenance tests:

a. Insulation resistance test on each winding to ground and between windings in accordance with Manufacturer's procedures and criteria;

b. Power factor test on each winding to ground and between windings;

c. Power factor test on all bushings equipped with a test tap or capacitance tap. Polarity check on all instrument transformers;

d. Winding ratio test on each tap. If the transformer is a load-tap-changing transformer, the winding ratio shall be checked on all load-tap-changing positions; and

e. Frequency Response Analysis (FRA)

Winding resistance of all windings shall be checked with a Kelvin bridge and compared with factory test results.

Operation of oil and hot-spot temperature indicating and control devices shall be verified.

Dielectric strength, power factor, interfacial tension water content, gas content, neutralization number and condition of the oil shall be checked in accordance with IEEE 64, Section 3 (Table 4).

Oxygen and total-combustible-gas content of nitrogen gas cushion shall be checked.

Operation of auxiliary equipment such as oil-circulating pumps, fans, and oil or water flow meters shall be verified in accordance with Manufacturer's instructions.

Operation of load-tap-changer shall be verified for all positions.

The dielectric strength of the oil shall be tested while still in the tankers or delivery containers in accordance with IEEE 64, Section 3 (Table 2). A certified test report shall accompany each oil shipment.

EW-2.3.2 Records, Documentation and As-Built Drawings

Contractor shall maintain records and shall furnish copies of such records as requested by NPC. The records shall include, but not be limited to, the following:

Test results during storage and before and after installation, together with the relevant ambient conditions, as well as inspection and test results made upon equipment receipt.

Marked up drawings or other documents showing any conflict discovered in drawings, specifications or other documents furnished to Contractor. The resolution of these conflicts shall be documented as appropriate on as-built drawings prepared by Contractor; such drawings may, if NPC agrees, be drawings duly marked up.

All field engineering sketches, drawings and other documents prepared by Contractor during the execution of the work.

Certified copies of test, inspection and examination results.

The documents shall be typewritten, shall be under Contractor's official name, and shall be signed by Contractor's representative at the site as well as by the person preparing the document or performing the test.

EW-2.4 HANDLING, STORAGE AND PROTECTION

EW-2.4.1 Handling

Receiving, unloading, storage, removal from storage, uncrating and handling of the equipment shall be performed in accordance with this specification and Manufacturer's instructions.

The transformer should always be handled in the normal upright position unless information from Manufacturer indicates it can be handled otherwise. Where a transformer cannot be handled by a crane or moved on wheels, it may be skidded or moved on rollers or slip plates (at least two pulling eyes shall be used when moving transformer), depending upon compatibility of the transformer base design and the type of surface over which it is to be moved. Transformers built in accordance with current standards have bases designed for rolling in two directions.

Lifting with Slings: The lifting lugs and eyes provided on the transformer are designed for vertical lift only; therefore, lifting cables must be spread apart by means of a lifting beam or spreader. As an added precaution to prevent buckling the tank walls the cover should always be securely fastened in place. The approximate total weight of the transformer and the weight of transformer shipping parts are given on the nameplate and on Manufacturer's outline drawing.

Raising with Jacks: Jack bosses or pads are provided on large power transformers so that the transformers can be raised by means of jacks. On some transformers, jacks may be placed under the transformer bottom plate at points designated by Manufacturer. Manufacturer's instruction book or drawings should be consulted.

The transformer may be equipped with lifting jack bosses or pulling eyes that are removed for shipment. The special hardware provided must be used. Do not use substitutes. Manufacturer's drawings and instruction book shall be referred to when bolting the parts in place.

Equipment shall be checked for complete drainage of water and be thoroughly dry. When such draining requires removal of plugs, drain valves, etc., Contractor shall ascertain that these parts are reinserted.

EW-2.4.2 Storage

Equipment shall be shipped prepared by Manufacturer for one year of field storage. Contractor shall check these provisions upon receipt. If found to be incomplete, Contractor shall restore these provisions as required.

Storage shall be in an environment similar to the installed location, i.e., indoor equipment will be stored indoors (generally without heating and ventilation), and outdoor equipment may be stored outdoors. Electric space heaters installed by Manufacturer shall be energized from appropriate power supply immediately upon arrival. Supplementary heat sources should be provided if deemed necessary by either Contractor or NPC. Desiccants furnished with the equipment shall be inspected at regular intervals and dried as required.

Transformers shall preferably be stored in their permanent location to minimize handling.

Transformers may be stored gas filled for the length of time specified by Manufacturer. Contractor shall warn NPC if it becomes apparent that this time may be exceeded.

Due to differences in transformer tank design and sealing systems, Manufacturer's procedures for storing transformers gas-filled shall be followed. This may involve installation of a gas bottle, regulator, bottle pressure gage (with alarm), tank pressure gage, low pressure alarm, and pressure relief valve.

When storing transformers gas filled, pressure and ambient temperature readings shall be taken every day for the first two weeks and then at weekly intervals. Monthly dewpoint measurements shall also be taken.

The preferred method for long-term storage of large transformers is to store them assembled (to the extent practical) and oil filled. Refer to Paragraph EW-2.2.4 for oil filling procedures.

When stored oil filled, refer to Manufacturer's procedures for tank oil levels (usually higher when in storage) and for pressurizing the space above the transformer oil. Low oil level and pressure alarms shall be provided.

When stored oil filled, the tank pressure (pressurized space above the transformer oil) shall be recorded daily for the first two weeks and then at weekly intervals. Oil levels shall be checked and dielectric tests of the insulating oil shall be made monthly.

Transformer accessories when not immediately installed shall be properly stored to protect against moisture, dirt, foreign materials and loss. Manufacturer's instructions shall be checked to determine which accessories require special storage (i.e., bushings, fan motors, pumps, gaskets, tape, relays, gages, valves, etc., require clean, dry, heated indoor storage).

Oil filled condenser bushings shall be stored in the proper orientation (i.e. 20 degrees minimum) to avoid damage. Consult Manufacturer's instructions for direction.

All components which are to be oil filled and are not immediately installed in or on the transformer shall be pressurized with dry air or nitrogen and checked for leaks (particularly around the shipping covers). A positive pressure should be left in these items (i.e., radiators, coolers, top section of a split tank, expansion tank, LTC, etc.). Items stored outdoors shall be stored up off the ground and covered by tarpaulins.

EW-2.4.3 Protection

Arrangements shall be made for the presence of representatives of Manufacturer, Carrier and NPC at the time of receipt of large power transformers and their components.

An external inspection of the transformer shall be made in accordance with Paragraphs EW-2.3.1.

An internal inspection of the transformer shall be made in accordance with Paragraphs EW-2.3.1.

If any indication of damage is evident, no further action shall be taken until a resolution of the problem has been made.

EW-2.4.4 Receiving

All openings and machined surfaces shall be provided with protection to prevent damage, corrosion and entrance of foreign matter during storage.

To protect galvanized and finished surfaces during material handling, slings or other devices in contact with the surfaces shall have adequate backing of soft material to prevent damage.

Nobody shall be permitted to work above an open transformer tank without first removing all loose articles from his person.

All tools should be tied with clean cotton tape or seine cord securely fastened to the outside of the transformer tank or an accessible point inside the tank. Tools with parts, which may become detached should be avoided.

EW-2.5 ACCEPTANCE TESTING

EW-2.5.1 General

If required in the Technical Data sheets of Section B-2.0, the Contractor shall perform all tests specified by equipment Manufacturer, applicable standards and as necessary to verify the proper operation of the equipment. All tests shall be performed in the presence of the NPC or his representative(s).

The Contractor shall provide five (5) copies of the certified test to NPC immediately upon completion of field tests.

These tests shall include as a minimum the following:

a. Insulation resistance (at 2.5 kV)
b. Insulation resistance (at 2.5 kV) of core and from to earth

c. Winding resistance on all windings and all taps
   - Tap changer (both local and remote)
   - Cooling equipment (if any)
   - Other ancillary equipment

e. Operation of all controls, trips and alarms, i.e. fans and pumps controls (if any), hot oil trip and alarm, hot winding trip and alarm, CT wiring

f. Voltage ratio, vector group and polarity

g. Pressure test

h. Moisture content and electric strength of oil before filling

i. Oil quality check (DGA, resistivity)

EW-3.0 POWER CIRCUIT BREAKERS

EW-3.1 SCOPE

EW-3.1.1 General

This specification covers the technical and associated requirements for ac power circuit breakers rated 69 kV and above, and associated equipment for use in electric power generating stations, switchyard and substations.

It is not NPC's intent to specify all technical requirements nor to set forth those requirements adequately covered by applicable codes and standards. Contractor shall furnish high quality power breakers meeting the requirements of these specification and industry standards.

The Contractor shall bear full responsibility that the equipment has been designed and fabricated in accordance with all codes, standards, and applicable governmental regulations and performs under the conditions and to the standards specified herein.

No departure shall be made from these specification and standards unless waived or modified in writing by NPC. The Contractor shall obtain from its subcontractors a statement as to the compliance with this specification without exception and/or if there are any exceptions, these shall be described in detail and included in the Contractor's proposal. The Contractor shall add a statement that no other exceptions are taken to this specification.

Unless portions are specifically indicated as applying to a certain type of circuit breaker (gas, blast, oil), requirements are applicable to all circuit breakers in this specification.

EW-3.1.2 Works to be Provided by the Contractor

The Contractor shall provide the power circuit breakers, accessories and services delineated in Section B.1.0 of the Technical Data Sheets.

EW-3.1.3. Works to be Provided by NPC

NPC will provide the materials (if any) and services listed in Section B.1.0 of the Technical Data Sheets.

EW-3.2 CODES AND STANDARDS

EW-3.2.1 General

The power circuit breakers furnished shall be in accordance with, but not limited to, the latest issues of the following applicable standards, including all addenda, in effect at time of purchase order unless otherwise stated in this specification. These shall include:

ANSI / IEEE	**American National Standards Institute and/or Institute of Electrical & Electronic Engineers**
C2	National Electrical Safety Code
C37.04	Rating Structure for AC High-Voltage Circuit Breakers, including Supplements
C37.09	Standard Test Procedures for AC High Voltage Circuit Breakers rated on a Symmetrical Current Basis
C37.010	Standard Application Guide for AC High Voltage Circuit Breakers rated on a Symmetrical Current Basis
C37.011	Application Guide for Transient Recovery Voltage for AC High Voltage Circuit Breakers rated on a Symmetrical Current Basis
C37.012	Application Guide for Capacitance Switching for AC High Voltage Circuit Breakers rated on a Symmetrical Current Basis
C37.081	Guide for Synthetic Fault Testing for AC High Voltage Circuit Breakers rated on a Symmetrical Current Basis
C37.082	Standard methods for Measurement of Sound Pressure Levels for AC Power Circuit Breakers
C37.90	IEEE Standard for Relays and relay Systems associated with Power Apparatus
C37.90.1	IEEE Standard for Surge Withstand Capability (SWC) tests for Protective relays and Relay System
ICBO	**International Conference of Building Officials**
UBC	**Uniform Building of the International Conference of Building Officials, Section 2312 - Earthquake Regulations**
IEC	**International Electrotechnical Commission (all parts of listed standards apply)**
60056	High-Voltage Alternating Current Circuit Breakers
60060	High Voltage Test Techniques Part 1 and Part 2
60071	Insulation Coordination (Parts 60071-1, 60071-2, 60071-3)
60267	Guide to the Testing of Circuit Breakers with respect to Out-of-Phase Switching
60376	Specification and Acceptance of New Sulfur Hexaflouride
60427	Report on Synthetic Testing of Circuit of High-Voltage AC Circuit Breakers
60480	Guide to the Checking of Sulfur Hexaflouride taken from electrical equipment
60474	Insulating oils (Part 60474-1, 60474-2, 60474-3)
60529	Classification of Degrees of Protection Provided by Enclosures
60567	Testing under Asynchronous Conditions
60694	Common Clauses for High Voltage Switchgear and Control Gear Standard
61634	SF6 Usage and Handling

ISO	**International Standards Organization**
9001	Quality System Model for Quality Assurance in Design/Development, Manufacture and Testing
9002	Quality System Model for Quality Assurance in Production, Installation and Servicing
SSPC	**Steel Structures Painting Council**
SP1	Solvent Cleaning
SP3	Power Tool Cleaning
PA1	Shop Field and Maintenance Painting
PA2	Measurement of Dry Paint Thickness with Magnetic Gages

These codes and standards set forth the minimum requirements which may be exceeded by Contractor if, in Contractor's judgment and with NPC's acceptance, superior or more economical designs or materials are available for successful and continuous operation of Contractor's equipment as required by this specification.

EW-3.3 TECHNICAL REQUIREMENTS

EW-3.3.1 Description of Services

The ac power circuit breakers together with the associated equipment with a rating of 69kV and over will be used either in electric power generating station, switchyard(s) or substation.

All materials and parts, which are not specifically mentioned herein but are necessary for the proper erection, assembly and safe operation of the circuit breaker, shall be furnished at no increase in cost to the NPC.

EW-3.3.2 Design Requirements

EW-3.3.2.1 General

The circuit breakers (all types) shall be capable of interrupting successfully its rated interrupting current for its entire operational life. It shall also be capable of withstanding all system lightning impulse and switching overvoltages less than or equal to its BIL or switching surge withstand capability. Generally, the circuit breaker shall meet or exceed all rated values listed in applicable ANSI standards or IEC standard.

Gas circuit breakers shall be provided with properly sealed system that will remain gas tight for the life of the breaker. Alarm devices activated internal gas pressure shall be provided in order to annunciate gas leaks.

The manufacturer must specify maximum and minimum SF6 pressures for the gas circuit breaker.

The capacity of energy facilities which are an integral part of the breaker shall be of sufficient size to permit at least two complete closing-opening operations, starting at normal working pressure and without replenishing the stored energy, at rated short-circuit current or at related capabilities.

Each circuit breaker shall be equipped with an operation counter. The preferred arrangement for this device is to operate only during the opening cycle of the circuit breaker operation. The counter shall be capable of counting at least 9999 operation cycles. It shall not be possible to reset the counter. For electrically operated counter, it shall have the same rated voltage as the operating equipment. Vibrations in the operating mechanism shall not affect the counter function.

Multiple-pole or single-pole tripping devices shall be protected against accidental operation and conveniently located for manual tripping.

For purposes of inspection and adjustment, means shall be provided for local operation of the circuit breaker. The mechanism and the maintenance operating means for all circuit breaker types, where it is feasible, shall be so designed that a person can slowly operate the contacts for their adjustment on a de-energized breaker.

The manufacturer must specify minimum and maximum control voltages necessary to the successful operation of the breaker. These values must be in accordance with the control voltage ranges indicated in ANSIC37.06, Table 0 or IEC standards and shall be given in the Technical Data Sheets.

Breaker vessels under pressure such as oil, gas or air tanks shall be designed and fabricated in accordance with Section VIII of ASME Code.

The circuit breakers shall be capable of switching out line faults (regardless of the distance between the circuit breakers and faults), no-load lines, transformers on no-load and reactive loads without causing restriking when switching overvoltage dangerous for electrical equipment. Overvoltage and restriking when switching inductive or line charging current shall be prevented by the use of suitable resistor, condensers or other approved means. Arc-extinguishing devices of proven design shall be provided.

The life of equipment is assumed to be at least 30 years. The number of operating cycles (CO) during this time shall normally be at least 2,000 or 15,000 for circuit breakers in reactor or capacitor circuits. Linkage system as well as joints, bearing and gears shall be maintenance free for intervals of at least 10 years. However, lubrication can be accepted.

For SF6 circuit breakers, low pressure lock-out relays shall be provided in order to prevent the operation of the circuit breaker when the internal SF6 gas pressure can not attain the rated interrupting capacity of the circuit breakers. An alarm shall be given if the gas density falls to preset value and if it falls further to a specified minimum, breaker operation shall be locked.

EW-3.3.2.2 Wiring and Alarm Devices

The Contractor's wiring shall be terminated on Contractor's terminal boards or equipment with flanged spade, or indented spade type insulation gripping insulated terminals. Wire markers shall be on both ends of a wire.

There shall be no taps or splices in the wiring, and all connections shall be made to terminal studs or terminal blocks.
No solder or "push-on" or "quick" type connectors shall be used in any wiring connections except on PC boards.

Terminal boards shall be provided for all equipment controls, instrument, meters and relays requiring external connections. They shall be rated not less than 5 amperes, 600 volts and provided with barriers, marking strips and terminal screws. Each terminal point shall be marked with the designations shown on Contractor's diagrams.

A reasonable number of spare terminals shall be provided, however, not less than 15 percent of terminals on any block shall be spare.

Not more than one wire shall be connected to one terminal blockpoint. Termination of two conductors at one terminal point shall be made by suitable bridges and links of the terminal. Terminals shall be of single insertion type and shall be suitable for connection of conductors from 2.5 mm^2 up to a cross-section at least 10 mm^2. Terminals for external connections shall be arranged for consecutive connections of conductors within one cable. One external wire will be connected to each outgoing terminal point.

Terminals for external wiring connections shall be sturdy and sufficiently large to accommodate 8 mm^2 stranded wire, not more than one wire will be terminated on terminal blocks for external connections. All such terminal blocks shall be rated not less than 25 amperes.

If accidental short-circuiting of certain wires can result in closing or tripping of a breaker, these wires shall not be terminated on adjacent terminals.

Both closing and tripping circuits shall utilize a separate dc supply voltage specified in the Technical Data Sheets, provided with two pole manually operated disconnect switch at the control cubicle. Each circuit shall be protected by a circuit breaker at the remote end of voltage source. Each disconnect switch shall simultaneously open both sides of the control circuit and when opened shall prevent electrical tripping or closing of the power circuit breaker both remotely and locally.

The power circuit breaker, when specified to have duplicated tripping shall have each tripping circuit and coil galvanic separated. It shall be designated such that one of the tripping circuits would be on the same circuit of the closing mechanism of the breakers and is independent of the other tripping circuit.

Provision shall be made such that the tripping circuits shall be supervised both when the power circuit breaker is open and closed. The supervision shall include the d.c. supply, tripping coil and cables (dc supply cable and tripping cable to the power circuit breaker). The auxiliary contact for the coil shall also be included in the supervision when the power circuit breaker is closed. An abnormal condition and/or damage in two coils shall cause an alarm to be relayed to the control room.

Each DC control device, relay, indicating light, etc., shall be capable of withstanding without damage or diminished function the battery equalizing voltage (140 volts for 125 Vdc systems).

Means shall be provided for quick and convenient access, preferably by a hinged door or panel, to the control disconnecting switches and associated protective devices.

All terminals of control wires and instrument transformer circuits shall be identified by permanent marking. Physical arrangement of all wiring terminals shall be identical on all similar circuit breakers.

Auxiliary switch contacts and bearing shall be made of corrosion resistant materials; the other parts shall be treated to resist corrosion.

If circuit breakers have auxiliary systems (such as compressors, etc.) with nominal power supply voltage exceeding 120 volts, this wiring shall be separated by physical barriers from low voltage control wiring.

The Contractor shall provide terminals for NPC's incoming stranded copper cables. They shall be compression type acceptable to NPC.

Control wiring shall show device identification with identified terminals, both arranged is reasonably accurate physical relationship, and shall make use of a cross-indexing wiring diagram system. The Contractor is solely responsible for the proper functioning of the equipment being furnished.

EW-3.3.3 Design and Construction Features

EW-3.3.3.1 General

All power circuit breakers shall be mounted on steel frames and shall have clamp type terminals for connections to line/bus and ground suitable for conductor specified in the Technical Data Sheets.

Each circuit breaker shall be fitted with an easily readable "On-Off" mechanical position indicator.

The circuit breakers shall be driven by one/three operating mechanism/s possible to operate electrically from the operating mechanism or by remote. The mechanism shall also be possible to operate manually and by compressed air, oil or spring when applicable. For manual operation only a trip function is necessary.

EW-3.3.3.2 Bushings

Material, dimensions, structural characteristics and the general contour of bushings and insulators shall be in accordance with ANSI and NEMA (or applicable IEC) bushing and insulator standards. The required number of cap screws, nut and lockwashers, all galvanized as specified in ANSI or IEC insulator standards, shall be furnished.

The bushing and all porcelain shall have the same voltage class and BIL as the circuit breaker and must be suitable for the operating environment described in the Section B.1.0 of the Technical Data Sheets.

The bushings shall be designed so that when operating at normal rated voltage, there shall be no electrical discharge between conductors and bushing of a nature which would cause corrosion or injury to the conductors or supports by the formation of chemically active substance.

The bushings shall be entirely free from radio disturbances and from external and internal corona when operating at normal rated voltage.

If dead tank type circuit breakers are to be supplied, each bushing shall be provided with bushing type current transformer(s) (BCT).

Porcelain used for insulating columns, bushings or other service shall be manufactured by the wet-process method in accordance with the highest standards for high voltage porcelain insulators and of a quality best-adapted to high-tension insulator use.

If bushing of oil-filled type is furnished; they shall be provided with suitable magnetic type oil gauges. Convenient means for sampling the oil and draining oil from the bushing shall be provided. Oil filled bushing shall be designed to prevent the accumulation of explosive gases and to provide adequate oil circulation to remove heat. The assembly shall be oil-tight and water tight.

EW-3.3.3.3 Operating Mechanism

The circuit breaker shall be provided with the type of operating mechanism prescribed in the Technical Data Sheets.

Working parts of the mechanism shall be of the corrosion resisting materials, and all bearings, which require grease shall be equipped with pressure-type grease filling. Bearing pins, bolts, nuts and other parts shall be adequately pinned or locked to prevent loosening or changing adjustment with repeated operation of the breakers.

The vital parts of the operating mechanism shall be easily accessible for inspection and service.

The operating mechanism shall be enclosed in a cubicle with at least protective class IP54 or NEMA equivalent. The cubicle shall have at least one easy-to-open door (hatch) which shall be lockable with a padlock. Opening and closing of the mechanism door shall be possible by means of a single, permanently attached hand grip conveniently located and accessible from the service area.

The operating mechanism shall be designed to permit CO-operations of the breakers in accordance with the duty cycles specified in the Technical Data by NPC. Two (2) CO-operations shall be possible before pumping or air compressing. After a close of a circuit breaker, an immediate trip shall always be possible.

The control circuit of the power circuit breaker shall be complete with anti-pumping device to assure the complete execution of initial operation and suitable interlocks to prevent simultaneous local and remote operation.

Control and supervision of pressure shall be provided particularly with pneumatic and hydraulic operating mechanism, which use nitrogen to store energy. A multiple pressure switch shall be provided which shall perform the following function:

- close replenishment valve, i.e. stop pump or compressor
- open replenishment valve, i.e. start pump or compressor
- interlock auto-reclosure if pressure is insufficient
- interlock CLOSE operation, prevents breaker closing if pressure is insufficient
- interlock OPEN operation, prevents breaker opening if pressure is insufficient

If the breaker is spring operated, it shall have compressing motor capable of duly compressing the closing spring in not more than ten (10) seconds. The spring shall be recharged immediately after the closing stroke has been completed. A device shall be provided for charging the spring by hand. An interlock feature shall prevent operating the motor electrically when the hand-charging device is in use. Means shall be provided to prevent overcharging of a spring and to prevent an insufficiently charged closing spring from attempting a close operation.

For all types of operating mechanism, provisions shall be made such that a continuous operation of the motor and/or compressor beyond its pre-set time of charging shall be interpreted as a disturbance and shall cause an alarm.

The mechanism nominal control voltage shall be as stated in the Technical Data Sheets with closing, auxiliary and tripping function operating voltage ranges in accordance with ANSI C37.06.

The supply voltage for compressor or hydraulic pump motors shall be as specified in the Technical Data Sheets. The supply voltage for spring charge motors shall be 230Vac, 60Hz, 1-phase, 3-wire unless otherwise specified in the Technical Data Sheets.

EW-3.3.3.4 Supporting Structure

Supporting structures shall be fabricated of steel and be hot-dip galvanized after fabrication in accordance with ASTM designation A123 and A153.

All necessary galvanized bolts, nuts and washers to complete the erection shall be furnished including embedded anchor bolts for securing the supporting structures to the concrete foundation.

All individual pieces of the structures shall be marked with correct designations shown on the approved shop drawings. Marking shall be done by die stamping the marks into the metal before galvanizing and shall be clearly legible after galvanizing. The number and letter shall be a minimum of 12mm in height and 8mm wide.

EW-3.3.3.5 Mounting Base

The circuit breaker pole base, if furnished, shall be of adequate strength to provide a rigid circuit breaker pole support.

The top surface of the circuit breaker pole base shall be flat so as to permit a person to walk safely from one end to the other.

Each individual pole circuit breaker base shall have either two or four lifting eyes located near opposite ends equidistant from the center of gravity of the complete circuit breaker pole and of sufficient strength to lift the circuit breaker pole, when assembled with insulators, interrupters and base mounted operating mechanism components.

Both the base and energized portion of the circuit breaker pole shall be drilled for direct connection to post type insulators.

EW-3.3.3.6 Withstand Capability

The circuit breaker, complete with auxiliary interrupters and resistors (if provided), shall pass successfully short line fault, line charging current and lightning impulse tests without requiring any maintenance or adjustments.

EW-3.3.3.7 Surge Suppression Resistors

If required, the circuit breaker pole shall be provided with surge suppression closing resistor for switching surge limitation.

The surge suppression resistors shall have an ohmic value and electrical pre-insertion time as specified on the Technical Data Sheets for Power Circuit Breakers.

Dielectric capabilities of the surge suppression resistors shall be as defined in ANSI/IEEE C37.04.

EW-3.3.3.8 Pole Discrepancy

The circuit breaker mechanism design of circuit breaker with 3–single pole mechanism, shall include the necessary pole discrepancy devices utilizing auxiliary switch contacts to cause automatic re-opening of all poles and the initiation of remote alarm and sequence-of-events recorder signals if all poles do not close after a pre-set time delay following the initiation of a three pole close signal.

Remote alarm and sequence-of-events recorder signals shall also be initiated if all poles do not open after a pre-set time delay following the initiation of a three-pole trip signal.

Provision shall also be included for initiation of breaker failure protection.

Each pole auxiliary switch used for pole discrepancy protection and indication shall indicate positively the closure or non-closure of the associated pole. The contacts for each function shall be electrically separate and shall be wired to control cabinet terminal block points.

EW-3.3.3.9 Mechanism Devices

Required mechanism devices shall include, but not limited to those devices itemized in ANSI C37.12 and the following:

a. Undervoltage alarm relays for remote alarm and sequence-of-events recorder indication of loss of air system compressor, hydraulic system pump or spring charge motor and control supply potential (two electrically separate contacts required for each alarm). The relays shall be installed inside the control cabinet and the alarm contacts shall be wired to terminal blocks therein.

b. Running time meter to register air compressor or hydraulic pump motor total elapsed running time. The time meter register shall have one-hour maximum unit graduations and be capable of a 10,000-hour total registration without recycling.

All control device and pressure switch contacts shall be suitable for dc supply voltage specified in the Technical Data Sheets.

EW-3.3.3.10 SF6 Gas System

The circuit breaker shall be provided with properly SF6 gas sealing system that will remain gas tight for the life of the breaker even extreme temperature conditions.

Gas density monitoring equipment with two level alarms shall be supplied. The first level shall indicate an alarm and the second level shall prevent closing or tripping of breakers in case the SF6 gas density is too low and shall also give both local and remote annunciation on the control cubicle/panel and on the control switchboard or the computer monitor system of the MBSC system for the substation inside the control room. SF6 gas pressure gauges shall be provided on each pole of the breaker to indicate SF6 gas density.

Gas density in the SF6 circuit breaker shall at all times be not less than the insulating density of SF6.

The breaker design shall prevent liquefaction and partial condensation of moisture on the insulating parts of the breaker operating mechanism and SF6 containers.

EW-3.3.3.11 Electrical Control Features

Circuit breakers shall be suitable for operation by electrical means either from the bay control and marshalling kiosk or local operating cubicle/panel or remotely from the control board or computer monitor of the MBSC system for the substation inside the control room.

A hand-operated switch shall be provided in the circuit breaker control cabinet to permit local three-pole closing and tripping.

For breakers having three single pole mechanism, each pole mechanism shall be provided with control switch to permit individual circuit breaker pole electrical control. Provision for individual pole selective tripping only by either trip coil or by both trip coils shall be included.

A multi-pole hand operated changeover switch labeled "**REMOTE**" and "**LOCAL**" shall be provided in each control cabinet for establishing the point of control. The switch REMOTE position shall permit remote electrical breaker control only while the switch LOCAL position shall permit only local three-pole or individual pole electrical control. The switch shall have ten electrically separate contacts - five each closed in the REMOTE and LOCAL POSITIONS wired to control terminal block points for remote indication.

Provision shall be included for both three-pole closing and tripping and single-pole tripping and reclosing to be performed from a remote location. Electrically separate contacts shall be provided for control room, area control center and the control house sequence-of-events recorder breaker position indication.

The circuit breaker mechanism shall make one complete closing operation including automatic cut off of the closing power after an initiating control device has operated and the first device in the control scheme has responded, even though the contacts of the initiating control device are opened before the circuit breaker closing operation is completed. This shall however not intervene with the trip free behavior of the circuit breaker.

The circuit breaker shall incorporate anti-pump feature, that is, only one closing operation of the circuit breaker mechanism shall result from each closing operation of a manually operated initiating control device, even though the circuit breaker trips while the initiating control device is being held in the closed position.

When power is removed from the closing control circuit after or during an incomplete closing operation, all electrically operated devices in the control circuit shall reset to normal circuit breaker open position, except for those devices which require a supply of control power in order to assume their normal circuit breaker open position.

When closing operation of a circuit breaker can not be completed successfully because of the absence of an adequate supply of stored energy, all actuating devices in the control circuit shall remain in the normal circuit breaker open position when the initiating control device is operated.

An alarm shall be actuated when the SF6 gas pressure drops below the minimum operating pressure and tripping lockout shall subsequently result in the event of gas pressure falling below the minimum value prescribed for the successful interruption of the current.

Electrical tripping facilities for the operating mechanism of the breakers shall be duplicated unless otherwise specified in the Technical Data Sheets and shall include, but not necessarily limited to the following:

a. Two electrically dependent and identical trip coils for each pole of the breaker and arranged to minimize the probability of the failure of one trip coil affecting the operation of the second trip coil.

b. Two electrically independent and identical sets of wiring, terminals and protecting equipment for connection to two independent control and/or tripping power circuits of supply voltage mentioned in the Technical Data Sheets.

In the event of three-phase operation, the control system shall include circuitry to trip the breaker by energizing both sets of trip coils if pole disagreement should occur.

EW-3.3.3.12 Outdoor Control Cubicles

Mechanism Housing

For breakers with individual pole, each breaker pole shall be provided with mechanism housing to house the circuit breaker operating mechanism, auxiliary switches, associated relays, control switches, control cables, terminations and other necessary mechanical and electrical control apparatus and ancillary equipment required for the breaker pole.

The cubicle for the operating mechanism shall be provided with flange opening for cable terminations in the bottom. Sufficient size and length of conduits/raceways for the control and power cables from the control cubicle down to the ground level shall be provided.

Control Cabinet

The circuit breaker equipment shall include a control cabinet, the construction of which shall comply with the requirements of this section. The control cabinet may be mounted on the circuit breaker supporting structure or on a separate structure at an elevation such that the gages are approximately 1.5 meters and control switches are approximately 1.0 meter, respectively. Suitable flatform shall be provided, if gages and switches are mounted above that level, at which a person will stand when viewing the gages or operating the control switches.

All external alarm, control and power connections shall terminate in the control cabinet.

All circuit breaker gages and common control devices shall be located in the control cabinet. Common operating mechanism equipment, except gages, may be located in a separate enclosure. Gages shall be readable through a safety type, shatterproof glass or plastic window without opening the control cabinet door.

Control Cabinet and Mechanism Housing Construction

All cabinets and housing shall be weatherproof, rigidly framed and fabricated from 3-mm minimum thickness sheet steel or aluminum.

The cubicles shall be suitable for mounting on the circuit breaker supporting structure or shall be self-supporting. It shall be vermin proof, dust proof and weatherproof. Suitable door gaskets made of rubber shall be provided to prevent the ingress of moisture etc.

Access to all compartments shall be provided by hinged doors. Bolts or carriage keys shall not be used to secure the panels or doors. All fastenings shall be integral with the panel or door and provision shall be made for padlocking. Sufficient openings in the base of cubicles shall be provided for the incoming cables and entrance shall be accomplished using glands to fix and seal the cubicles. Opening and closing of doors shall be possible by means of a single permanently attached handgrip which is easily accessible.

The cubicles shall be furnished with space heaters with thermostat setting as well as one 20-watt fluorescent lamp and one duplex convenience outlet with rating specified in the Technical Data Sheets. The heaters shall be sized to provide minimum temperature rise of 5°F above ambient temperature. Low-high temperature alarm shall be provided as well as high temperature cut-off. A manually 2-pole operated disconnect switch shall be provided to open and close both sides of the circuit for maintenance purpose.

Cubicles shall be well ventilated through vermin-proof louvers comprising a brass gauze screen attached to a frame and secured to the inside of the cubicle. Divisions between compartments within the cubicle shall be perforated to assist air circulation.

Access doors or panels shall be glazed where necessary to enable instrument to be viewed without opening the cubicle. Arrangement of equipment within the cubicle shall be such that access for maintenance or removal of any item shall be possible with the minimum disturbance.

Grounding terminals shall be provided at the bottom of all the panels for earthing. It shall be suitable for accepting 100 mm² stranded copper conductor.

An approved schematic diagram of the part of the control system local to the circuit breaker, identifying the various components within the cubicle and on the circuit breaker and referring to the appropriate drawings and erection instruction shall be affixed to the inside of the cubicle access door. The diagram shall be marked on durable non-fading material suitable for the specified climatic conditions.

EW-3.3.3.13 Terminals

Terminal pads of the bushing shall be of high conductivity bronze or copper and shall be plated with hot-flowed electro silver or electro-tin to a thickness of not less than 0.127 mm (0.005 in), or an aluminum alloy with hardness of Hb minimum of 750 N/mm².

The flat surfaces of single-tang terminal pads shall be horizontal and shall be aligned for straightaway take-off.

Each terminal pad shall have four 14.3 mm (9/16") diameter holes drilled with 45 mm (1-3/4") center line spacing per applicable ANSI and NEMA Standards and suitable for use with copper or aluminum conductors.

When current rating dictates the use of terminal pads with other hole drilling, the same shall be in accordance with applicable ANSI and NEMA Standards and shall be submitted to the NPC for approval.

The static force (horizontal and vertical forces) that can be applied at the outermost point of the terminals including the greatest static and dynamic forces permitted shall be specified by the Contractor.

EW-3.3.3.14 Ground Connectors

Two flat grounding pads each complete with a clamp type pressure connector suitable for stranded copper grounding conductor with sizes specified in the Technical Data Sheets and located approximately 300 mm above the base and on diametrically opposite sides shall be provided on each circuit breaker supporting structure. For multiple-column live-tank circuit breaker, it shall have one grounding pad and connector per column supporting structure.

Each circuit breaker mounting base, if furnished, shall have a flat grounding pad complete with a clamp type pressure connector suitable for stranded copper ground conductor specified in the Technical Data Sheets.

Each cabinet mounted on a supporting structure and not having a grounding bus shall be connected to the structure via flexible copper conductor of suitable size.

EW-3.3.3.15 Terminal Blocks

Terminal blocks shall be mounted at an easily accessible position and shall be equipped with barriers, terminal strips and color-coded strips.

The AC and DC circuits shall be physically segregated in groups. The AC 230 and 460volts circuit terminals shall be fitted with non-inflammable, transparent plastic covers to prevent accidental contact with live parts. Each incoming and outgoing conductor shall be connected to an individual terminal.

Each terminal block shall have an individual marking strip, which shall be machine lettered or engraved with the circuit designations of the terminals, which shall also be shown on the wiring diagrams.

One spare marking strip shall be provided for each terminal block. Approximately 10 percent extra terminals shall be provided on each terminal block for terminating spare conductors and for future changes. In case of hinged panels, matching terminal blocks shall be provided on both sides of the hinged section.

EW-3.3.4 Sound Control

The sound level of the equipment covered by this specification will be reviewed by NPC with respect to the permissible exposure limits for personnel as defined in Part 1910.95, "Occupational Noise Exposure", of the U.S. Code of Federal Regulations. Accordingly, it is required that the sound level measured according to ANSI C37.082 or IEC equivalent shall not exceed the allowable limit specified in the Technical Data Sheets.

If the Contractor expects the maximum sound level of the equipment to exceed the specified allowable limit, the Contractor shall use acoustical treatment features, subject to NPC's review and acceptance, to achieve the sound control design objectives.

EW-3.3.5 Other Technical Requirements

Other features for the breakers, if required by the NPC, are stated in the Technical Data Sheets.

EW-3.4 INSTALLATION

Installation will be by Contractor unless specified otherwise in Section B.1.0 of the Technical Data Sheets.

The Contractor shall submit complete details of proper handling, transport and storage, installation, testing, commissioning, performance guarantees, etc. for NPC's review and approval.

EW-3.5 FACTORY ASSEMBLY AND TESTS

EW-3.5.1 General

Each circuit breaker shall be completely assembled and adjusted at the factory and given the manufacturer's Routine Shop Tests and also other tests as specified herein. All parts shall be properly marked for ease of assembly in the field. All routine tests required herein should be witnessed by the NPC or his authorized representative unless waived in writing and no equipment shall be shipped until released for shipment by the NPC or his authorized representative.

The test equipment, test methods, measurements and computation shall be in accordance with the latest applicable requirements of ANSI/IEEE C37.09 and IEC 60060 and/or 60267 in cases where otherwise set forth and shall be subject to the approval of the NPC.

EW-3.5.2 Shop Tests

EW-3.5.2.1 For the Circuit Breaker

The circuit breaker shall meet all its ratings as defined in the applicable provisions of ANSI/IEEE or IEC Standards.

Design tests in accordance with ANSI C37.09 or IEC equivalent, and corresponding certified test reports, are always required when the breaker type and rating is Contractor's new design or the Contractor's previous design with significant design changes (i.e., prototype).

Design tests in accordance with ANSI C37.09 or IEC equivalent and corresponding certified test reports are required if so specified in the Technical Data Sheets.

If breaker is not a prototype and if design tests are not specified in the Technical Data Sheets for the circuit breaker, certified test reports of duplicate production type are acceptable, if so specified in the Technical Data Sheets.

If tests are required, the Contractor shall submit the test procedures the Contractor intends to use. Actual test procedures to be used shall be subject to NPC's acceptance.

All applicable quality conformance, production and routine tests in accordance with ANSI C37.09 or IEC equivalent shall be performed on each breaker and reports are required.

Additional tests, if specified in the Technical Data Sheets, are required by NPC.

EW-3.5.2.2 For the Porcelain Insulation (Circuit Breaker Support Column & Interrupter Housing)

Design Tests in accordance with ANSI C29.1 and 29.9 or equivalent IEC Standard shall be performed as a minimum, these shall include:

a. Cantilever test; and
b. Thermal shock test

NOTE: Sample subjected to cantilever strength and thermal shock tests shall not be included as part of the equipment to be furnished under this specification.

Quality conformance, production and routine tests for the porcelain insulation shall be in accordance with ANSI C29.1 and 29.9 and shall include as a minimum the following:

a. Dimensional check in accordance with ANSI C29.9;
b. Quality conformance visual, porosity and galvanizing tests in accordance with ANSI C29.1 and C29.9; and
c. Internal Pressure tests.

EW-3.5.3 Other Tests

In addition to the tests mentioned above, the other equipment attached as an accessory to the circuit breaker, i.e. bushing current transformers, if dead tank type circuit breakers are supplied, shall be tested in accordance with the test mentioned on the applicable provisions for the accessory equipment.

EW-3.6 DATA AND DOCUMENTATION REQUIREMENTS

EW-3.6.1 General

Contractor-furnished data and information shall be guaranteed performance data, predicted performance, interface requirements and construction features of all Contractor's furnished equipment. The accuracy of such information and its compatibility with overall performance requirements specified by NPC are the sole responsibility of the Contractor.

All information submitted as part of Proposal Data would become part of contract data for successful bidder. Any deviation from such data requires NPC's approval.

EW-3.6.2 Data and Information to be Submitted with the Proposal

Contractor shall furnish with his proposal the filled-in Section A.2.0 of the Technical Data Sheets.

EW-3.6.3 Data and Information to be Submitted During Post Qualification

Contractor shall furnish during post qualification the following:

a. Filled-in Section B.3.0 of the Technical Data Sheets.

b. Contractor shall furnish the brochures and catalogues during post qualification to support the filled-in Technical Data Sheets and to allow NPC to evaluate the equipment/materials being offered.

EW-3.6.4 Data and Information to be Submitted After Award of Contract

The Contractor shall furnish drawings and information in quality and quantity as specified herein and in purchase order for NPC's review and comments as follows:

a. Outline drawings of the power circuit breaker and accessories showing all critical dimensions and weights, including the following:

   1. Mounting dimensions and details and transport dimensions;
   2. Plans, elevation and sectional views;
   3. Details of control cabinet and operating mechanism and its location;
   4. Control and power cable entrance openings at the control cabinet;
   5. Details of main terminals and grounding connections;
   6. Bushing and support column outline drawing

b. Schematic diagrams for control and protection including interlocking scheme;

c. Arrangement of terminal blocks inside the local control cabinet;

d. Current transformer connection diagrams, if circuit breaker is dead tank type;

e. Instrument transformers characteristic curve showing open circuit secondary saturation, ratio and phase angle correction;

f. Bill of material and parts list of control cabinet components;

g. Power circuit breakers instruction manual covering installation, operation and maintenance;

h. Typical installation instruction;

i. Support and/or foundation drawings for circuit breaker and separate auxiliary equipment;

j. Certified test data, if specified in the Technical Data Sheets;

k. Close and trip currents time curve;

l. Detailed QA Program based on ISO 9001 Certification;

m. Routine Tests Reports duly signed and witnessed by NPC's representative(s) if Factory Acceptance Tests are required to be witnessed by NPC's representative(s);

n. ISO 9001 Certification of the proposed manufacturer;

o. Field Test to be performed and Field Test Reports duly signed and witnessed by NPC's representative(s); and

p. As- built drawings as finally approved.

The Contractor shall provide in the manner, number of copies and within the time set forth in the NPC order, instruction manuals in accordance with Section GW-2.9 of the General Works.

EW-4.0 DISCONNECT/EARTHING SWITCH

EW-4.1 SCOPE

EW-4.1.1 General

This specification covers the technical and associated requirements for disconnect/earthing switches, rated 69 kV and above for use in electric power generating stations, switchyard and substation.

It is not NPC's intent to specify all technical requirements nor to set forth those requirements adequately covered by applicable codes and standards. The Contractor shall furnish high quality disconnect/earthing switches meeting the requirements of these specification and industry standards.

The Contractor shall bear full responsibility that the equipment has been designed and fabricated in accordance with all codes, standards, and applicable governmental regulations and performs under the conditions and to the standards specified herein,

No departure shall be made from these specification and standards unless waived or modified in writing by NPC. The Contractor shall obtain from its subcontractors a statement as to the compliance with this specification without exception and/or if there are any exceptions, these shall be described in detail and included in the Contractor's proposal. The Contractor shall add a statement that no other exceptions are taken to this specification.

EW-4.1.2 Works to be Provided by the Contractor

The Contractor shall provide the equipment, accessories and services delineated in Section B.1.0 of the Technical Data Sheets.

EW-4.1.3 Works to be Provided by NPC

NPC shall provide the materials (if any) and services listed in Section B.1.0 of the Technical Data Sheets.

EW-4.2 CODES AND STANDARDS

EW-4.2.1 General

The disconnect/earthing switches furnished shall be in accordance with, but not limited to, the latest issues of applicable ANSI/IEEE or IEC standards, including all addenda, in effect at time of purchase order unless otherwise stated in this specification. These shall include:

ASTM	**American Society for Testing and Materials**
A123-89	Standard Specification for Zinc (Hot-Galvanized) Coatings on Products Fabricated from Rolled, Pressed, and Forge Steel, Plates, Bars and Strips

IEC	**International Electrotechnical Commission (all parts of listed standards apply)**
60129	Alternating Current Disconnectors and Earthing Switches
60265	High Voltage Switches
60273	Characteristics of Indoor and Outdoor Post Insulators for Systems with Nominal Voltages Greater than 1000V
60694	Common Clauses for High Voltage Switchgear and Control Gear Standard
1128	Alternating Current Disconnectors: Bus-transfer Current Switching by Disconnectors
1129	Alternating Current Earthing Switches: Induced Current Switching
ISO	**International Standards Organization**
9001	Quality System Model for Quality Assurance in Design/Development, Manufacture and Testing
9002	Quality System Model for Quality Assurance in Production, Installation and Servicing

These codes and standards set forth the minimum requirements which may be exceeded by Contractor if, in Contractor's judgment and with NPC's acceptance, superior or more economic designs or materials are available for successful and continuous operation of Contractor's equipment as required in this specification.

EW-4.3 TECHNICAL REQUIREMENTS

EW-4.3.1 Description of Services

The disconnect/earthing switch(es) covered by this specification is (are) for use in a generating station and/or substation. The application details are in the Technical Data Sheets for the disconnect/earthing switch.

All materials and parts, which are not specifically mentioned herein but are necessary for the proper erection, assembly and safe operation of the disconnect switch(es), shall be furnished at no increase in cost to the NPC.

EW-4.3.2 Design Requirements

EW-4.3.2.1 General

The switching device shall withstand simultaneously acting forces due to specified service conditions. Actual forces to be accounted are those depending on wind, connection at terminals and short-circuit. The switching device shall operate without malfunction, with simultaneously acting forces from wind and connection terminals. The safety factor against break of an insulator shall be at least 1.25 times these simultaneously acting forces plus operating forces.

The type of mounting for the disconnect switches shall be as required in the Technical Data Sheets. It can be of the rotary type, either with double break on three poles with common base frame or rotary type with two columns. If grounding contacts are specified, they shall be vertical closing at one outside pole. Disconnect switches shall be complete with safety interlocks and all necessary accessories to make a complete unit.

Service conditions require that the disconnect/earthing switch shall remain alive and in continuous service for periods of up to two years without operation or maintenance. Emergency hand operation shall be provided where power driven types are required.

Disconnect operating mechanism, auxiliary switches, control switches and other ancillary equipment shall be accommodated in sheet steel or stainless steel, vermin proof and weatherproof cubicles. The disconnectors shall be so designed as to discourage the building of bird's nest.

The disconnect/earthing switches shall be supplied with supporting structures, piping and conduit for control cables, line and earth terminals and fittings and accessories for conduit and earthing conductors running along the supporting structures.

EW-4.3.2.2 Temperature Rise

The temperature rise of any part of the switch shall not exceed the maximum temperature rise specified on ANSI Standard and/or IEC publication.

EW-4.3.3 Design and Construction Features

Bases

The bases shall be rigid and self-supporting, without cross bracing between phases. It shall be constructed so that the deflection under maximum operating force will not interfere with successful operation of the switch when the bases are mounted rigidly at the points of support. The switches shall have no guying or cross bracing between phases other than the supporting structures. All steel or iron part of the bases shall be hot-dip galvanized after fabrication in accordance with ASTM 123.

Both the base and energized portion of the switch shall be drilled for direct connection to post-type insulators.

Each individual pole switch base shall be provided with lifting points or with four lifting eyes located near opposite ends equidistant from the center of gravity of the complete switch pole and of sufficient strength to lift the switch pole, when assembled complete with insulators and blade.

Contacts

The contacts of the switches shall be self-aligning with self-cleaning action, and provided with high-pressure contact in the closed position.

All current carrying contacts shall be silver to silver except that contacts sealed and insulated from contamination and corrosion may be either silver to silver or silver to copper. Exposed contacts shall be self-wiping and field replaceable.

The contact surfaces shall be of silver plated copper or with an inlay of high-purity silver for heavy duty or special cases. The switch component shall have an adequate strength to withstand all torsional and bending stresses arising from operation of the switches. Contact parts switch shall be non-ferrous and must withstand all mechanical and electrical stresses arising from momentary current.

Switchblades and Clips

The blade of the disconnect/earthing switch shall be of an approved design and must be able to adequately withstand all torsional and bending. The contact part shall be designed to assemble with shield ring for the purpose of reducing corona discharge losses to a minimum. All switches shall be designed to carry the rated current continuously without exceeding an observable (by thermometer) temperature rise in accordance with IEC or equivalent ANSI standards at an altitude of 1,000 meters or less, and must be capable of withstanding the thermal and mechanical stresses induced by the short time rating specified. Switchblades shall be of aluminum with bolted silver plated copper tips. However, copper switchblade with silver plated tips is also acceptable.

Grounding/Earthing Switch

Disconnect switches shall be equipped with a rotary/linear earthing switch if specified in the Technical Data Sheets. Depending on the requirement, it can be manually or motor operated. All electrical clearances and characteristics of the grounding switch shall be fully coordinated with the associated disconnect switch. The earthing switches shall be supplied with auxiliary contacts and interlocking devices.

Grounding or earthing switch shall either cooperative grounding switch furnished for installation on the main switch or independent grounding switch as specified.

Each grounding switch shall have a momentary rating as the main switch.

Each grounding switch shall be supplied with all necessary linkages, clamps, couplings, operating pipes, operating handle, supporting bracket, guide plates, auxiliary switches and other miscellaneous equipment to make a complete installation.

The blade of earthing switch shall be painted with black with yellow stripes to make it more visible.

Line Terminals

The primary terminals shall be suitable for connection of copper or aluminum conductors without the use of bimetal inserts.

Each equipment terminals for connecting to the line or other equipment shall be equipped with a suitable terminal pad unless otherwise specified. The terminal pad shall be provided with four 14.3mm (9/16 inch) diameter holes with 45mm (1-3/4 inch) spacing between the centers of each hole in accordance with the standard NEMA 4 holes arrangement.

The terminal pad shall be of high conductivity bronze or copper and shall be plated with hot flowed electro-silver of electro-tin to a thickness of not less than 0.127 mm (0.005 inch), or an aluminum alloy with hardness Hb minimum of 750 N/mm^2. Whenever the larger terminal pads are required for higher current rating, the mounting holes shall conform to NEMA standards, and details of the mounting holes shall be submitted for approval.

The static forces (horizontal and vertical forces) applied at the outermost point of the terminals including the greatest static and dynamic forces permitted shall be specified by the Contractor.

The line terminal connectors shall be suited for conductors specified in the Technical Data Sheets.

Insulators

Insulators shall conform to IEC/ANSI standard station post type and specified color. It shall be homogeneous wet-porcelain, free of lamination, cavities and other flaws affecting its mechanical or electrical strength. Insulators shall be tested in accordance with specified standards.

The required number of cap screws, nuts and lockwashers, all galvanized as specified in ANSI insulator standards, shall be furnished.

Rain shields, if furnished, shall either be separate from the insulator unit or cast or formed as part of the cap or base. Rain shield diameter shall be approximately 50 mm larger than the insulator unit largest diameter.

Operating Mechanism

General

Disconnect switches, if required, shall be provided by a motor driven or manual operating mechanism or both as specified in the Technical Data Sheets.

For earthing switches, it can also have manual or motor operating mechanism as described in the Technical Data Sheets.

The operating mechanism shall also incorporate annunciator switches for indicating the switching position and for control and interlock purposes.

Each operating mechanism shall be furnished complete with all necessary operating pipes, interphase shafts, pipe couplings, guide bearings, ground braids, mounting brackets, mounting bolts, operating handle, auxiliary switches and offsets required for operation from the ground. All operating rods and levers shall be cut to length and all machining operations and threading shall be complete in the factory.

The entire design shall be such that cantilever torsional stresses imposed upon any insulator column by the operation of the switch shall not exceed the safe limits of the column.

Mechanical devices indicating the "OPEN" and "CLOSED" positions of the switches whether single or each pole or three-pole units shall be provided for the main and grounding blades. Mechanical devices indicating the direction of the mechanical rotation for opening and closing shall also be provided. The indicators shall be of metal approved by NPC and shall be located where they will be readily visible from the ground.

All switch bearings and gears shall be contained in a weather sealed housing and shall be designed to provide maximum axial and lateral loading capacity with minimum friction. All ball or roller bearings shall be stainless steel packed with permanent type grease and with a corrosion inhibitor to eliminate future lubrication or maintenance.

Motor Operating Mechanism

The motor operating mechanism shall be mounted in a weather-proof, rigidly framed housing fabricated from 1.2 mm min. thickness stainless steel and suitable for mounting on the supporting structure of the disconnect switch approximately 1000 mm above the level at which an operator will stand when operating the switch electrically of manually.

The housing shall be of the dead-front type with a gasketed, hinged front door having 180 degree opening and latching handle. The door handle shall be provided with a key lock. Baffled louvers complete with insect screens shall be provided. The housing shall also include an interior convenience light lamp holder with switch and a universal 2-wire single phase duplex convenience outlet rated 10A, 250V.

The motor operated mechanism shall be furnished complete with operation "REMOTE-LOCAL" selector switch and control switch for opening and closing operation. The selector switch shall be wired so that remote electrical control is operative only when the switch is in the REMOTE position and so that local electrical control is operative only when the switch is in the LOCAL position. Provision shall be included for individual electrical control of each switch pole for test purposes when the selector switch is in the LOCAL position.

The operating mechanism operating time for a complete open to close or close to open operation shall be as follows:

For voltage up to 138 kV	:	not exceeding 5s
For 230 kV and above	:	not exceeding 10s

The mechanism drive motor shall be maintenance free, high torque, reversible motor wound with moisture resistant insulation. The motor shall be capable of operating at a nominal voltage rating as specified with a voltage variation between 25% under and 15% over the rated voltage. A thermal overload relay with two normally open electrically separate contacts for remote alarm and sequence of events recorder indication shall be provided for motor overload protection.

A space heater with temperature supervised humidity control for connection to a 230 V AC single-phase supply shall be provided in each motor operating mechanism housing. The heater shall be located to promote warm air circulation to prevent housing interior condensation while avoiding insulating material accelerated deterioration. Heater shall be protected against unintended touch.

All motor-operated mechanism housing equipment electrical connections shall be wired to a terminal block ready for connection to external circuits.

Manual Operating Mechanism

All switches shall be equipped with a manual operating mechanism. The manual operation mechanism shall be of torsion type suitable for operation in the horizontal plane with an operating force not greater than 22 kg.

The manually gang-operated mechanism shall effect a thoroughly smooth controlled movement throughout the entire operating cycle. The operating handles shall be equipped with each switch and shall be arranged for mounting on the steel base supporting structures at approximately 1.00 m above the foundation.

Means shall be provided on each switch for taking up loose motion in the operating mechanism and for adjusting the travel of each blade independently. The Contractor shall furnish all supplemental members required to secure the installation of the complete switch mechanism to the supporting structures.

The manual operating mechanism shall be provided with a padlock arrangement to lock the switches and grounding blades in either open or closed position.

All manual operated switches shall be suitable for future conversion to motor operation without major modification to the control mechanism.

Interlocking

Disconnect/earthing switch shall be electrically interlocked with the associated circuit breaker to prevent the possibility of making or breaking load current.

Manual operated DS shall also have an interlocking circuit, which consist of one contact from the associated PCB. Interlock could be a blocking coil interlock. Blocking coil (blocking when de-energized) for the purpose of blocking the operation of the DS unless the interlocking circuit is closed.

To prevent maloperation, the operating mechanism of disconnect switches and earthing switches shall be interlocked relative to each other (motorized system electrically, compressed-air system electro-pneumatically and manual system mechanically) such that when the main disconnect switch is in "closed" position, the earthing switch can not be closed and conversely, when the earthing switch is in "closed" position, the main disconnect switch can not be closed.

The above interlocking arrangements shall be effective both in local and in remote control operation.

For substation where bus coupler is required by the substation scheme, interlocking to prevent paralleling of voltage transformer secondaries if two buses are not synchronized through bus coupler shall be provided.

Manual and motorized systems can also be equipped with a locking solenoid which when the interlock voltage is dead shall prevent actuation by hand. Local operation is then possible only if the interlock voltage is present and the specified interlocking conditions are satisfied. For instance, a disconnect switch can only be closed or opened if its associated breaker is open.

Auxiliary Contacts

Auxiliary potential free contacts for signaling and interlocking purposes shall be provided. These shall have a minimum current carrying capacity of 10 A continuous. The contacts shall be electrically independent, shall be readily interchangeable and shall be adjustable for timing with the switchblades.

Each main switch and grounding switch mechanism shall be provided with a mechanically driven auxiliary switch with all necessary contacts for proper motorized disconnect operation, electrical interlocking, remote indication and control, local control and indication including eight (8) "a" and eight "b" spare contacts.

The auxiliary switches shall be supplied in a weatherproof housing provided with detachable conduit plates suitable for drilling in the field and shall be located approximately 1.50 m above ground level. The housing shall be mounted such that switch adjustments and maintenance can be accomplished while the equipment is energized.

Ground Terminal Connection

A flat grounding pad complete with a clamp-type grounding connector suitable for accepting a stranded copper ground conductor specified in the Technical Data Sheets shall be provided on diametrically opposite sides of the switch supporting structure. An additional similar grounding pad and connector shall be provided on the grounding blade hinge end of the supporting structure when a disconnect switch is furnished with a grounding blade.

Each motor operating mechanism housing and the separate control cabinet, if furnished, shall have a 25-mm wide x 6-mm thick copper ground bus. A clamp type connector suitable for accepting 60 mm^2 copper ground conductor shall be provided at one end of the ground bus.

Terminal connector shall be made of high conductivity material and shall be completed with corrosion resistance bolts, nuts and lockwashers.

Terminal Blocks

All wiring which connect to external circuits shall terminate on terminal blocks installed in the control cabinet. The terminal blocks shall be 600 V molded block type with insulating barrier between terminals.

Each terminal block shall have marking strips, and shall be equipped with the compression type, ring tongue type terminal lugs for 2 mm^2 or higher to make connection with outgoing cable.

The terminal blocks shall be provided with ten (10) percent but not less than ten (10) additional terminals as spares besides the necessary number. Two (2) or more external wires shall not be connected in one (1) terminal.

Supporting Structure

The equipment supporting structure shall be galvanized after fabrication, in accordance with ASTM A123 and A153. All necessary galvanized bolts, nuts and washers to complete the erection shall be furnished, including embedded anchor bolts for securing the supporting structure to the concrete foundation.

All individual pieces of the supporting structure shall be marked with the correct designations shown on the approved shop drawings. Marking shall be done by die stamping the marks into the metal before galvanizing and shall be clearly legible after galvanizing. The number and letter shall a minimum of 12 mm in height and 8 mm wide.

EW-4.3.4 Other Technical Requirements for the Disconnect/Earthing Switch

Other features for the disconnect switches, if required by the NPC, are stated in the Technical Data Sheets.

EW-4.4 INSTALLATION

Installation will be by Contractor unless specified otherwise in Section B.1.0 of the Technical Data Sheets.

When the installation is by Contractor, such as for turnkey contracts, complete details of proper handling, transport and storage, installation, testing, commissioning, performance guarantees, etc. shall be provided for NPC's review and approval.

EW-4.5 FACTORY ASSEMBLY AND TESTS

EW-4.5.1 General

The Contractor shall carry out at his own expense all tests necessary to ensure the satisfactory design and manufacture of the disconnect switch in accordance with ANSI or equivalent IEC Standards.

Each disconnect switch shall be completely assembled and adjusted at the factory and given the manufacturer's Routine Shop Tests and also other tests as specified hereunder in the Technical Data Sheets. All parts shall be properly marked for ease of assembly in the field. All tests required in Section EW.4.5.2.2 shall be witnessed by the NPC or his authorized representative unless waived in writing, and no equipment shall be shipped until released for shipment by the NPC or his authorized representative.

The Contractor shall make all preparations for tests and provide the test apparatus and personnel and shall notify the NPC the date of the test forty-five (45) days in advance.

Design Tests in accordance with applicable ANSI or IEC Standard and corresponding certified test reports are always required when the disconnect /earthing switches type and rating is Contractor's new design or Contractor's previous design with significant design changes (i.e. prototype).

If disconnect switch is not a prototype and if design tests are not specified in the Technical Data Sheets, certified test reports of duplicated production type are acceptable if so specified in the Technical Data Sheets.

If tests are required, the Contractor shall submit the test procedures the Contractor intends to use. Actual test procedures to be used shall be subject to NPC's acceptance.

All applicable production tests in accordance with ANSI C37.34 and C37.30 or IEC 60129 shall be performed on each disconnect switches and reports are required.

Additional tests, if specified in the Technical Data Sheets, are to be performed by the Contractor without additional costs to NPC.

EW-4.5.2 Tests at Workshop

EW-4.5.2.1 Design Test

One (1) unit disconnect switch of each type shall be subjected to the following tests. These tests may be omitted if a design test record can be submitted unless otherwise specified. The design tests shall include the following:

a. Switches

1. Dielectric including impulse tests. For 500 kV switches, switching surge line-to-ground and open gap withstand shall be performed.
2. Radio influence test (RIV)
3. Corona-free voltage test for switches having rated maximum voltage of 121 kV and above
4. Temperature rise test at 40° ambient
5. Short-time current test. Grounding blades shall be subjected to the same short-time current tests as the main switchblades.
6. Operating and mechanical endurance test according to IEC Standard Publication 60129 Clause 39.
7. Creepage distance measurement. The test shall be performed on DS being supply.

Note: Any switch or switch pole subjected to short time current and/or mechanical endurance tests will not be accepted as part of the supply in accordance with this specification. This shall be considered by the Contractor in the price for the disconnect switch.

b. Post Type Insulators

1. Low frequency wet withstand test
2. Positive critical impulse flashover test
3. Impulse withstand voltage test
4. Radio influence voltage test
5. Thermal shock test
6. Compression strength test
7. Creepage distance measurement. One unit of each type and rating shall be subjected to this test. This test shall be performed on insulator being supplied.

Note: Samples subjected to compression strength and thermal shock test shall not be included as part of the equipment furnished under this specification. This shall be considered by the Contractor in the price for the disconnect switch.

EW-4.5.2.2 Routine Tests

The NPC will witness the following routine tests unless otherwise waived in writing:

a. Switch

1. Voltage tests on control and auxiliary circuit in accordance with IEC Standard Publication 60129.
2. Measurement of the resistance of the main circuit in accordance with IEC Standard Publication 60129.
3. Power frequency dry withstand test of completely assembled switch.

b. Post Type Insulators

1. Dimensional check in accordance with ANSI C29.9 or relevant IEC Clause.
2. Quality conformance visual, porosity, galvanizing and cantilever, torsional and tensile strength tests in accordance with ANSI C29.1 and C29.9 or relevant IEC Clause.
3. Routine flashover and tension proof tests in accordance with ANSI C29.1 and C29.9 or relevant IEC Clause.

EW-4.5.3 Other Tests

In addition to the tests mentioned above, the other equipment attached as an accessory to the disconnect switch shall be tested in accordance with the test mentioned on the applicable provisions for the accessory equipment.

EW-4.6 DATA AND DOCUMENTATION REQUIREMENTS

EW-4.6.1 General

Contractor-furnished data and information shall be the performance data, predicted performance, interface requirements and construction features of all Contractor's furnished equipment. The accuracy of such information and its compatibility with overall performance requirements specified by NPC are the sole responsibility of the Contractor.

All information submitted as part of Proposal Data would become part of contract data for successful bidder. Any deviation from such data requires NPC's approval.

EW-4.6.2 Data and Information to be Submitted During Post Qualification

Contractor shall furnish during post qualification the filled-in B.4.0 of the Technical Data Sheets.

EW-4.6.3 Data and Information to be Submitted After Award of Contract

The following shall be submitted before final shipment of equipment:

a. Brochures and catalogues to support the filled-in Technical Data Sheets and to allow NPC to evaluate the equipment/materials being offered;

b. Complete assembly drawings showing plan elevation and section views of the DS complete with supporting structures and operating mechanism, with mounting dimensions and details, weights, and cable entrance openings;

c. Details of base;

d. Detail and Schematic wiring diagram, including interlocking scheme;

e. Detail of terminals and contacts;

f. Instruction manual covering installation, operation and maintenance;

g. Complete assembly drawings showing elevation and section views, mounting dimensions and details;

h. Bill of material and parts list or identifying sketch showing components;

i. Insulator support column outline drawing;

j. Support and/or foundation drawings for disconnect switch;

k. Detail drawing of grounding terminal connection.

l. Certified test data, if specified in Section EW-4.5;

m. Detailed QA Program based on ISO 9001;

n. ISO 9001 Certification of the proposed manufacturer;

o. Routine Test Reports; and

p. Field Tests to be performed and field tests reports duly signed and witnessed by NPC's representative(s).

The Contractor shall furnish in the manner, number of copies and within the time set forth in the contract, instruction manuals in accordance with Section GW-2.9 of the General Works.

EW-5.0 MAIN CONTROL SWITCHBOARD

EW-5.1 SCOPE

EW-5.1.1 General

This specification covers the technical and associated requirements for the conventional type of main control switchboard including all the various equipment and devices necessary for instrumentation and control requirements of a substation(s). All materials and parts, which are not specifically mentioned herein but are necessary for the proper erection, assembly and operation of the equipment, shall be furnished at no increase in cost to the NPC.

It is not NPC's intent to specify all technical requirements nor to set forth those requirements adequately covered by applicable codes and standards. The Contractor shall furnish control switchboard meeting the requirements of these specification and industry standards.

The Contractor shall bear full responsibility that the control board has been designed and fabricated in accordance with all codes, standards and applicable governmental regulations and performs under the conditions and to the standards specified herein.

No departure shall be made from these specification and standards unless waived or modified in writing by NPC. The Contractor shall obtain from its subcontractors a statement as to compliance with this specification without exception and/or if there are any exception, these shall be described in detail and included in Contractor's proposal. The Contractor shall add a statement that no other exceptions are taken to this specification.

EW-5.1.2 Works to be Provided by the Contractor

The Contractor shall provide the equipment, accessories and services delineated in Section B.1.0 of the Technical Data Sheets.

EW-5.1.3 Works to be Provided by NPC

NPC shall provide the materials (if any) and services listed in Section B.1.0 of the Technical Data Sheets.

EW-5.2 CODES AND STANDARDS

EW-5.2.1 General

The equipment furnished shall be in accordance with, but not limited to, the latest issues of the following applicable standards, including all addenda, in effect at time of purchase order unless otherwise stated in this specification. These shall include:

ANSI/IEEE	**American National Standards Institute and/or Institute of Electrical & Electronic Engineers**
C12.10	Electromechanical Watthour Meters
C12.16	Solid-state Electricity Meters
C33.10	Safety Standard for Fuseholders
C33.65	Safety Standard for Cabinets and Fuseholders
C37.1	Standard Definition, Specification and Analysis of Systems used for Supervisory Control, Data Acquisition, and Automatic Control
C37.2	Standard Electrical Power System Device Function Numbers
C37.21	Standard for Control Switch Boards
C37.90	Standard for Relays and Relay Systems Associated with Power Apparatus
C37.90.1	Standard for Surge Withstand Capability (SWC) tested for Protective Relays and Relay Systems.
C37.100	Definitions for Power Switchgear
C39.1	Requirements for Electrical Indicating Instruments
C57.13	Standard Requirements for Instrument Transformers
C57.13.1	Guide for Field Testing of Relay Current Transformers
C57.13.3	Guide for the Grounding of Instrument Transformers
Z55.1	Gray Finishes for Industrial Apparatus and Equipment
8802-2, to -6	Information Technology, Local & Metropolitan Area Networks, Parts 2,3,4,5 & 6
ICBO	**International Conference of Building Officials**
UBC	**Uniform Building Code of the International Conference of Building Officials, Section 2312 - Earthquake Regulation**
ICEA	**Insulated Cable Engineers Association**
S-66-524	Crossed-linked-thermosetting-polyethylene-insulated Wire and Cable for the Transmission and Distribution of Electrical Energy
IEC	**International Electrotechnical Commission (all parts of listed Standards apply)**
60051	Direct acting indicating analogue electrical-measuring instruments and their accessories
60145	Var-hour (reactive energy) meters
60211	Maximum demand indicators, class 1.0
60255	Electrical Relays
60258	Direct acting recording electrical measuring instruments and their accessories
60337	Control Switches
60359	Expression of the Performance of Electrical and Electronic Measuring Equipment
60414	Safety requirements for indicating and recording electrical measuring instruments and their accessories

60473	Dimensions for panel-mounted indicating and recording measuring instruments
60521	Class 0.5 and 2 ac watt-hour meters
60625	An interface system for programmable measuring instruments
60687	Alternating current static watt-hour meters for active energy
60688	Electrical Measuring transducers for converting ac electrical quantities
1143	Electrical Measuring Instruments - x-t recorders
ISO	**International Standards Organization**
9001	Quality System Model for Quality Assurance in Design/Development, Manufacture and Testing
9002	Quality System Model for Quality Assurance in Production, Installation and Servicing
SSPC	**Steel Structure Painting Council**
PA1	Shop, Field and Maintenance Painting
PA2	Measurement of Dry Paint Thickness with Magnetic Gages
UL	**Underwriters Laboratories, Inc. (all parts apply)**
44	Rubber-Insulated Wires and Cables

These codes and standards set forth minimum requirements which may be exceeded by Contractor if, in Contractor's judgment and with NPC's acceptance, superior or more economic designs or materials are available for successful and continuous operation of Contractor's equipment as required in this specification.

EW-5.3 TECHNICAL REQUIREMENTS

EW-5.3.1 Description of Services

The control boards covered by this specification shall include all electrical features for complete control and instrumentation of a substation and/or switchyard. The application details are in the Technical Data Sheets.

All materials and parts, which are not specifically mentioned herein but are necessary for the proper erection, assembly and safe operation of the control boards, shall be furnished at no increase in cost to the NPC.

EW-5.3.2 Design Requirements

EW-5.3.2.1 General

The main control switchboard shall be supplied complete with all instrument, meters, indicators, control switches, annunciators, push buttons, indicating lamps, terminal blocks, wiring and miscellaneous devices as called for by this Specification or indicated in the Bid drawings. The control board shall include all required auxiliary and accessory devices such as auxiliary current and voltage transformers, phase shifters, auxiliary relays, resistors, etc., whether or not expressly called for or indicated on the bid drawings. All instrument scales, recorder charts, relay coils, contacts and other features shall be suitable for the apparatus controlled or for the purpose intended. A large number of cables will be brought in through the bottom of the control board and adequate provisions shall be made to accommodate, support and terminate these cables on the terminal blocks.

The main control switchboard shall be designed and wired with relays and devices adequate to control not only the equipment supplied under this contract but also the future equipment shown in the single line diagram or in the substation layout.

The Contractor shall ensure that all equipment will allow sufficient room for operation, maintenance, future additions and possible future replacement of defective components.

A basic single line diagram together with other layouts is included in the Bid Drawings issued with this Specification to give additional information on the extent, general locations and arrangement of the equipment. Bidders shall submit a tentative layout with the bid.

The Contractor shall ensure that all equipment he supplies, functions correctly and safely.

The characteristics and ratings of the equipment and devices given in the applicable sections are not necessarily the standards of any particular manufacturer but they are the minimum requirements that must be satisfied by the Contractor.

The construction of the different parts of the Supply must be as standard as possible in order to reduce to a minimum the spare parts and to make the maintenance and replacement operation easy. All similar parts must be interchangeable.

The main control switchboard shall be complete with grounding connection and with all accessories and shall be such as to guarantee correct and trouble free operations.

EW-5.3.3 Design and Construction Features

EW-5.3.3.1 Panel Construction

The control panel shall be of the type specified in the Technical Data Sheets either with a stationary mosaic panel on the front panel or a complete sheet steel front panel if required in the Technical Data Sheets. For control board adopting the mosaic tiles, the front panel should conform to the adoption of both the mosaic tile for the upper (greater) part of the front panel and sheet steel for the lower part of the front panel.

For all types of control boards, the control panel shall be made of smooth sheet steel panels with angle or channel frame and with edges bent to 6.0 mm radius, seam-welded at corners and ground smooth. The panels shall be bolted at the bottom to suitable steel channel sills to be furnished as part of this supply. Suitable grounding and anchor boltholes shall be provided in the channel sills. Butt joints on outside surfaces shall not be permitted. Outside panels shall not be drilled or welded for attaching wires, resistors or other devices where such holes or fastening will be visible from the front of the panel. All screws and bolts used for assembling members and panels and mounting wire cleats and devices shall be provided with lockwashers or other locking devices. Vertical edges of panels shall be formed and bolted together in such a manner that no part of edges are exposed to view. The panels shall not deviate more than 1.6 mm from the true plane. To prevent warping of panels, all heavy devices shall be adequately supported by means of rear-mounted brackets or straps.

The cubicles or panels shall be constructed from a minimum of 2.0 mm sheet steel with edges formed into a rectangular pattern or welded to steel shapes so that each section is rigid and self-supporting and enclosed.

End plates shall be removable to facilitate future extension of the control board.

The panels, trim, doors and frames shall match and shall present a neat appearance when assembled. Electrical clearance shall be provided without cutting away the adjacent steel framework. Vents or louvers shall be provided, where required, to give adequate ventilation. All ventilation openings and all opening in the floor shall be provided with screens to prevent entrance of insects and rodents. Thermostatically controlled heaters with switches shall be furnished for prevention of condensation. Heaters shall be suitable for the voltage source specified in the Technical Data Sheets. Switchboard shall have fixed panels on the front panel and shall utilize the end panels for future extensions.

The design of the control board and arrangement of devices shall be such that adequate space is provided for inspection and maintenance of wiring, terminals and equipment. Equipment inside the panels shall be so mounted that the studs of the equipment mounted on the panels will be accessible without removing any device. American Standard device number shall be used and marked on the rear of the panels near the corresponding device. The device numbers shall be marked legibly with permanent marking fluid that will form a contrast with the panel finish.

The phase arrangement when facing the front panels shall be A-B-C from the left to right and from top to bottom. All relays, instrument, other devices, busses and equipment involving three-phase circuits shall be arranged and connected in accordance with this phase arrangement whenever possible. Similar devices shall be wired in a similar manner.

Provisions for future equipment and devices shall also include cutouts and blank covers having an outline the same as that of the future devices and with color the same as that of the board. The covers shall have concealed fasteners which shall be one (or some combination) of the following kinds:

a. Threaded studs welded on the rear of the covers, with the studs projecting through standard drilling (such as screw holes for mounting of future control switch escutcheons)
b. Threaded studs welded on the rear of the covers, with the studs projecting through corner spaces in board rectangular cutouts (such as for those instruments which do not require individual screw holes for standard mounting)
c. Snap-in welded on the rear of the covers, in positions or locations indicated above for threaded studs.

For a dual type switchboard, the main control switchboard and sections shall include hinged doors. The hinges of all doors shall be fully concealed type and shall allow the doors to swing through by not less than 105° from the closed position. Stops or restraining chains shall be provided where required limiting the swing and preventing damage to hinges. Each door shall be provided with a three-point locking catch and with chromium plated level handle and pin tumbler locking mechanism with keys removable in both locked and unlocked positions. All locks shall be keyed alike. Two keys shall be furnished for each lock supplied.

The dimensions of a single panel shall be as follows unless otherwise specified in bid drawings and/or the Technical Data Sheets:

a. Depth 700 mm
b. Width 800 mm (minimum)
c. Height 2200 mm (maximum)

Control switchboards shall be assembled from individual panels and shall be such that wiring and equipment for each main circuit is clearly separated from the others. All panels and sections of panels shall be clearly labeled from the front and from the rear. Rear-mounted auxiliary relays shall be mounted as to allow free access to wiring and panel mounted equipment.

EW-6.3.3.2 Mimic Buses and Equipment Symbols

Arrangement of switches, meters and relays in the drawings accompanying this specification are only indicative and shown only for reference purposes. The manufacturer of the panels could propose their own arrangement and layout based on the actual size of meters and relays that will be supplied.

For control board adopting the mosaic tiles, part of the panel comprising the mimic diagram, annunciators, discrepancy switches, indicating lamps, push buttons and meters shall be fitted with clip fitting mosaic tiles preferably 25 x 25 mm for easy exchange of individual block. The control board shall be so dimensioned that it can be adapted to the future extension possibilities of the substation.

The control switchboards shall have mimic buses and symbols which shall provide a simple and clear representation of the substation. It shall be in accordance with the single line diagram and, as far as possible, also with the physical layout of the substation. All symbols used shall correspond to either ANSI or IEC Standard. Transformer, reactor and capacitor bank symbols shall be backlit when it is operating and shall flash for unit alarms. Discrepancy type control switches and position indicators with discrepancy function shall be incorporated in the mimic diagram for all circuit breakers, disconnectors and earthing switches.

Mimic bus shall be arranged for adequate operation and as shown on the single line diagram and panel arrangement drawings. Mimic buses shall be at least 6.0 mm (¼") wide. Color-coding shall be as follows:

500 kV	Golden
230 kV	Vermillion Red
138 kV	Bright Red
115 Kv	Orange
69 kV	Medium Yellow
34.5 kV	Maroon
13.8 kV	Silver Bright
4.16 kV	Silver
480 V	Blue
Ground	Medium Green

EW-5.3.3.3 Panel/Cubicle Wiring

Wires shall be 600V, stranded copper conductor with thermoplastic insulation, and shall comply with the requirements of ICEA Standard No. S-61-402. Minimum size shall be 2.0 sq., mm. or larger for control circuit except annunciator wire which shall be 1.2 sq. mm. or larger. Minimum test voltage shall be 2000 V at 60 Hz.

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

As far as possible, all circuits shall be run along the shortest path to their addresses but shall be run only in horizontal and vertical planes. Diagonal runs are not acceptable. However, the wire runs shall not block access for ready test or removal of any device without disturbing other devices.

If wiring is provided between swinging panels, bundled conductors shall be used on the hinged doors or panels with extra/flexible wire, so arranged that a twisting rather than a bending motion is imparted to the moving bundled conductors. Each bundle shall be anchored such that the moving bundle length is the maximum available without loops.

Conductors within cubicles and between terminal blocks and apparatus shall be laid in plastic ducts or covered with plastic bands.

All power circuits, control and protection wiring and low level signal shall be physically separated. Separate laying-way shall be provided for power cables, and the working voltage of each power circuit shall be marked on the associated boards.

Conductor ends not connected to compression-type terminal blocks shall be provided with approved claw-washers, which neatly retain all strands, "Push-on" or "quick" type connectors shall be used for current transformers and trip circuits. These connectors maybe used for alarm and control system and within an equipment assembly only. Sample of any such connectors shall be submitted for NPC's approval.

Wiring shall be arranged to give easy access to the terminal or relays and other apparatus.

Soldered or wire strapped connections shall only be inside electronic systems. Any wire wrapping shall be in accordance with IEC Publication 60352.

As far as reasonably possible, all outgoing wiring shall be grouped by function (CT, VT, Trip, Alarm, etc.) with those going to a common destination allocated to adjacent terminal blocks. Terminal block configuration shall be submitted for NPC's approval. Labels shall be provided on the fixed portion of the terminal boards showing the function of the group.

Connections for indicating instruments, and for the telecommunication circuits from transducers, or modem outputs, shall use individually shielded wire pairs. One (1) extra terminal per pair of terminals shall be provided to connect this shield to ground.

Wiring required to interconnect shipping sections shall be terminated on a terminal board in one section, to which the loose wires of the other section will be connected when the sections are assembled. All wiring from a section that must cross the shipping split shall be terminated in the last section of the split and the interconnecting wiring shall be arranged so that the wiring extends between the two adjacent compartments. The wiring shall be tagged, bundled, terminated and then pulled back into one of the section.

EW-5.3.3.4 Control Circuit Protection

The control branch circuits shall be protected by 600volt rated indicating type fuses having the required interrupting capacity. Each branch circuit shall be identified with a nameplate. The control circuit positive, negative and trip legs shall be sequentially wired from terminal to terminal to permit supervision of the circuit by a lamp and/or supervisory relay connected to the end of the circuit.

Potential circuits, for instrumentation, and for metering, shall be provided with 250 volts, and appropriate fuses located in such a position that they are easily and safely accessible. Each fuse and each set of fuses shall be fully identified for potential origin and equipment supplied.

EW-5.3.3.5 Control System

The control system of the substation if required in the Technical Data Sheets shall be designed for remote and local operation and indication. All interface devices and other accessories necessary for the remote control function shall be provided by the Contractor, if indicated in the Technical Data Sheets.

The design of the control system shall make it easy to add new control devices, indicators, and meters, mimic objects, etc. and future modifications and extension of the control board. Modifications shall be possible with minimum interference to the operation of other parts of the installation.

The control system for manual operations from the control room shall be of an acknowledgment type. Manual operation shall be possible from the control room for circuit breakers, disconnect switches and tap changers (if tap changer is required to be installed at the control board). It shall be possible to initiate all control actions necessary for the daily operation of the substation from the main control board.

The control system shall be designed to allow remote control of the substation (i.e. outside the substation) from the Remote Centers (ACC, RCC, NCC), if required in the Technical Data Sheet. It shall also be possible to transfer all control functions in the main control board to these remote centers. Such provisions likewise prevent simultaneous control operation from two or more locations. Selectivity in terms of priority shall be made available in the main control board. Statistical indications shall always be available at main control board and remote locations.

If required in the Technical Data Sheets, remote supervision of the substation shall likewise be possible from the Remote Control Centers (ACC, RCC, NCC). The control system and main control board shall be designed for connection to Remote Control Centers. Supervisory data acquisition items shall be as follows, and shall be made available at the Remote Control Centers.

<u>Statistical Indications</u>

Frequency
Bus Voltage
Line MW and MVAR
Transformer MW and MVAR
Line MWh and MVARh

<u>Position Indication</u>

Circuit Breakers
Disconnect Switches
Earthing Switches
Tap Changer/s

<u>Group Alarms</u>

Each contact for position indication and group alarm dedicated for connection to Remote Control Centers shall be potential free. Transducers for the above mentioned remote statistical indication shall be included in this supply Contract. The transducer's output signal requirements for statistical indication are described in appropriate topics dealing with the remote terminal units (RTU's) and communication equipment.

Selection for the location of control operation is to be made via selector switch with two positions located at the main control board:

Position 1	:	Remote control (ACC, RCC, NCC)
Position 2	:	Local control

Group alarms and position of circuit breakers, disconnect switches, earthing switches and tap changer/s shall be sent to Remote Control Centers, irrespective of control location selector switch position mentioned in this section.

The control operation and position indication of circuit breakers, and disconnect switches; and position indication of earthing switches shall be through miniature discrepancy type switches.
If the position of the discrepancy switch is not in accordance with the position of the substation equipment, the discrepancy switch shall show a flashing light and a synthesized acoustic signal shall be emitted after an adjustable delay of 5-15 sec.

All controls shall be operated at station battery voltage specified in the Technical Data Sheets. Signals for the position indication of circuit breakers, isolators and earthing switches shall be separately fed from individual terminal blocks.

Facilities shall be provided for common lamp test. Lamps shall be easily removable from the front, have a voltage rating of at least 33 % higher than the nominal supply voltage.

Interlocking circuit shall be included and the following interlocking concept shall apply:

a. The disconnect switch shall be interlocked so as to be free from switching with the load current and charging current associated with the main bus. The disconnect switch shall be operable only when the relevant circuit breaker is in the off-position and that the earthing switch have been cleared.

b. The earthing switch is operable only when the isolators have been opened and that the relevant location is perfectly free of voltage.

c. The closing of circuit breaker shall only be possible when the relevant protective relays and corresponding lock-out relays have not actuated, or if they have actuated; the faults have been cleared and the respective lock-out relays have been reset. See Section EW-5.3.3.6 for synchronizing check requirements.

d. When a low pressure signal is received from gas monitoring devices for a SF_6 circuit breaker, the tripping and the closing signal shall be locked out. At the first level, closing signals shall be locked out; and at the second level, both closing and tripping signals shall be locked out.

e. The interlocking system is to be designed in such a way that it can be tested.

EW-5.3.3.6 Synchronizing System

When specified in the Technical Data Sheets, a synchronizing equipment separate from that used for auto-reclosing shall be provided for the substation for controlling manual closing of circuit breakers. This shall also control remote closing orders from any of the Remote Control Centers if specified in the Technical Data Sheets.

The equipment shall be common for all circuit breakers and shall be provided with an integrated voltage-check and synchro-check functions. The voltage-check function shall include live-bus/dead-line conditions, dead-bus/live-line conditions and dead-bus/dead-line conditions. It shall be possible to set or select which one or combinations of these conditions that will allow closing. For live-bus/live-line conditions synchro-check function shall take precedence.

Dead conditions shall be detected when the voltage of a bus or line is measured to be less than about 30% of the rated voltage. Live condition shall be detected when the measured bus or line voltage is greater than 80% of the rated voltage.

The synchro-check function of the equipment shall allow circuit breaker closing only if the voltages on both sides of the breaker fulfill the preset conditions as to magnitude, phase angle and frequency difference. The voltages are considered to be in synchronism when their phase angles are considered to be within the preset angle, adjustable from 20^0 to 60^0.

A synchronizing switch shall be provided for each circuit breaker which will automatically connect the voltage circuits related to the breaker being closed to the synchronizing equipment. The equipment system shall be designed in such a way that it shall not be possible to inadvertently interconnect the voltage circuits, even when two or more synchronizing switches are closed at the same time.

Also, when performing synchronizing at the control board, provision shall be made such that closing order, from any of the Remote Control Centers will be blocked. A suitable means shall be provided for this purpose.

Isolating transformers shall be provided for all input voltages to the synchronizing equipment to provide galvanic separation of the equipment from the remainder of the substation.

Auxiliary relays shall be provided to supervise or block closing orders when the permissible closing conditions are not satisfied.

The synchronizing equipment shall be mounted on a 19-inch standard rack frame or on the main control board as directed by the NPC and must have the following synchronizing points positions: Local Auto-Remote Auto-Manual-Test.

EW-5.3.3.7 Synchronizing Panel

In addition to the integrated synchronizing equipment, a separate synchronizing unit/panel provided with two frequency meters, two voltmeters, and a synchroscope shall be installed on the control panel to interface with the operator during manual synchronization. Voltage inputs to these units shall also be controlled by the synchronizing switches. The synchronizing panel shall be attached to the upper left corner of the Main Control Switchboard.

It shall be possible to move or swing the synchronizing equipment so as to bring it in sight from any point along the switchboard during the synchronizing operation and to return it to its original position when not in use.

Provision shall be made such that when performing synchronizing using the synchronizing panel, closing orders from any of the Remote Control Centers shall be blocked.

The panel shall be approximately 200 mm deep. The back of the synchronizing panel shall be readily removable for access to the interior. The panel design shall permit ready removal and relocation of the panel when additional control switchboard sections are installed.

Synchronizing lamps, shall be special incandescent synchronizing type with medium base keyless sockets. The lamps shall be connected so that they will be "dimmed" when the incoming and running circuits are in synchronism. Vibrating reed type frequency meters are not acceptable.

Synchroscopes shall be furnished with indication pointer rotating 180 mechanical degrees for a change of 180 electrical degrees in the relative phase of the incoming and running synchronizing potential circuits. The synchroscope shall operate satisfactorily over a range of 80 to 150 V with the pointer coming to a stop when potential to either incoming or running circuit is lost. The synchroscope shall have full 360° scale and shall be marked to show synchronism point and to indicate whether the incoming circuit is fast or slow in synchronism.

The legend "INCOMING" shall be marked on the left or top frequency meter and voltmeter scales, and the legend "RUNNING" shall be marked on the right or bottom frequency meters and voltmeter scales.

EW-5.3.3.8 Fault Annunciator System (Alarm System)

The annunciator system shall distinguish any abnormal conditions during operation in the control room by means of visual and audible warning.

Under normal conditions, the annunciator relays shall be de-energized so that there will be no power drain on the DC system when all trouble points are normal. However, the design of the annunciator system shall be based for continuous operation of all alarms simultaneously.

The annunciator system shall be of modular design and microprocessor based, designed for operation on a DC supply system specified in the Technical Data Sheets. It shall consist of window cabinets, mounting chassis, plug-in relay assemblies, flashers, alarm relays, isolating relays, lamps, test buttons, acknowledged and reset buttons. It shall be mounted on a standard

19" rack as a separate panel or integrated in the main control board as directed in the Technical Data Sheets.

Relays and flashers shall be of the draw out type and shall be capable of being easily repaired by parts replacements. Relay assemblies shall be interchangeable.

The supply voltage for the annunciator system shall be monitored and must give an alarm in case of interruption of the alarm equipment power supply.

Each alarm relay shall have an auxiliary relay with multiple contacts for local alarm, sequence of event recorder (SER), Area Control Center (ACC) and spare. In addition, group alarms for circuit breaker, transformers, etc. shall also be available. All alarms shall work independent of other alarms, synthesized audible and visual alarm shall function in the following sequence:

a. Fast flashing visible alarm light and synthesized audible alarm shall commence when an alarm occurs. This shall continue until acknowledged, whether the fault has been automatically or manually cleared or not.

b. When the alarm is acknowledged, the audible alarm shall cease while the light shall cease only if the fault has likewise ceased or have been cleared or the alarm initiating equipment has reset. If the fault has not ceased or have not been cleared or the alarm initiating equipment has not reset, the visual indication shall change to a steady light.

c. Pressing the lamp test button, all lamp relays will operate and lamps shall light-up, but without audible sound.

The annunciator window shall be color coded for immediate distinction of the type of alarm. Red for critical alarm and white for non-critical alarm.

Critical alarms are those which cause tripping and trip indications. Critical alarms and non-critical alarms are freely convertible from one to the other type.

The auxiliary equipment for the fault signals shall be designed in such a manner that it will enable group testing of the relays.

The time delay shall be individually adjustable and the setting range shall be between 0 and 30 seconds in steps of 1 seconds.

Alarm, which is initiated from possible discrepancy between the status of the object controlled and the position indicated on the control switch (i.e. discrepancy switch), shall have a time delay which is adjustable from 0 to 30 seconds in steps of 1 second.

Two different kinds of audible alarms shall be provided; one for critical alarm and one for non-critical alarm. In addition, a separate horn shall be supplied which will be installed at the substation area to call the attention of the people at the substation area when a critical alarm occurs. This horn will be wired to air critical synthesized audible alarm only.

Each kind of audible alarm shall have different sound which are subject to the approval of the NPC.

Acknowledgment push buttons and switches or lamp test shall be one separate set for each of the annunciator.

In case of prolonged audible alarm, an automatic reset of the alarm bells shall take place within adjustable time of 0.5 to 5 minutes.

EW-5.3.3.9 Indicating Instruments

All indicating instruments shall be of the flush mounted back connected type. The indicating plate shall be white faced with black markings and black pointer, long scaled (at least 210° wide) provided with anti-parallax, direct reading type and unless otherwise specified herein, scales of indicating meters shall be submitted for approval of the NPC. For control boards adopting mosaic tile, the size presented in front of the mosaic panel shall be approximately equivalent to three (3) x three (3) mosaic tile block. All indicating instruments shall comply with ANSI C39.1, "Requirements for Electrical Indicating Instruments".

All indicating instruments shall fulfill the requirements for accuracy class 0.5 except for the frequency meter which shall have ±0.01 Hz. The cases shall be dust-tight and the moving element or pointer having a zero adjustment screw or knob readily accessible from the front without needing to remove the cover.

All indicating instruments shall be designed for 60 Hz circuits and shall be suitable and calibrated for use in voltage transformer secondaries and a current transformer secondary specified in the Technical Data Sheets. Potential coils shall be designed for 150 V AC continuous operations while current coils shall be designed to withstand 40 times the rated rms current rating for 2 seconds.

All voltmeters and ammeters for lines and transformers shall be provided with a selector switch for phase selection. If the selector switch for the ammeter is located in the CT circuit, the switch shall be designed to prevent opening of the CT circuit during phase selection.

Wattmeters and varmeters shall have zero center to indicate the direction of power flow. The right part shall show the incoming power to the main bus and the left part shall show power outgoing from the main bus. All power indicating instruments shall be designed for a neutral grounded system, 3-element, 3-phase, 4-wire type with 3 current and 3 potential coils.

Frequency meters shall be complete with external reactors (if needed). The scale range shall be from 55 Hz to 65 Hz.

The control switchboard shall be provided with the following indicating instruments:

Lines
- Voltmeters
- Ammeters
- Varmeters
- Wattmeters

Power Transformers Primary Side:
- Ammeters

Power Transformers Secondary Side:
- Ammeters
- Varmeters
- Wattmeters

Power Transformers Tertiary Side:
- Ammeters

Shunt Reactors
- Ammeters

Shunt Capacitors
- Varmeters
- Ammeters

Buses (each bus-section)
- Voltmeter (indicating and recording)
- Frequency meter

EW-5.3.3.10 Control and Instrumentation Switches

All control and instrumentation switches shall be of the miniature type adaptable to a mosaic tile board. Each switch shall be provided with ample contact stages and suitable for arrangements to perform the functions of the control system. Contacts for all control and instrument switches shall be self-aligning and shall operate with wiping action. Positive means of maintaining high pressure on closed contacts shall be provided.

Pressure springs shall not carry current. The covers on the switches shall be readily removable for inspection of contacts. All control and instrument switches shall be suitable for operation on voltage circuits specified in the Technical Data Sheets, and shall be capable of satisfactorily withstanding a life test of at least 10,000 operations under rated current. All control and instrument switches shall be capable of carrying 20 amperes without exceeding a temperature rise of 30°C. The inductive load interrupting rating shall not be less than 2 amperes at 230 V AC or 125 V DC control circuit power supply.

Circuit Breaker and Disconnect Switch Control Switches shall be of the discrepancy type both for mosaic tile panel and for sheet steel board panel. Ammeter switches shall be of the non-current breaking type while voltmeter switches shall be of the maintained contact type.

Synchronizing switches shall be of the maintained contact type, operable only by use of a key which is removable only when the switch is in the "off" position.

Test switches shall be provided where test facilities are required. The test switches shall be back connected, semi-flush mounted with removable covers.

Ammeter Selector (AS) switches shall three independent circuits, maintained contact type with intermediate position overlapping contacts and with one or more OFF positions.

Voltmeter Selector (VS) switches shall be maintained contact type suitable for either phase-to-neutral or phase-to-phase voltage selection.

EW-5.3.3.11 Switchboard Accessories

Terminal Blocks

Terminal blocks shall be mounted so as to give easy access to wires, terminations and ferrules and shall give a clear view of the arrangement of cable tails. The AC, DC current and voltage transformer inputs shall be separately grouped and adequately protected. Each wire shall be connected to an individual terminal which shall have a clearly lettered marking strip corresponding to the wiring diagram. To allow for extensions and alterations, approximately 25% extra terminals should be provided per terminal block.

Terminal blocks for control wiring shall be rated not less than 30 A, 600 V with barriers of the type approved by the NPC.

Isolation-type terminal blocks shall be provided for the auto-reclosing scheme isolation and for all external alarms on each panel. Isolation type terminal blocks for the sequence of events and transient fault recorder terminals shall also be provided. Shorting type of terminal blocks for current circuit isolation to transient fault recorder shall be provided.

Terminal blocks shall not have more than twelve positions per block, shall be rated 600 volts, 30 amperes, shall be one-piece type and shall have vinyl marking strips. They shall have terminal screws on both sides; box clamps or saddle clamp terminals are not acceptable. No live metal shall be exposed at the back of the terminal blocks.

Every terminal point shall have individual and complete identification identical to those on the wiring diagrams and shall be acceptable to the NPC. Terminals for NPC's external connections shall be arranged for consecutive connections of conductors within one cable. Only one external wire will be connected to each outgoing terminal point. Wires (usually three to five, including ground isolating jumpers) for a given current transformer or voltage transformer circuit shall be connected to a single terminal block; they shall not be split between two blocks.

Nameplates

Each piece of equipment mounted on or inside the panels shall be provided with a nameplate. Nameplate shall be made of black surface, white core micarta or sheet plastic with lettering engraved on the white surface exposing the white core. Single phase items shall be identified by nameplates as to the particular phase in which they are connected. Nameplate sizes shall be approximately 25 by 75 mm or 50 by 150 mm. The nameplates shall be fastened to the panels with the black finished round-head screws. Nameplate design shall be submitted for approval to the NPC, together with samples of engraved nameplates.

Ground Bus

A ground bus of copper bar not less than 60 sq.mm shall be bolted to the frame of each panel in such a way as to make a good electrical contact. For the switchboards and other panels, a ground bus shall be provided along the front and rear of the switchboards and shall be cross-connected at each panel end.

The ground bus shall have drilling at each end to permit interconnections with the ground busses in adjacent units. The necessary copper bar jumpers, bolts, nuts and washers for making interconnection shall be furnished.

The ground busses in the switchboard units at the left and right ends of the control switchboard end sections each shall be provided with a solder bus clamp type pressure connector for terminating 100 mm^2 of stranded copper ground connector.

Test Terminals

Test terminals of plug-in type shall be provided for each group of metering or indicating instruments connected to the same instrument transformer. In cases where indicating instruments or meters connected to the same current transformer secondaries are installed on separate assemblies, test blocks shall be provided on each assembly to permit calibration and checking. Sufficient test plugs shall be provided for each test block.

All test devices and test switches shall permit complete isolation of the associated device or devices from the instrument transformers and other external circuits, and shall permit means for testing the device or devices from an external source through the use of appropriate test plugs.

Current transformer secondary circuits shall not be open-circuited at any time during operation of the test devices and test switches or during insertion or removal of the test plugs.

Interior Lighting and Convenience Outlets

A switch controlled fluorescent lamp shall be installed at the top of each switchboard unit for internal illumination. The switch shall be located at a convenient height inside the unit. A duplex convenience outlet with rating specified in the Technical Data Sheets of Section E.1.5 shall be furnished and installed in each switchboard section at a convenient location.

The lamp switch and convenience outlet shall be located near the latch side of the door in single door units and near the hinge side of a door in double door units. The lamp and convenience outlet shall be wired to terminal block points for connection to a power source in the Technical Data Sheets.

EW-5.3.4 Metering Panel Requirements

A Metering Panel shall be provided, if required by the type of control board specified in the Technical Data Sheets. The Metering Panel basically supports the functions of the Main Control Panel. The panels shall include the following:

a. Watt-hour meters
b. Recording meters
c. other accessories

EW-5.3.4.2 Watt-Hour Meters

Watt-hour meters shall be semi-flush mounted, front connected, drawout, switchboard type. The meter cases shall be dust-tight and moisture proof and shall fit into the switchboard in such a way as to permit reading without opening the corresponding front cover.

It shall be of the electronic metering module type with LED digital displays with limits of error according to IEC 60070.

The meters shall be suitable for continuous three-phase operation from the secondaries of current transformers and voltage transformers, with the ratio and connections indicated on the bid drawings or as required.

Meters for ungrounded systems shall be 2-element, 3-wire type with 2 current and 2 potential coils while meter for neutral grounded system shall be 3-element, 4-wire with 3 current and 3 potential coils.

Meters shall be equipped with a photoelectric 3-wire pulse initiator, which shall operate a polarized relay for multiplying the pulse initiator contacts to provide inputs to remote terminal units.

EW-5.3.4.3 Recorders

Recorders shall be of the null balance, pen type, strip chart type, operating from ungrounded 230volt AC, 60 Hz power supply unless otherwise specified in the Technical Data Sheets.

The MW scale shall be unidirectional and the MVAR scale shall be bi-directional.

Chart width shall be approximately 250 mm. Recorders shall have 100 mm per hour chart speed and shall be provided with means for convenient cutting and removal of chart records.

Recorders shall have dust-tight, moisture resistant cases, designed for semi-flush mounting, with fluorescent chart illumination and glare-free glass. Each recorder shall be provided with a two year supply of chart paper and ink.

Scaling resistors shall be provided as necessary for correct operation of recorders in transducers circuits.

Recorders shall have an accuracy class of 1.5 or better.

EW-5.3.5 Transducers

EW-5.3.5.1 General

The transducers shall be located at the main control board and shall employ electronic circuitry to provide DC current output for an AC current or voltage input. It shall be designed for continuous operation with no deterioration in specified performance.

The transducers shall have galvanic separation between input and output. The transducers shall possess, but not limited to the following characteristics:

a. All transducers shall meet IEEE surge withstand capability tests.
b. Transducers output signal shall be free from electromagnetic interference and noise.
c. The transducers shall not require frequent calibration or maintenance.
d. Transducers shall have integrated output current amplifiers with a range of 0 to 1 mA DC (unidirectional) or -1 to 0 to +1 mA DC (bi-directional) through a load resistance of 0 to 3000 ohms for all analog measurement values. Final considerations as to the output of the transducers shall be made during the checking of manufacturer's drawings after award of contract.
e. Response time to 99.5% of final values shall not exceed 400ms.
f. Maximum adverse temperature and humidity effect on accuracy of the transducers shall not exceed $\pm$ 0.25% over the temperature range of + 5 to + 55°C and conditions of relative humidity of 0 to 95%.

EW-5.3.5.2 Watt-Var Transducers

Watt and Var transducers shall be of the three-element type. Suitable for single phase, 115V AC, 60Hz power supply.

Current elements shall be rated 5 amperes continuously, 10 amperes continuous overload, 200 amperes overload for 1-second, and shall have a burden not exceeding 0.5 volt-amperes per element.

Voltage elements shall be rated 115volts, 150volts continuous overload, shall have an operating range of 0 to 143volts and shall have a burden not exceeding a volt-ampere per element.

Transducer shall operate satisfactorily with any input power factors between zero leading or lagging and unity.

Var transducers shall be complete with required phase shifting transformers. Watt and Var transducers shall provide an output signal of 1-0-1-milli-amperes DC through any external load resistance between 0 and 3000 ohms for full scale input.

Means shall be provided for the transducers to have ± 10 percent calibration adjustment.

EW-5.3.5.3 Voltage Transducers

Voltage transducers shall be of the single-element type, suitable for single-phase 60 Hz operation. The voltage element shall be rated 115volts, 150volts continuous overload, and shall have a burden not exceeding 2 volt-amperes. Full scale input rating shall be 150 volts.

Voltage transducers shall provide an output signal of 1 milli-ampere DC through any external load resistance between 0 and 3000 ohms for full scale input. Transducers shall have ± 10 percent calibration adjustment.

EW-5.3.5.4 Current Transducers

Current transducers shall be of the single-phase type, suitable for single-phase, 60 Hz operation. The current element shall be rated 0.5 amperes full scale input, 10 amperes continuous overload, 200 amperes overload for 1 second, and shall have a burden not exceeding 2 volt-amperes.

Current transducers shall provide an output signal of 1 milli-ampere DC through any external load resistance between 0 and 3000 ohms for full scale input. Transducers shall have ± 10 percent calibration adjustment.

EW-5.3.5.5 Frequency Transducers

Frequency transducers shall be of the single-element type, suitable for single-phase, 60 Hz operation. The element shall be rated 115volts, 150volts continuous overload and shall have a burden not exceeding 2 volt-amperes.

Frequency transducers shall have a rated operating range from 85 to 145 volts. For input frequencies ranging between 55 to 65 Hz the transducer output shall be 0 to 1 milli-ampere DC through an external load resistance between 0 to 3000 ohms.

EW-5.3.5.6 Transducer Panel

All transducers are envisioned to be installed inside the Main Control Switchboard. However, in case that the transducers can not be accommodated inside the Main Control Switchboard, a separate transducer panel shall be included in the supply and the construction of which is similar to the Main Control Switchboard.

EW-5.3.6 Test Equipment and Accessories

The Contractor shall include the necessary test equipment, tools and other accessories for the testing, commissioning and maintenance of the main control switchboard aside from those mentioned in the Technical Data Sheets. Cost of these test equipment shall be included in the price of the Main Control Switchboard.

A list of these test equipment and tools shall be supplied with the Bid.

EW-5.3.7 Other Technical Requirements for the Main Control Switchboard(s)

Other features for the main control switchboard, if required by the NPC are stated in the Technical Data Sheets.

EW-5.4 INSTALLATION

Installation will be by Contractor unless specified otherwise in Section B.1.0 of the Technical Data Sheet.

When the installation is by Contractor, such as for turn-key contracts, complete details of proper handling, transport and storage, installation, testing, commissioning, performance guarantees, etc. shall be provided for NPC's review and approval.

EW-5.5 FACTORY ASSEMBLY AND TESTS

EW-5.5.1 General

The main control switchboard shall be completely assembled and adjusted at the factory and given the manufacturer's routine shop tests and also other test as specified herein. All parts shall be properly marked for ease of assembly in the field. All routine and quality conformance tests required herein shall be witnessed by the NPC or his authorized representative unless waived in writing, and no equipment shall be shipped until released for shipment by the NPC or his authorized representative.

The test equipment, test methods, measurements and computations shall be in accordance with the latest applicable requirements of ANSI and IEC Standard except in cases where otherwise set forth, and shall be subject to the approval of the NPC.

EW-5.5.2 Routine Test

These tests shall include material tests and tests during manufacture as per the manufacturer's established practice and/or other approved standards. However, on electronic equipment individual component tests and burn-in tests of important modules (temperature and voltage stress) shall be performed.

Routine testing shall be performed using automatic processes wherever practical, in particular for wiring testing. Routine tests prescribed by the applicable standards shall be performed on the completed apparatus, and in particular dielectric and interference tests as follows:

a. Power frequency tests (insulation) according to IEC 60255-1 or equivalent ANSI/IEEE standard.

b. Impulse voltage test (insulation) according to IEC 60255-A (Class III) or equivalent ANSI/IEEE standard.

c. HF interference test according to IEC 60245-4 or ANSI/IEEE C37.90a-74.

The Contractor shall make all preparation for tests and provide the test apparatus and personnel and shall notify the NPC the date of the test forty-five (45) days in advance.

The tests noted below shall be performed and maybe witnessed by the NPC or his authorized representative on the equipment covered by the Specification at the manufacturer's plant before shipment:

a. Complete Ringout of All Wiring

A complete point to point ringout of all wiring against the latest wiring diagram shall be made to ensure that the assembly has been wired in accordance with its wiring diagram and further to ensure that the wiring diagram for any assembly is an accurate representation of that assembly.

b. Check of All Meters and Instruments

The calibration and internal connection of all meters and instruments are assumed to have been made in the normal production process. However, to establish that the connections between the associated incoming blocks and these instruments and meters are correct it is required that three-phase voltage and current be applied at the terminal blocks with the proper phase angle relationship to check the direction of rotation.

c. Complete Functional Test

This test is intended to completely check the functional operation of the equipment. The test shall be a check of all the tripping, closing, auxiliary circuits, interlocking, etc., for each panel or unit.

d. 1000 Volts Megger Test

Each circuit or bus shall be given an individual 1000V megger test with a minimum permissible reading of 6 megohms.

e. Mechanical Inspections

This shall be a physical inspection of the equipment as a whole to ensure that all components are mechanically sound and that there are no imperfections. Also attention should be given to establishing that all special requirements of the Specification have been met.

EW-5.5.3 Type Tests

For all standard equipment, the Contractor shall submit five (5) certified copies of the results of type tests on each type of equipment to be supplied to show the adequacy of its design.

EW-5.6 DATA AND DOCUMENTATION REQUIREMENTS

EW-5.6.1 General

Contractor-furnished data and information shall be the guaranteed performance data, predicted performance, interface requirements and construction features of all Contractor's furnished equipment. The accuracy of such information and its compatibility with overall performance requirements specified by NPC are the sole responsibility of the Contractor.

All information submitted as part of Proposal Data will become part of contract data for successful bidder.

EW-5.6.2 Data and Information to be Submitted During Post Qualification

Contractor shall furnish during post qualification the filled-in Section B.5.0 of the Technical Data Sheets.

EW-5.6.3 Data and Information to be Submitted after Award of Contract

The following items shall be submitted by the Contractor after award of contract:

a. Brochures and catalogues to support the filled-in Technical Data Sheets and to allow NPC to evaluate the equipment/materials being offered;

b. Outline drawings of the main control switchboard and accessories showing all critical dimensions and weights, including the following:

   1. Mounting dimensions and details and transport dimensions;
   2. Plans, elevation and sectional views;
   3. Details of mounting and anchoring;
   4. Control and power cable entrance openings;
   5. Details of main terminals and grounding connections;

c. Schematic diagrams for control and protection including interlocking scheme;

d. Arrangement of terminal blocks inside the control board;

e. Certified test reports, if specified in the Technical Data Sheets;

f. Bill of material and parts list or identifying sketch showing components;

g. General arrangement drawings showing the layout and information for design of foundation details, overall dimensions of all equipment with details of external cable entry height and clearances;

h. Specifications and brochures of each of the component of the control and instrumentation panel;

i. Detailed material list contained in each panel;

j. Detailed functional diagram, schematic diagram, panel wiring diagram, terminal block diagram and cabling layout;

k. General assembly and erection/installation drawings and procedures;

l. Detailed test procedures to be followed after installation of the panels;

m. Instruction, maintenance and operation manuals;

n. Detailed QA Program based on ISO 9001;

o. ISO 9001 Certification of the proposed manufacturer;

p. Field Test to be performed and Field Test Reports duly signed by NPC representative(s); and

q. As- built drawings as finally approved.

The Contractor shall furnish in the manner, number of copies and within the time set forth in the contract, instruction manuals in accordance with Section EW-2.9 of the General Works.

EW-6.0 METALCLAD SWITCHGEAR

EW-6.1 SCOPE

EW-6.1.1 General

This specification covers the technical and associated requirements for medium voltage metal-clad switchgear, complete with all accessories as hereafter specified and as shown on the attached drawings.

It is not NPC's intent to specify all technical requirements nor to set forth those requirements adequately covered by applicable codes and standards. The Contractor shall furnish high quality metal-clad switchgear and accessories meeting the requirements of these specification and industry standards.

The Contractor shall bear full responsibility that the equipment has been designed and fabricated in accordance with all codes, standards, and applicable governmental regulations and performs under the conditions and to the standards specified herein.

No departure shall be made from these specification and standards unless waived or modified in writing by NPC. The Contractor shall obtain from its subcontractors a statement as to compliance with this specification without exception and/or if there are any exceptions, these shall be described in detail and included in Contractor's proposal. The Contractor shall add a statement that no other exemptions are taken to this specification.

EW-6.1.2 Works to be Provided by the Contractor

The work to be provided by Contractor shall include, but not necessarily be limited to, supplying the equipment and services delineated in Section B.1.0 of the Technical Data Sheets.

EW-6.1.3 Works to be Provided by NPC

The assignment of responsibility of work to be performed by NPC is designated also in Section B.1.0 of the Technical Data Sheets.

EW-6.2 CODES AND STANDARDS

EW-6.2.1 General

The equipment furnished shall be in accordance with, but not limited to, the latest issues of the following codes and standards, including all addenda, in effect at time of Contract unless otherwise stated in this specification:

ANSI/IEEE	**American National Standards Institute and/or Institute of Electrical & Electronic Engineers**
C37.04	Rating Structure for AC High-Voltage Circuit Breaker, including Supplements
C37.06	Preferred Ratings for Circuit Breakers

C37.09	Standard Test Procedure for AC High Voltage Circuit Breakers rated on a Symmetrical Current Basis
C37.010	Standard Application Guide for AC High Voltage Circuit Breakers rated on a Symmetrical Current Basis
C37.011	Application Guide for Transient Recovery Voltage for AC High Voltage Circuit Breakers rated on a Symmetrical Current Basis
C37.012	Application Guide for Capacitance Current Switching for AC High Voltage Circuit Breakers rated on a Symmetrical Current Basis
C37.081	Guide for Synthetic Fault Testing of AC High Voltage Circuit Breakers rated on a Symmetrical Current Basis
C37.1	Standard Definition, Specification, and Analysis of Systems used for Supervisory Control, Data Acquisition, and Automatic Control
C37.11	Power Circuit Breaker Control
C37.20.2	Standard for Metal-Clad and Station Type Cubicle Switchgear
C37.20.3	Standard for Metal-Enclosed Interrupter Switchgear
C37.23	Standard for Metal-Enclosed Bus and Calculating Losses in Isolated-Phase Bus
C37.24	Guide for Evaluating the Effect of Solar Radiation on Outdoor Metal-Enclosed Switchgear
C37.30	Standard Requirements for High Voltage Air Switches
C37.34	Standard Test Code for High Voltage Air Switches
C37.35	Guide for the Application, Installation, Operation, and Maintenance of High Voltage Air Disconnecting and Load Interrupter Switches
C37.37	Standard Loading Guide for AC High Voltage Switches (in excess of 1000 volts)
C37.40	Standard Service Conditions and Definitions for High Voltage Fuses, Distribution Enclosed Single-Pole Air Switches, Fuse Disconnecting Switches and Accessories
C37.41	Standard Design Test for High Voltage Fuses, Distribution Enclosed Single-Pole Air Switches, Fuse Disconnecting Switches and Accessories
C37.48	Guide for Application, Operation, and Maintenance of High Voltage Fuses, Distribution Enclosed Single-Pole Air Switches, Fuse Disconnecting Switches and Accessories
C37.90	Standard for Relays and Relay systems associated with Power Apparatus
C37.90.1	Standard for Surge Withstand Capability (SWC) tests for Protective Relays and Relays System
C37.97	Guide for Protective Relay Applications to Power System Buses
C37.100	Definitions for Power Switchgear
C57.13	Standard Requirements for Instrument Transformers
C57.13.1	Guide for Field Testing of Relay Current Transformers
C57.16	Requirements, Terminology and Test Code for Current-Limiting Reactors
C57.99	Guide for Loading Dry-Type and Oil Immersed Current-Limiting Reactors
C62	Guides and Standards for Surge Protection

Z55.1	Gray Finishes for Industrial Apparatus and Equipment
4	Standard Techniques for High Voltage Testing
32	Standard Requirements, Terminology, and Testing Procedures for Neutral Grounding Devices
IEC	**International Electro-Technical Commission**
60044	Instrument Transformers
60052	Direct acting analog electrical-measuring instruments and their accessories
60056	High voltage alternating-current circuit breakers
60129	Alternating current disconnectors (isolators) and earthing switches
60255	Electrical relays
60267	Guide to the testing of circuit breakers with respect to out-of-phase switching
60298	A.C. metal-enclosed switchgear and controlgear for rated voltages above 1 kV and up to and including 52 kV
60359	Expression of the Performance of electrical and electronic measuring equipment
60420	High voltage alternating current switch-fuse combinations
60427	Synthetic testing of high voltage alternating current circuit breakers
60439	Low Voltage Switchgear and Control Gear Assemblies
60466	A.C. insulation-enclosed switchgear and controlgear for rated voltages above 1 kV up to and including 38 kV
60694	Common clauses for high voltage switchgear and controlgear standards
60932	Additional requirements for enclosed switchgear and controlgear from 1 kV to 72.5 kV to be used in severe climatic conditions
60947-5-1	Control circuit devices and switching elements
1208	High voltage alternating current circuit breakers guide for maintenance
ICEA	**Insulated Cable Engineers Association**
S-66-524	Cross-linked-thermosetting-polyethylene-insulated Wire and Cable for the Transmission and Distribution of Electric Energy
ICBO	**International Conference of Building Officials**
UBC	**Uniform Building Code of the International Conference of Building Officials**
ISO	**International Standards Organization**
9001	Quality System Model for Quality Assurance in Design/Development, Manufacture and Testing
9002	Quality System Model for Quality Assurance in Production, Installation & Servicing

NEMA	**National Electrical Manufacturers Association**
SG-4	Alternating Current High Voltage Circuit Breakers
SG-5	Power Switchgear Assemblies
SSPC	**Steel Structure Painting Council**
PA-1	Shop, Filed and Maintenance Painting
PA-2	Measurement of Dry Paint Thickness with Magnetic Gages
SP-1	Solvent Cleaning
SP-3	Power Tool Cleaning
SP-5	White Metal Blast Cleaning
SP-6	Commercial Blast Cleaning
SP-10	Near White Blast Cleaning
UL	**Underwriters Laboratories, Inc. (all parts apply)**
44	Rubber-Insulated Wires and Cables
PEC	**Philippine Electrical Code, Part II**

These codes and standards set forth the minimum requirements which may be exceeded by the Contractor, if, in the Contractor's judgment and with NPC's acceptance, superior or more economical designs or materials are available for successful and continuous operation of the Contractor's equipment as required by this specification.

EW-6.3 TECHNICAL REQUIREMENTS

EW-6.3.1 Description of Services

The switchgear covered by this specification is for use generally in substation or switchyard. The equipment will be intended to supply the required station auxiliary service of a substation or where necessary to supply power needs of an electric cooperative having jurisdiction of the service area.

All materials and parts which are not specifically mentioned herein but are necessary for the proper erection, assembly and safe operation of the switchgear shall be furnished at no increase in cost to the NPC.

EW-6.3.2 Design Requirements

The equipment shall be designed to perform in accordance with the standards and as specified herein, when operating under the environmental and operating conditions given in Section B.1.0 of the Technical Data Sheets.

In all respects, equipment shall incorporate the highest quality of modern engineering, design and workmanship. It is not the intent to specify all details of design and construction; therefore, equipment shall be fabricated and equipped with accessories in accordance with Contractor's standard practices when such practices do not conflict with this specification.

The metalclad switchgear shall be supplied complete with all equipment, instruments, meters, indicators, control switches or push-buttons, annunciators, indicating lamps, terminal blocks, wiring and miscellaneous devices as called for by this specification, or indicated in the Bid drawings.

For each feeder and bus section of the Metal-clad switchgear, an independent compact medium voltage control unit with a graphic display (LCD) to be used for metering, measurement, protection, control and supervision, including I/O and A/D modules for interfacing with the switchgear and to be used for communication with the Microprocessor Based Substation Control (MBSC) System (if substation control is thru the MBSC) shall be provided.

EW-6.3.3 Coordination of Equipment

The Contractor of equipment covered by this specification shall be responsible for coordination with equipment supplied by others. The Contractor shall also determine and coordinate the requirements for proper physical fit, ratings, etc. The above activity shall include, but not limited to, the following:

a. Location and phasing of main transformer terminals including support structures on transformer with respect to the herein supplied non-segregated bus duct, bus bar or the medium voltage cables.

b. Location and phasing of equipment terminals

c. Current transformer (CTs) coordination for differential relays located in the switchgear when all CT's are not within switchgear.

List of equipment supplied by others with which coordination is required is indicated in the Technical Data Sheets.

The Contractor shall inform the NPC of his coordination activities by forwarding copies of correspondence(s).

EW-6.3.4 Construction Features

EW-6.3.4.1 General

As shown in the basic single line diagram, each line up of metal-clad switchgear is either 3-phase, 3-wire or three-phase, 4-wire 60 Hz compartment and shall be totally enclosed, outdoor type unless otherwise specified in the Technical Data Sheets, freestanding, with sections bolted together to form one rigid structure.

The construction of the different parts of the supply must be as standard as possible in order to reduce to minimum the spare parts and to make the maintenance and replacement operations easy. All similar parts must be interchangeable.

Outdoor switchgear shall be weatherproof and designed so that driving rain, sand, coal dust (where present) or other materials shall not interfere with the successful operation of the switchgear. Care shall be taken so that no water can be collected on top of the switchgear and enter through ventilation slots. The housing shall be constructed so that the operating heat losses and solar radiation will not produce total temperatures in the equipment beyond those allowed by the applicable standards. The housing should have thermal insulation as well as electric heaters to minimize moisture condensation.

When "walk-in" type outdoor switchgear is specified in the Technical Data Sheets, it shall be provided with adequate space between the switchgear and the outer shell doors to permit the circuit breakers to be removed and maintained with the outer shell door closed. Adequate space with lighting and polarized convenience outlets shall be provided.

Doors on weatherproof enclosures shall be full height, equipped with latches and devices to hold the door in the full open position against 10 lb/ft^2 wind pressure. The doors are not required to be gasketed unless specified in the Technical Data Sheets. For "walk-in" type, two weatherproof doors, one located at each end of the aisle and each equipped with crank mechanisms, which permit quick release from inside shall be provided. For "non walk-in" type, one door shall be provided for each vertical section of switchgear.

Ventilating openings shall be provided at the top and bottom of the enclosure, screened, and baffled to prevent entrance of driven rain, insects, and rodents. Dust filters shall also be furnished for the switchgear.

In case of an explosion or internal arcing, persons standing in front of the panel will not be endangering. The compartments shall be naturally ventilated but the ventilation slots in the panels shall not allow hot ionized gases to spread to an adjacent unit. Internal arcs shall be confined to the compartment in which they have originated.

In walk-in type, a sufficient number of interior aisle lights with switches inside of each door shall be provided to make all nameplates readily readable. Interior lighting shall likewise be provided for non-walk-in type metal clad switchgear. The voltage rating shall be as specified in the Technical Data Sheets.

Two (2) polarized duplex convenience outlets with rating specified in the Technical Data Sheets and with grounding shall be provided in each walk-in area. Exposed wiring shall be in conduit.

Lighting and heating shall be supplied from a Contractor furnished 230/120-volt distribution or lighting panel. Separate branch circuits shall be provided for lights, switchgear space heaters, fans, and each motor space heater.

The understructure of outdoor housings shall be covered by a sealing undercoating, at least 0.80 mm (1/32 inch) thick.

EW-6.3.4.2 Structure

Enclosure shall be metal enclosed, free standing with the required number of circuit breakers per vertical section stated in the Technical Data Sheets.

The enclosure shall be provided with separate hinged doors for access to circuit breaker and instrument compartments on the front of the structure and removable plates on the rear of each vertical section. Door handles shall have provisions for multiple padlocking (3 minimum).

Each breaker shall be isolated by externally operated drawout stabs with shutter mechanism, and safety interlocks shall be provided to prevent:

a. Inadvertent operation of the isolating mechanism under load
b. Opening the compartment door while the breaker is closed
c. Closing the breaker when in operating position with door opened

Assemblies longer than 4 vertical sections shall be divided into shipping sections for ease of handling. Each section shall be shipped fabricated with all doors, operators, etc. All necessary connecting hardware, conductor links, supports, closure pieces and material as required for restoring the electrical, mechanical and structural integrity of each section shall be provided. Each shipping section shall be provided with lifting angle(s) suitable for the task. Instructions for field work necessary prior to energization shall be included with each section.

Phase relationship of stabs in all compartments shall be the same when facing the respective device and compartment covers.

Complete closure sheets on all sides, top and bottom shall be provided. The top and bottom plates of each vertical section shall be removable to facilitate drilling for conduit or tray entry.

Each unit compartment within the switchgear shall be positively grounded.

The switchgear shall be designed to permit future additions, changes, or regrouping of units by the NPC. Provisions shall be included for the future addition of vertical sections on both ends of the switchgear.

All space not presently used or indicated as spare, shall be furnished with all necessary bussing and stabs for insertion of circuit breakers at a later date.

Enclosed wireways shall be provided on multiple stack assemblies to provide separate power cable isolation for cable passing through to the adjacent compartment.

All cubicles or sections of the switchgear shall be fitted with means of lifting, e.g. lifting hooks or beams, for each cubicle or composite section of the switchgear.

EW-6.3.4.3 Main Bus and Bus Taps

Depending on the requirement stated in the Technical Data Sheets, the main bus and bus taps can either be made of high conductivity copper or aluminum bars continuously welded or bolted, rated as specified in the Technical Data Sheets and shall incorporate the following features:

a. All bolted main bus joints and tap joints shall be silver plated for copper conductors or tin-plated for aluminum conductors and shall be bolted in such a manner that initial contact pressure around the bolt holes will remain substantially undiminished at bus temperatures ranging from standard rated ambient to rated full load temperatures for an unlimited service life.

b. Main bus supports and bus insulation shall have low moisture absorption characteristics and shall retain substantially undiminished mechanical and dielectric strength for the service life of the equipment.

c. All conductors shall be supported to withstand stresses resulting from current values equivalent to the close and latch current rating of the breakers to which they are connected.

d. Main bus shall be fully insulated to a thickness that withstand the dielectric tests specified for 4-wire service, it shall also be fully insulated. Its current rating shall be 50% of the main buses. If the system neutral is to be grounded, this neutral bus shall be connected to the switchgear ground bus by two separate strap connections.

EW-6.3.4.4 Ground Bus

The ground bus material shall be the same as that used for the main bus and bus taps continuously welded or bolted. The minimum dimensions shall not be less than 6.35 mm x 50 mm (1/4 x 2 inch).

Bolted joints, splices and taps to the ground bus shall each be made with not less than two bolts each.

The ground bus, designed for the indicated maximum earth fault current, shall run along the whole length of the structure, and shall be bolted or brazed to the framework of each unit, and to each breaker grounding contact bar.

Compression type terminals acceptable to NPC, shall be provided by the Contractor at each end of the complete line-up for copper grounding cable with size specified in the Technical Data Sheets.

EW-6.3.4.5 Circuit Breakers and Operating Mechanism

Individual compartments shall be designed to house a horizontal drawout circuit breaker with wheels. The stationary primary disconnecting contacts shall be constructed of silver plated copper. All movable contact fingers and springs shall be mounted on the drawout module where they may be easily inspected. It shall be possible to open and close the breakers mechanically and electrically.

The operating mechanism shall be as stated in the Technical Data Sheets. With the breaker in the closed position, the charged up spring operating mechanism shall have sufficient energy to perform the three movements operation (open-close-open) without being charged up in between.

The mechanism shall be suitable for motor and/or hand rewinding. Hand rewinding shall be possible only:

a. if there is no DC or AC voltage available for closing;
b. if the breaker is in the test position; and
c. if the breaker is completely withdrawn

Position switches shall be provided on each drawout module. Switches shall be suitable for 3 modes of operation, fully closed and racked in, a test position and fully open and disconnected. Test position shall permit complete testing of individual units or testing continuity of control circuits without energizing the loads. Eight (8) extra NO and eight (8) extra NC contacts shall be provided on each switch for NPC's use.

All low voltage relays, terminal blocks, controls and protective relays shall be accessible while the switchgear is energized.

Circuit breakers type shall be as stated in the Technical Data Sheets, mechanically and electrically trip free, and completely interchangeable. Provisions for padlocking the circuit breaker in either the test position or disconnect position shall be furnished.

If vacuum circuit breaker is specified, they shall be provided with surge protection equipment, if required, to limit switching surge voltage during any switching operation of the circuits (motors, dry type transformers, cables).

For each breaker, the following features shall be provided:

a. Auxiliary contacts for interlocking and indication, including three (3) sets of spares, suitable for voltage rating specified in the Technical Data Sheets;
b. Mechanical position indication visible from the front;
c. Circuit breaker operation counter for number of openings; and
d. "Spring charged" indicator

Means shall be provided for locally closing and tripping electrically operated breakers without opening the door of the breaker compartment.

Guides shall be provided for easy removal and insertion of the removable circuit breaker unit as well as stops or indicators for the accurate positioning in the "connect" and "test" positions.

The general construction shall be such that all parts of stationary and movable assembly will continuously maintain an accurate alignment of the component parts under all operating conditions within its rated capacity and also under all normal handling concerned with the insertion in and withdrawal from the operating position.

All electrically operated breakers shall be of the fast closing type. The closing time shall not exceed 0.133 seconds (8 cycles on 60-cycle basis) from receipt of closing signal. The switchgear units shall be so designed as to exclude replacement of a fast breaker with a slow closing one and vice versa.

When power is removed from the closing control circuit after or during an incomplete closing operation, all electrically operated devices in the control circuit shall reset to the normal "breaker-open" position.

Maintenance intervals of circuit breakers shall not be less than 50 full rated short circuit interruptions, 10,000 rated current interruptions or 10 years, whichever comes first.

Safe replacement of the breaker interrupter must be possible while the remaining switchgear is "**live**" and must not involve the use of special tools or delicate alignments.

Breakers of the same rating and control scheme shall be completely interchangeable within the switchgear installation.

Trip and release coils shall be as required. In addition, a manually operable local trip push-button (mechanically working onto the trip shaft) shall be available. Manual, mechanical ON-switching shall be prevented if interlocking conditions exist. Mechanical indicators shall be provided to show the ON/OFF position of the breaker contacts.

EW-6.3.4.6 Instrument Transformers

Current transformers shall be mounted with polarity marking toward the bus and non-polarity side of the secondaries shall be wired together and grounded. Ground connection shall be made at the first terminal block and not at the current transformer. The first terminal block shall be of the shorting type.

Current transformers shall be installed so as to be readily accessible for maintenance and replacement.

The current transformer protective relay combination selected by NPC shall be reviewed by Contractor and modified if necessary to attain the following:

a. The instantaneous overcurrent protection of any branch (motors and step-down transformers) shall operate when rated short circuit current with a 1.6 offset factor is flowing through it.

b. The time delay overcurrent, or any other protection of a bus tie breaker shall properly coordinate with any downstream protection for the same short circuit as described in Item "a".

If Contractor's current transformer arrangement require that the cables pass through the phase and/or residual current transformers, the current transformer window shall be large enough to accommodate the cables.

Potential transformers and associated fuses shall be mounted in individual compartments on smooth rolling drawout carriages or rotating trunnions. The potential transformers shall be equipped with dead front type primary fuses of the current limiting type with an interrupting capacity not less than the rated interrupting capacity of the largest circuit breaker. The potential transformers and primary fuses shall be completely disconnected and visibly grounded when in the drawn out position to permit inspection or to permit access for removal or replacement of primary fuses. Safe and convenient front accessibility shall be provided for the fuses. No low voltage fuses shall be mounted in the high voltage compartments. In addition to local potential transformer connections for metering and relaying, potential transformer leads shall be wired to a terminal block for NPC's remote use.

Cubicles for the above measuring transformers and surge arresters (if required) which include unprotected live parts shall have a protective screen door inside the cubicle door. The screen shall prevent accidental access to live parts, but it shall make visual examination of the cubicle possible.

Potential transformers shall be supplied with two high rupture capacity primary fuses for each potential transformer.

EW-6.3.4.7 Surge Arresters

If required in the Technical Data Sheets and shown in the basic single line diagram, surge arresters for metalclad switchgear use shall be of the gapless metal-oxide built-up of modular, identical elements with a current limiting characteristic.

The arresters shall have the characteristics and rating features specified in the Technical Data Sheets.

EW-6.3.4.8 Ground and Test Equipment

When a removable grounding and testing unit is specified in the Technical Data Sheets, it shall permit the user to safely energize primary circuits of instrument transformers, test phase relationship of primary conductors, determine the presence of high voltage, and to short-circuit and ground primary conductors.

EW-6.3.4.9 Wiring

Terminal boards shall be provided for all controls, instruments, meters and relays requiring external connection. They shall be rated not less than 25 amperes, 600 volts and provided with barriers, marking strips and terminal screws. A reasonable number of spare terminals shall be provided. However, not less than 15 percent of terminals on each block shall be spare. Each terminal point shall be marked with the designations shown on Contractor's Control Wiring Diagram (CWD).

Terminal blocks for current transformer (CT) terminals shall be the shorting type designed to protect the CTs while calibrating and/or maintaining relays or instruments.

Current and potential transformer secondary circuits not requiring external connections shall be grounded at the switchgear. Required grounding of each circuit shall be by independent connection to the switchgear ground bus.

Wiring shall be stranded copper switchgear wire with Type SIS insulation (heat-, moisture-, and flame-resistant) in most cases. Variations which may be needed in some cases (depending on possible special needs in certain systems) are:

a. No. 18 AWG Teflon Type E hook-up wire for modules if space and/or extreme flexibility are critical.
b. Special stranding where moderate flexibility is important.

All circuits shall use nothing smaller than No. 14 AWG wire. On other circuits where maximum current does not exceed 5 amperes, No. 16 AWG wire may be used. Wire shall be of adequate rating for the current to be carried.
Control wiring shall be Nos. 10, 12 and 14 AWG stranded copper cables. Current transformer secondary current leads will be No. 8 AWG.

Wiring shall be free of abrasions and tool marks, including no nicks or frays from stripping of insulation. Wiring shall also:

a. Have a minimum bending radius of 6.25 mm (1/4 inch)
b. Have sufficient surrounding space to avoid jamming near terminal blocks, or between terminal blocks and wireways
c. Be adequately supported to prevent sagging and breakage, caused by vibration or shock in transit.

Wiring required to interconnect shipping sections shall be terminated on a terminal board in one section, to which the loose wires of the other section will be connected when the switchgear sections are assembled. All wiring from a section that must cross the shipping split shall be terminated in the last compartment of the split and the interconnecting wiring shall be arranged so that the wiring only extends between the two adjoining components. The wiring shall be tagged, bundled, terminated and then pulled back into one of the compartments.

Where cables must be carried across hinges to devices mounted on doors, extra flexible, ICEA (Insulated Cable Engineers Association) Class D stranding conductors shall be used.

The wiring bundle shall be carried between a clamp on the door and one on the fixed portion of the cabinet. These shall be adjacent to the hinge and shall be between 300 mm and 600 mm (12 and 24 inches) apart, with the door fully open.

Clamps elsewhere shall be spaced uniformly at distances approximately no greater than 600 mm (24 inches) apart.

Contractor's wiring shall be terminated on terminal boards or equipment with insulation-gripping insulated wire terminal lugs. The tongue portion of the terminal lugs shall be flanged-spade, identical-spade or ring type.

Ratchet-type tools shall be used in attaching lugs to wires, to avoid loose connections due to insufficient pressure while crimping.

Box-clamp or saddle-clamp terminals are not acceptable because of possible damage to wire ends. Relays and other devices sometimes provided with saddle clamps shall be procured minus such clamps, or the clamps shall be removed in panel assembly; ring-type lugs shall be used for panel wiring to these devices.

No solder or "push" or "quick" type terminals shall be used except:

a. Solder type for pushbuttons, on indicating lights
b. Solder type for flat resistors
c. Push-on for indicating lights

Terminals for NPC's external connections shall be arranged for consecutive connection of conductors within one cable. One external wire will be connected to each outgoing terminal points.

Terminations of two conductors at one terminal point shall be made by suitable bridges and links of the terminal. Terminals shall be of single insertion type and shall be suitable for connection of conductors from 2.5 mm^2 up to a cross-section of at least 10 mm^2. Not more than one wire shall be on any terminal lugs. Individual termination on each lug is necessary to facilitate trouble-shooting.

If accidental short-circuiting certain wires can result in malfunction of equipment, such as closing or tripping of a circuit breaker, these wires shall not be terminated on adjacent terminal points.

Wire markers on both ends of each wire that is longer than 300 mm (12 inches), with indelible designations in accordance with Contractor's wiring diagrams, shall be provided. The markers shall be for NPC's approval.

The system used for designation of control wiring shall show device identification with identified terminals arranged in substantially correct physical relationship, and shall provide sufficient information at each wire termination to locate the other termination without the need of tracing actual wiring, supplementary tabulations, or to information on the function of the wire. Contractor is solely responsible for correctness of the internal wiring and for the proper functioning of the equipment being furnished. Contractor's internal wiring shall conform to NPC's control wiring diagrams terminal-to-terminal connection between devices, physically as well as electrically, for the convenience in trouble shooting.

Switchgear units internal and external connection wiring diagram shall show clearly any connection to be made in the field, because of shipping sectionalizing. Contractor shall show all external cabling information for easy reference during wiring laying and installation.

EW-6.3.4.10 Control and Auxiliary Power

The control buses shall extend throughout the length of the structure and shall be metal enclosed in conduit or by means of Manufacturer's standard duct or barriers in order to isolate them from all other voltage circuits rated 1000 volts and above. DC control buses shall be double ended so that any single break in the bus shall not prevent operation of protective or control equipment.

The closing and tripping circuits of each electrically operated circuit breaker shall be separately protected by means of a circuit breaker in each conductor with a voltage rating specified in the Technical Data Sheets. The tripping circuit miniature circuit breaker shall be suitable for short circuit protection only and shall have a continuous rating of not less than 30 amperes.

Two pole switches or non-automatic air circuits breakers shall be provided for connecting control supply to switchgear control bus, one at each end.

Means shall be provided for quick and convenient access, preferably by a hinged door or panel, to the control disconnecting switches and associated protective devices.

Contractor shall provide terminals for incoming stranded copper power cables specified in the Technical Data Sheets. They shall be compression type, Burndy YA or other types acceptable to NPC.

EW-6.3.4.11 Space Heaters

Thermostatically controlled space heaters with rating specified in the Technical Data Sheets, shall be provided for each cubicle to keep the air inside the cubicle above the dew point to prevent condensation. The heaters shall be so located so that wiring, buses, equipment and control device will not be overheated.

EW-6.3.5 Instrumentation and Control

EW-6.3.5.1 Instrument, Meters and Relays

Protective relays, meters and instruments shall be switchboard type, semi-flush mounted, finished dull black and must be suitable for outdoor use. It shall be placed in a separate compartment fully isolated from the M.V. power equipment. Protective relays shall be of the drawout type and shall have targets. Auxiliary relays for NPC's remote use shall be surface mounted. All relays and targets shall be labeled as to function. Specific requirements for solid state motor protection systems shall be reviewed with NPC and included in Contractor's base bid.

Relays, instruments, solid state devices, and wiring shall withstand electrical surges in accordance with ANSI C37.90 or equivalent IEC standard.

All instruments, relays indicating lights, and other control devices, specifically the DC motor for the energy storage mechanism, shall operate without overheating, loss of life or function for the continuous operating voltage and its variation specified in the Technical Data Sheets. For a 125V DC system, variation shall be between 90volt (discharged battery) and 140volt (battery equalizing charge); duration at or near 140volt will not exceed 24hours per month, and duration at 90volt will be only in emergency or during short periodic tests. The 125volt DC system is normally float charged. Thus the continuous operating DC voltage of the items covered by this paragraph is 135volts. When tripping is via AC supply then a capacitor discharge, or similar device shall be used so that breakers can still be tripped on loss of AC power.

The breaker closing and tripping circuits shall operate properly over a voltage range specified in the Technical Data Sheets without overheating or loss of life.

All watthour meters, if required, shall be furnished with solid state pulse transmitters.

Relays shall not be located in a position that would result in inadvertent operation (close or trip), of the relays, when the cubicle door is either closed or opened.

EW-6.3.5.2 Control System

The control system of the switchgear shall be designed for manual, local and if required in the Technical Data Sheets, remote operation and indication. All devices and other accessories necessary for the local and remote control function shall be provided by the Contractor. Necessary interlocking scheme, however, should be provided so that no simultaneous control operation of the switchgear from two or more locations is possible.

Selection for the location of control operation is to be made via selector or auxiliary switch with three positions located at the breaker cubicle:

Position 1: Local Control - control function to be done on the independent compact medium voltage control unit at the switchgear cubicle

Position 2: Substation Control - control function to be done on the main control board at the substation control room or through the MMI display if substation control by MBSC System

Position 3: Remote Control - control function to be done at the Remote Center (either ACC – Area Control Center or RCC – Regional Control Center)

When required at the Technical Data Sheets, control function can be incorporated on the microprocessor based substation control system.

Earthing switches if provided in each feeder cubicle shall be operated locally and manually at the switchgear. A position indicator mechanically operated shall be provided in the cubicle.

There shall be three (3) possible function of the medium voltage circuit breaker.

- Operation
- Test
- Maintenance

In the "operation" position, both power and control circuits shall be connected to the (removable) circuit breaker carriage with the breaker ready for operation. In the "test" position, the main contacts are disconnected while the control circuits connected; in the "maintenance" position, the power and control circuits are disconnected.

EW-6.3.5.3 Control and Instrument Switches

Control switches shall have pistol grip handles and instrument switches shall have round knurled handles. Synchronizing switches, if required shall have oval handles so keyed that they are removable in the "OFF" position only. Discrepancy type control switches are also acceptable.

The switches shall be rated 600volts and 20amperes continuous current. If NPC's circuit diagrams do not fulfill interrupting requirement, Contractor shall modify diagram and furnish switches having the correct series combination of contacts.

EW-6.3.5.4 Interlocking System

The electromechanical interlocking system shall prevent the following operations:

a. The circuit breaker being withdrawn from or inserted into the "service position" when it is closed and when the feeder is earthed with the cubicle earthing switch;
b. The closing of the circuit breaker, unless correctly located in the service, earth or isolated positions or unless the circuit breaker is withdrawn from the fixed portion of the equipment;
c. Closing of the earthing switch, if provided, while the circuit breaker in the same cubicle is at "operation" position (closed or open);
d. Operation of the bus sectionalizer (if bus sectionalizer is required or indicated in the single line diagram provided) when any circuit breaker or one bus bar section is in the closed position; and
e. The moving position being withdrawn or replaced unless the circuit breaker is isolated and in the appropriate position for withdrawal or replacement.

Safety shutters and/or isolating barriers shall be provided for safety. Full details of the proposed interlocking facilities shall be submitted.

EW-6.3.5.5 Accessories

Accessories shall be furnished by Contractor in quantities indicated in the Technical Data Sheets.

The accessories furnished shall include any necessary devices for withdrawing and inserting the removable elements, devices for manual operation of the breakers, and any other special devices listed.

Handling truck(s) or equivalent device (if required) used for elevating or lowering the circuit breaker to and from its movable carriage shall have a safe margin of stability to prevent upset.

Means shall be provided for locking the wheels of handling devices to prevent movement when raising or lowering the circuit breaker.

Any manually operated device for raising and lowering the breaker shall have an advantage ratio so that one man can readily elevate the largest breaker that it is designed to handle. It shall be equipped with a simple and rugged safety device which will prevent dropping the breaker or reverse rotation caused by release of the operating handle.

Cable termination complete with necessary accessories shall be provided for the outgoing or incoming feeders. The cable to be used shall be as indicated in the Bid Drawings. Cable termination shall be designed in such a way that DC voltage test of the cable can be carried out safely and conveniently.

EW-6.3.6 Medium Voltage Power Cable or Non-Segregated Busduct

For the purposes of connecting the metalclad switchgear to the transformer, a medium voltage power cable or a non-segregated busduct assembly shall be supplied as required in the Technical Data Sheets.

If medium voltage cables will be used or specified in the Technical Data Sheets for the connection between the transformer and the metalclad switchgear, the supply shall include but is not limited to the following:

a. medium voltage cable;
b. termination kit and accessories;
c. cable duct and supporting structures

If bus and busduct assembly will be used or specified in the Technical Data Sheets for the connection between the main transformer and the metalclad switchgear, the supply shall include but is not limited to the following:

a. bus and accessories;
b. non-segregated busduct and supporting structures

Terminal connector hardware and accessories shall be coordinated with the material used in the bushing terminal of the transformer and the material used for the medium voltage cable (copper) to prevent electro-chemical action and corrosion.

EW-6.3.7 Other Technical Requirements for the Metalclad Switchgear

Other features for the metalclad switchgear, if required by the NPC are stated in the Technical Data Sheets.

EW-6.4 INSTALLATION

Installation will be by Contractor unless specified otherwise in Section B.1.0 of the Technical Data Sheets.

When the installation is by Contractor, such as for turnkey contracts complete details of proper handling, transport and storage, installation, testing, commissioning, performance, guarantees, etc. shall be provided for NPC's review and approval.

EW-6.5 FACTORY ASSEMBLY AND TESTS

EW-6.5.1 Shop Tests

Shop tests shall be applied to all the equipment being furnished as follows:

a. The equipment being furnished shall be checked to assure that physical fit and clearances between the mobile unit and stationary structure are satisfactory

b. Design tests, if required in the Technical Data Sheets, shall be performed on each generic piece of equipment, i.e., switchgear, circuit breaker, current transformer, potential transformer, current limiting reactor, etc., in accordance with the applicable ANSI, IEC, IEEE, NEMA and UL Standards listed in Section EW-6.2. Certified test reports shall be furnished.

c. If design tests are required, data from previously conducted test, meeting the same or more stringent requirements specified herein, are acceptable. Certified tests reports shall be submitted to NPC for review and approval.

d. Design, Production (Routine) and Conformance Tests shall be done in accordance with Section EW-6.5.2 or equivalent IEC requirement.

Contractor shall provide equipment, instruments, tools and personnel and all expenses incidental to the foregoing tests, including replacement of parts damaged during testing.

Special test requirements, if required, are indicated in the Technical Data Sheets.

Where electrical interlocks between breakers on the same switchgear assembly are required or indicated in the one-line diagram, operating tests shall be made to verify the correctness of the key and electrical interlocking circuits.

EW-6.5.2 Tests Summary and Governing Standards

Equipment Component Tests	Switchgear	Breaker	Current Transformer	Potential Transformer	Relays	Cables
Design	ANSI C37.20 (5.2)	ANSI C37.09 (4)	ANSI C57.13 (4.5, 4.6, 4.7, 7.9, 8)	ANSI C57.13 (4.5, 4.6, 4.7, 7.9, 8)	ANSI C37.90 (8, 9)	IPCEA S-66-524 (Part 6, 6.2 to 6.13) UL 44 (Section 85)
Production Routine	ANSI C37.20 (5.3)	ANSI C37.09 (5)	ANSI C57.13 (4.5,4.7, 6.11, 8)	ANSI C57.13 (4.5, 4.7, 7.9, 7.10, 8)	Manufacturer Standard	IPCEA S-66-524 (Part 6, 6.14 to 6.16)

Conformance	ANSI C37.20 (5.4)	ANSI C37.09 (6)				
Field	ANSI C37.20 (5.5, Dieletric)	ANSI C37.09	ANSI C57.13		Utility Standard	IPCEA S-66-524 (Part 6, 6.14.7)

Note: (n) Indicates Paragraph numbers in corresponding standard.

EW-6.6 DATA AND DOCUMENTATION REQUIREMENTS

EW-6.6.1 General

Contractor shall furnish the data and documents required by this specification and/or listed in Section EW-6.6.4 within the time specified, for NPC's review and/or NPC's records.

Contractor shall submit with his proposal, a proposed schedule of work including equipment delivery dates, in sufficient detail to demonstrate Contractor's ability to perform the work within NPC's required schedule.

EW-6.6.2 Data and Information to be Submitted with the Proposal

Contractor shall furnish with his proposal the filled-in Section A.3.0 of the Technical Data Sheets.

EW-6.6.3 Data and Information to be Submitted During Post Qualification

Contractor shall furnish during post qualification the following:

a. Filled-in Section B.6.0 of the Technical Data Sheets.

b. Contractor shall furnish the brochures and catalogues during post qualification to support the filled-in Technical Data Sheets and to allow NPC to evaluate the equipment/materials being offered

EW-6.6.4 Data and Information to be Submitted After Award of Contract

Contractor shall submit drawings, in the manner and within the time specified, showing NPC order number and item number(s), outline and overall dimensions, clearance dimensions, connection details, weights, weld end preparation, sectional views showing functional parts, parts list and materials. All drawings which show fabrication by welding, shall indicate the joints together with the required weld joint geometry, welding procedure number and extent and type of inspection in accordance with AWS Standard A2.4.

The drawings, instruction manuals, and information submitted shall be as follows:

a. Dimensions general assembly drawing showing arrangement of all major items, required maintenance and operating clearances, NPC's terminal pads, surfaces, and clearances required for mounting gear, including:

1. Installation or erection drawings and details including as appropriate
   i. required
   ii. Installation Manuals
   iii. Installation details for Contractor furnished loose items
   iv. Record of all clearances, tolerances and other pertinent data required for installation
   v. Welding and/or bolting specification and extent of field work

2. Foundations requirements, loads, fastening details
3. List of loose instruments, devices, accessories

b. Total weight of complete assembly and individual weight of typical units

c. Weight and dimensions of major pieces to be shipped

d. Ratio correction factor, phase angle correction and saturation curves, as well as the internal resistance and short time and overload ratings for current transformers

e. Rating of control transformer for NPC's auxiliary power supply, if furnished

f. Type and catalog designation of all instruments, meters and transducers

g. Size, material, continuous rating and temperature rise guarantee of bus conductor and method of connections of unit buses to main bus and insulation level of the buses.

h. Size, material and three-second current rating of ground bus

i. Description and rating of the ground and test equipment

j. Equipment bill of material (including complete rating of breaker)

k. Device internal connection diagrams if not available in instruction books complete with Manufacturer's standard terminal designations.

l. Contractor shall supply one complete set of Control Wiring Diagrams after completion of shop tests with the following information added:

   1. Any changes required because of component substitutions or other reasons
   2. Actual wiring at the completion of tests
   3. Component and external connection terminal identification

m. Contractor shall supply unit internal connection wiring diagram with identification of devices, terminals and connecting wires.

   The system used for designation of control wiring shall show device identification with identified terminals arranged in substantially correct physical relationship, and shall provide sufficient information at each *wire termination to locate the other termination without referring to supplementary tabulations or information on function of wire. Contractor is solely responsible for correctness of the internal wiring and for proper functioning of the equipment being furnished. Contractor's internal wiring shall conform to other equipment CWD's supplied under this Contract and shall conform physically as well as electrically to Contractor's detailed wiring diagrams.*

n. Switchgear units internal and external connection wiring diagram shall be provided. The diagram shall show clearly any connections to be made in the field (because of shipping sectionalizing). Contractor shall show all external cabling information and space shall be reserved on Contractor's drawings for additional external wiring information;

o. Detailed QA Program based on ISO 9001;

p. Routine Test Reports;

q. Field Tests to be performed and Field Test Reports duly signed and witnessed by NPC representative(s);

r. Complete instruction manuals covering installation, operation and maintenance;

s. ISO 9001 Certification of the proposed manufacturer; and

t. As-built drawings as finally approved.

The Contractor shall furnish in the manner, number of copies, and within the time as set forth in the contract, instruction manuals in accordance with Section EW-2.9 of the General Works.

EW-7.0 SURGE ARRESTERS

EW-7.1 SCOPE

EW-7.1.1 General

This specification covers the technical and associated requirements for outdoor surge arresters of 69kV voltage system and above for use in electric power generating station, switchyard and substation.

It is not NPC's intent to specify all technical requirements nor to set forth those requirements adequately covered by applicable codes and standards. Contractor shall furnish high quality outdoor surge arresters meeting the requirements of these specification and industry standards.

Contractor shall bear full responsibility that the equipment has been designed and fabricated in accordance with all codes, standards, and applicable governmental regulations and performs under the conditions and to the standards specified herein.

No departure shall be made from these specification and standards unless waived or modified in writing by NPC. The Contractor shall obtain from its subcontractors a statement as to the compliance with this specification without exception and/or if there are any exceptions, these shall be described in detail and included in the Contractor's proposal. The Contractor shall add a statement that no other exceptions are taken to this specification.

EW-7.1.2 Works to be Provided by the Contractor

The Contractor shall provide the equipment, accessories and services delineated in Section B.1.0 of the Technical Data Sheets.

EW-7.1.3 Works to be Provided by NPC

NPC shall provide the materials (if any) and services listed in Section B.1.0 of the Technical Data Sheets.

EW-7.2 CODES AND STANDARDS

EW-7.2.1 General

The surge arresters furnished shall be in accordance with, but not limited to, the latest issues of the following codes and standards, including all addenda, in effect at time of purchase order unless otherwise stated in this specification:

ANSI/IEEE	**American National Standards and/or Institute of Electrical and Electronics Engineers**
C62.11	Standard for Metal Oxide Surge Arresters for AC Power Circuits

ICBO	**International Conference of Building Officials**
UBC	**Uniform Building Code of the International Conference of Building Officials, Section 2312 - Earthquake Regulation**
IEC	**International Electrotechnical Commission (all parts of listed Standards apply)**
60071	Insulation coordination
60099-3	Artificial Pollution Testing of Surge Arresters
60099-4	Metal-oxide Surge Arresters without Gaps for A.C. System
60815	Guide for Selection of Insulators in Respect of Polluted Conditions
NEMA	**National Electrical Manufacturers Association**
107	Methods of Measurements of Radio Influence Voltage (RIV) on High Voltage Apparatus
ISO	**International Standards Organization**
9001	Quality System Model for Quality Assurance in Design/Development, Manufacture and Testing
9002	Quality System Model for Quality Assurance in Production, Installation and Servicing

These codes and standards set forth minimum requirements which may be exceeded by Contractor if, in Contractor's judgment and with NPC's acceptance, superior or more economic designs or materials are available for successful and continuous operation of Contractor's equipment as required by this specification.

EW-7.3 TECHNICAL REQUIREMENTS

EW-7.3.1 Description of Services

The surge arrester(s) covered by this Specification is (are) for use in a generating station and/or substations. The application details are in the Technical Data Sheets.

All materials and parts which are not specifically mentioned herein but are necessarily for the proper erection, assembly and safe operation of the surge arrester shall be furnished at no increase in cost to the NPC.

EW-7.3.2 Design Requirements

EW-7.3.2.1 General

Each arrester shall be new and a current standard production model with modifications as may be required to satisfy the requirements stated herein.

Each arrester shall be station class metal oxide type without gaps and shall be self-supporting, base mounted outdoor type, suitable for frame or transformer tank mounting as specified in the accompanying Technical Data Sheets. When so specified in the Technical Data Sheets, each arrester shall be furnished complete with an insulating base and a cyclometer type discharge counter with integral continuous AC leakage/internal current indicator.

When so specified on the accompanying Technical Data Sheets, each arrester shall be furnished complete with a frame type supporting structure.

The arresters shall conform to the applicable requirements of Proposed Standard ANSI/IEEE C62.11or IEC 60 099 and NEMA Publication LA1, except as stated herein or as shown in the accompanying Technical Data Sheets.

Arrester insulator columns shall conform to the requirements of applicable ANSI, IEC and NEMA Standards, except as stated herein, or as shown in the accompanying Technical Data Sheets.

Supporting steel structure for the arrester shall be hot-dip galvanized after fabrication in accordance with the applicable provisions of ASTM 123 and A153. Threads shall be undercut an amount sufficient to allow for the galvanized coating. All galvanizing shall be performed in accordance with the best modern practice.

Arresters shall require no routine maintenance, upkeep, or attendance, except as required to remove pollution contaminants.

EW-7.3.2.2 Working Stresses

The design of all components, particularly those subject to shock or stress reversal, shall incorporate reasonable factors of safety in all cases.

EW-7.3.2.3 Service Condition

The equipment shall be suitable for outdoor installation and use at service conditions specified in Section B.1.0 of the Technical Data Sheets without corrosion, deterioration or degradation of performance characteristics.

EW-7.3.3 Construction Features

EW-7.3.3.1 General

The arrester design and construction shall comply with the applicable requirements of ANSI/IEEE C62.11 or equivalent IEC Standards.

The arrester assembly shall consist of arrester unit, line terminal, earth terminal, insulating base, surge counter and leakage current meter and supporting structure if so specified in the Technical Data Sheets and other hardware required for installation.

The unit shall be hermetically sealed, moisture free and provided with a pressure relief system. The arresters are intended for vertical mounting on a horizontal surface.

EW-7.3.3.2 Insulators

Material, dimensions, structural characteristics and the general contour of insulators shall be in accordance with ANSI or equivalent IEC insulator standards.

The required number of cap screws, nuts and lockwashers, all made of stainless steel as specified in ANSI insulator standards, shall be furnished.

EW-7.3.3.3 Terminals

The primary terminals shall be suitable for the connection of the type of conductors specified in the Technical Data Sheets which can be either copper or aluminum conductors without use of bimetal inserts.

Each arrester shall have a metal cap with an attached flat surface terminal pad having four (4) 14.3 mm (9/16") diameter holes drilled with 45 mm (1-3/4") center line spacing per applicable ANSI and NEMA Standards. When current rating dictates the use of terminal pads with other hole drilling, the same shall be in accordance with applicable ANSI and NEMA Standards and shall be submitted to NPC for approval.

Depending on the requirement mentioned in the Technical Data Sheets, the terminal pad shall be either of high conductivity bronze alloy of copper or aluminum alloy. If copper-alloy terminal pad is required, it shall be completely and uniformly hot flowed electro-tinned with commercially pure tin to a minimum thickness of 0.127 mm (0.005").

EW-7.3.3.4 Ground Connectors

Each arrester shall be furnished complete with a non-corroding clamp type ground connector suitable for copper stranded conductor specified in the Technical Data Sheets.

Arrester supporting structure, if so required in the Technical Data Sheets, shall be provided with two grounding pads for EHV arresters located diametrically on opposite side of the structures and one grounding pad for 230 kV and below. The grounding pad shall be located approximately 400 mm above finished ground level.

Each grounding pad shall be flat and shall be provided with a clamp type connector suitable for the size of the copper stranded ground conductor specified in the Technical Data Sheets.

Copper ground conductor connections between arresters and discharge counters shall be furnished with the arresters and shall be insulated and insulator supported to prevent conductor movement.

EW-7.3.3.5 Discharge Counter

If so specified in the Technical Data Sheets, the arrester shall be furnished complete with a discharge counter.

The discharge counter shall be of the cyclometer dial type for automatically recording the number of arrester surge discharges. Each counter housing shall include a continuous AC leakage/internal current indicator. The counter/indicator shall have negligible effect on arrester protective level. Discharge counter operation shall not require an external power source. Each discharge counter assembly shall include a suitable non-corroding arrester connector and a non-corroding clamp type ground connector suitable for accepting stranded copper ground conductor with the size specified in the Technical Data Sheets.

The discharge counter shall be fully weatherproofed and sealed for life and provided with means enabling the removal of the counter without disconnecting the surge arrester.

Discharge counter shall be mounted approximately 1500 mm above finish ground level both for structures and transformer tank mounted arresters.

No special maintenance or servicing shall be required by the discharge counter apart from cleaning the viewing window of the counter and the moulded epoxy resin line terminal bushing.

The discharge counter shall be provided with auxiliary contacts for use in remote indication of counter operation and if required in the Technical Data Sheets, be interfaced with the Microprocessor Based Substation Control (MBSC) System for the substation, if control system for the substation is through the MBSC.

EW-7.3.3.6 Pressure Relief Device

Each arrester units shall be equipped with a pressure device or devices to limit the internal arrester pressure so as to prevent explosion or violent shattering of the porcelain housing, if porcelain type of housing is required, with the short circuit current specified in the Technical Data Sheets.

The design of the pressure relief shall be such that it will not operate under the specified conditions or rated operating duty.

EW-7.3.3.7 Corrosion Protection

Fittings and flanges shall be hot-dip galvanized iron or bronze while surge counter housing shall be of die cast aluminum casing PVC coated for lasting resistance to surface corrosion.

EW-7.3.3.8 Mechanical Strength

The arrester shall be designed to withstand the mechanical stresses which can arise as a result of forces on the line terminal, in accordance with Section EW-7.3.3.3.

EW-7.3.3.9 Line Discharge Energy Capability

The arresters shall be capable of discharging the energy of a transmission line as specified in ANSI/IEEE C62.11. Test to verify this capability shall be made as described in the proposed standard.

EW-7.3.3.10 Supporting Structures

Supporting structures shall be fabricated of steel and be hot-dip galvanized after fabrication in accordance with the applicable provisions of ASTM 123 and A153.

All galvanized bolts, nuts and washers required for complete structure assembly and erection, including foundation anchor bolts, shall be furnished.

All individual pieces of the structures shall be marked with correct designations shown on the approved shop drawings. Marking shall be done by die stamping the marks into the metal before galvanizing and shall be clearly legible after galvanizing. The number and letter shall be a minimum of 12 mm in height and 8 mm wide.

EW-7.4 INSTALLATION

Installation will be by Contractor, unless specified in Section B.1.0 of the Technical Data Sheets.

When the installation is by Contractor, such as for turn-key contracts complete details of proper handling, transport and storage, installation, testing, commissioning, performance guarantees, etc. shall be provided for NPC's review and approval.

EW-7.5 TESTS

EW-7.5.1 Design Test

All design tests, described in ANSI/IEEE C62.11 and IEC 60099-4 shall be performed on arresters of new design. The Contractor shall submit with the proposal, certified copies of design test reports conducted on similar surge arresters design, in accordance with ANSI/IEEE C62.11 or IEC 60099-4. As minimum, these tests must include:

a. Insulation Withstand Tests
b. Long Duration Current Impulse Withstand Test
c. Residual Voltage Test
d. Duty Cycle Tests
e. Pressure Relief Withstand Tests
f. Test to verify thermal equivalency between complete arrester section

g. Contamination Tests
h. Impulse Discharge or Residual Voltage Tests

The surge arrester shall be opened subsequent to all test. If inspection of the internal parts reveal evidence of overheating, flashovers, or parts cracking or breaking, the surge arrester shall be considered to have failed the test.

The arrester used for these test purposes shall not be furnished as part of the scope of supply by the Contractor.

EW-7.5.2 Routine Tests

Minimum requirement for routine tests to be performed shall be as specified in IEC 60099-4. In addition, the following shall also be performed:

a. All ZnO-blocks are individually checked regarding their electrical properties and energy capability, as well as life stability:

b. Power losses are measured at 0.8 times rated voltage on each arrester unit.

c. Check of internal corona made at 1.05 times COV. Each unit is checked to have a steady internal corona level less than 5 pC in a pass/no-pass test.

d. Tightness check to be made on each unit in pass/no-pass test. Maximum permissible leakage is 0.0001 cc/sec at a pressure difference of 0.1 MPa.

The routine tests shall be made on each arrester to be supplied.

EW-7.5.3 Acceptance Tests

Acceptance tests shall be done in accordance with IEC 60099-4. These shall include:

a. Lightning impulse residual voltage test on complete arrester;

b. Measurement of power frequency voltage on the complete arrester at the reference current measured at the bottom of the arrester;

c. Partial discharge test;

d. Thermal stability test

The number of arrester units that will undergo the acceptance tests shall be as stated in IEC 60099-4, Clause 8.2 but in no case shall be lower than three (3) units. Test samples shall be chosen at random by the NPC.

EW-7.6 DATA AND DOCUMENTATION REQUIREMENTS

EW-7.6.1 General

Contractor shall furnish all data and documents required by this specification for NPC's review.

Contractor shall submit with his proposal a proposed schedule of work, including equipment delivery dates, in sufficient detail to demonstrate Contractor's ability to perform the work within NPC's required schedule.

EW-7.6.2 Data and Information to be Submitted During Post Qualification

Contractor shall furnish during post qualification the filled-in Section B.7.0 of the Technical Data Sheets.

EW-7.6.3 Data and Information to be Submitted After Award of Contract

The Contractor shall furnish in the manner, number of copies and within the time set forth in the purchase order, installation and instruction manuals in accordance with Section GW-2.9 of the General Works.

The Contractor shall also furnish the following information:

a. Brochures and catalogues to support the filled-in Technical Data Sheets and to allow NPC to evaluate the equipment/materials being offered;

b. Outline drawings of each arrester assembly and supporting structure, showing:

   1. Overall dimensions;
   2. Mounting dimensions including location and size of anchor bolt holes;
   3. Grounding pad and ground terminal location and details;
   4. Recommended minimum clearance;
   5. Total net weight of arrester assembly and supporting structure;
   6. Center of gravity of complete assembly;
   7. Shipping dimensions and weight of component parts;
   8. Net weight of each part to be assembled in the field;
   9. Elevations and sectional views with component parts identification by description and/or catalogue number;
   10. Rating and identification nameplate location. The nameplate shall also include the creepage distance and cantilever strength of insulator column;
   11. Detailed design calculation and stress diagrams of the supporting structures;
   12. Line terminal location and dimensional data including hole size and spacing;
   13. Grading ring location and dimensions;
   14. Porcelain color.

c. Outline drawings of discharge counter with integral continuous AC leakage/internal current indicator showing:

   1. Dimensions and mounting details;
   2. Arrester and ground terminal location and details;
   3. Net weight

d. Radio influence voltage (RIV) test data;

e. Typical wiring diagram;

f. Discharge counter schematic diagram;

g. Outline drawings of each insulating base showing dimensions and mounting details;

h. Certificate Design Test and Routine Tests Reports

i. Field Tests to be conducted after installation at site and Field Tests Reports duly signed and witnessed by NPC's representative(s);

j. Complete instruction manuals for installation, operation and maintenance;

k. ISO 9001 Certification of the proposed manufacturer;

l. Detailed QA Program based on ISO 9001; and

m. As-built drawings as finally approved.

NPC's general review of drawings and information or waiver of same shall not in any way relieve Contractor or any of its responsibilities to meet all requirements of this specification.

EW-8.0 INSTRUMENT TRANSFORMERS

EW-8.1 CURRENT TRANSFORMER

EW-8.1.1 SCOPE

EW-8.1.1.1 General

This specification covers the technical and associated requirements for current transformers rated 69kV and above for use in electric power generating stations, switchyard and substation.

It is not NPC's intent to specify all technical requirements nor to set forth those requirements adequately covered by applicable codes and standards. The Contractor shall furnish high quality current transformer meeting the requirements of this specification and industry standards.

The Contractor shall bear full responsibility that the equipment has been designed and fabricated in accordance with all codes, standards, and applicable governmental regulations and performs under the conditions and to the standards specified herein.

No departure shall be made from this specification and standards unless waived or modified in writing by NPC. The Contractor shall obtain from its subcontractors a statement as to the compliance with this specification without exception and/or if there are any exceptions, these shall be described in detail and included in the Contractor's proposal. The Contractor shall add a statement that no exceptions are taken to this specification.

EW-8.1.1.2 Work to be Provided by the Contractor

The Contractor shall provide the equipment, accessories and services delineated in Section B.1.0 of the Technical Data Sheets.

EW-8.1.1.3 Work to be Provided by NPC

NPC shall provide the materials (if any) and services listed in Section B.1.0 of the Technical Data Sheets.

EW-8.1.2 CODES AND STANDARDS

EW-8.1.2.1 General

The current transformer furnished shall be in accordance with, but not limited to, the latest issues of the following codes and standards, including all addenda, in effect at time of purchase order unless otherwise stated in this specification:

ANSI/IEEE	**American National Standards Institute and/or Institute of Electrical & Electronic Engineers**
C57.13	Standard Requirements for Instrument Transformers
C57.13.1	Guide for Field Testing of Relay Current Transformers

IEC	**International Electro-Technical Commission**
60044-1	Current Transformers
60044-6	Requirements for Protective Current Transformers for Transient Performance
60060-1	High Voltage Test Techniques – Part 1: General Definitions and Test Requirements
60071-1	Insulation Coordination
60085	Thermal Evaluation and Classification of Electrical Insulation
60287	Partial Discharge Measurements
60567	Guide for Sampling of gases and of Oil from Oil-filled Electrical Equipment and for the Analysis of Free and Dissolved Gases
60815	Guide for the Selection of Insulators in Respect of Polluted Conditions

ISO	**International Standards Organization**
9001	Quality System Model for Quality Assurance in Design/Development, Manufacture and Testing
9002	Quality System Model for Quality Assurance in Production, Installation and Servicing

These codes and standards set forth minimum requirements which may be exceeded by Contractor if, in Contractor's judgment and with NPC's acceptance, superior or more economic designs or materials are available for successful and continuous operation of Contractor's equipment as required in this specification.

EW-8.1.3 TECHNICAL REQUIREMENTS

EW-8.1.3.1 Description of Services

The current transformer(s) covered by this specification is (are) for use in a generating station and/or a substation. The application details are in the Technical Data Sheets.

All materials and parts which are not specifically mentioned herein but are necessary for the proper erection, assembly and safe operation of the current transformer shall be furnished at no increase in cost to the NPC.

EW-8.1.3.2 Design Requirements

Current transformers shall be provided for all breakers as shown in the bid drawings. It shall be of single pole, outdoor, free standing type or of bushing type erected in the circuit breaker bushings. Depending on the requirement stated in the Technical Data Sheets, the insulation medium could either be oil or gas (SF6) insulated current transformer.

For bushing type CT, it shall be installed in the bushing turrets of the breaker. Three (3) secondary windings shall be provided in each bushing turret of the circuit breakers unless otherwise specified in the Technical Data Sheets.

For free standing type CTs, it shall be mounted on a separate structure or on the breaker structure. Each CT shall be equipped with the required secondary windings mentioned in the Technical Data Sheets.

The free-standing oil insulated current transformer shall be hermetically sealed by stainless steel metallic bellows. All sealing shall be located below the oil level. Expansion room shall be of gas cushion type. Oil level indicators shall be easily readable from the ground level and without having to move parts.

The primary and secondary winding of the SF6 gas insulated CTs shall be housed in a non-corrosive cylinder. SF6 gas detection system shall be provided which continuously monitors the condition of the gas inside the cylinder. Alarm signals shall be initiated in case of gas leakage or low density of gas. Auxiliary contacts shall be provided for remote indication of the gas level and shall be interfaced with the Microprocessor Based Substation Control (MBSC) system for the substation, if required in the Technical Data Sheets.

The CTs shall have adequate thermal capacity to carry without injury the momentary current capability of the circuit breaker.

Current transformers provided for protective purposes shall have overcurrent and saturation factors not less than those corresponding to the design short circuit level of the system. The CT output must accurately represent the transmission line values during both steady-state and transient conditions.

The CTs can either have a single or multi ratio as described in the Technical Data Sheets with the taps shown on the single line diagram. The design of one of the winding can be changed without affecting the ratio of the other winding.

The knee-point voltage of the CT shall be according to applicable ANSI of IEC Standards such that the CT will not saturate during normal or maximum design short circuit current operation.

All taps of each winding shall be connected to a terminal block in the secondary terminal junction box so that changes in ratio can be made at the terminal box.

EW-8.1.3.3 Design and Construction Features

General

The material and workmanship throughout shall be of best quality and in accordance with the modern practices. The design shall be such that installation, replacement and general maintenance may be undertaken with a minimum of time and expense.

The metal housing which forms the top of the CTs and complete protection from weather shall be easily removable, should it be necessary to "top-up" the oil chamber, if free standing CTs are supplied.

For oil insulated CTs, an oil gauge and an oil drain valve shall be fitted on each unit containing oil. The porcelain used for the free standing CTs shall be single piece type.

Housing and Tanks of Free Standing CTs

The housing or tanks shall be of welded steel plate construction and of sufficient strength and rigidity to provide a tight-fitting gasket and sealed enclosure. All components shall be manufactured from non-corrosive material or shall be suitably protected against corrosion.

The complete assemblies shall form sealed enclosures capable of sustaining full pressure developed within housing or tank, either above or below atmospheric, under normal conditions of operation. The windings and bushings shall be hermetically sealed to prevent the entrance of moisture or leakage of dielectric when the current transformer is installed or when under transportation.

Core and Windings

The core shall be made of high quality non-aging oriented silicon steel to give the best magnetic characteristics. The windings shall be properly insulated for the specified insulation class and shall be capable of withstanding the maximum temperature under service conditions specified.

The core and winding structure shall be rigidly braced and clamped to sustain the mechanical forces under rated dynamic current and to prevent shifting of parts under transportation handling and installation.

The design of core and windings shall be such as to ensure high accuracy, uniform impulse distribution and low leakage reactance. Each secondary winding shall be wound on a separate core.

Temperature Rise

The temperature rise of the current transformer under conditions specified in IEC 60044-1 and ANSI C57.13 shall be based on a 55°C rise.

Primary Terminals of Free Standing CT's

The primary terminals shall be suitable for connection of copper or aluminum conductors without the use of bimetal inserts.

The terminal pads shall be provided with four 14.3 mm (9/16 inch) diameter holes with 45 mm (1-3/4 inch) spacing between the centers of each hole in accordance with the standard NEMA 4 holes arrangement.

The terminal pads shall be of high conductivity bronze or copper and shall be plated with hot flowed electro-tin to a thickness of not less than 0.127 mm (0.005 inch) or an aluminum alloy with hardness Hb minimum of 750 N/mm^2. Whenever larger terminal pads are required for higher current rating, the mounting holes shall conform to NEMA Standards, and details of the mounting holes shall be submitted for approval.

The static forces (horizontal and vertical forces) that it can withstand when applied at the outermost point of the terminals the greatest static and dynamic forces permitted shall be specified by Contractor.

Secondary Terminals

Secondary terminals shall be fixed studs mounted in a non-corrosive weatherproofed terminal box in the side of the transformer.

Terminal clamps for secondary windings and earthing clamps shall be designed for the connection of one or two conductors of stranded type up to 8 mm^2 and be so constructed that the conductors, without damage can be connected without the cable lugs.

Secondary Terminal Box

The box shall be weatherproof and corrosion-proof and shall have top and bottom hub plates drilled and tapped for standard type of rigid conduit of the following size:

Secondary winding having two or three or four cores	3-62 mm (2-inch hole)

The secondary terminal box shall have protection degree of IP55.

Interconnecting conduits including accessories, necessary to run the cables between the secondary terminal box of the individual and the common terminal box or junction box shall be provided by the Contractor as part of the supply for current transformer.

The terminal box shall be spacious enough to allow connection of necessary connecting leads to be performed comfortably.

Protective Devices

For 500kV system voltage, the free standing current transformer shall be equipped with a primary bypass protective device or surge arrester for protection of the winding from high voltage surges unless data can be furnished for NPC's approval which demonstrates that primary protective devices are not required.

Earth Terminals

Size of earth terminals shall be suitable for the ground conductors specified in the Technical Data Sheets.

Terminal connector shall be made of high conductivity material and shall be completed with corrosion resistance bolts, nuts and lock washers.

Secondary Terminal Junction Box

For interconnection of the current transformers on the secondary side, common terminal box or junction box shall be provided and mounted on the supporting structure. Junction boxes if specified in the Technical Data Sheets, shall be rigid, weather proof, rain-tight type complete with ring tongue type terminal blocks suitable for cable size for 2 x 8 mm^2 for termination of the secondary circuit connections.

It shall be made of metal which will resist corrosion on both inside and outside surfaces; otherwise they shall be suitably protected by galvanizing (hot-dip) or painting.

Surface preparation and coatings of the common interconnecting junction box shall conform to the provision of Section EW-1.12 of the General Technical Requirements.

Cover of the junction box shall be of the hinged door type complete with sealing gaskets and door handle.

In case the junction box is made of steel sheet, the thickness of such steel sheet shall be at least 3mm.

Junction boxes shall be sized and arranged to provide easy access for external cables, with adequate space for internal wiring and installed equipment.

For each junction box type, provisions for knockout type holes of sufficient size and dimension shall be provided.

The mounting accessories of junction boxes on supporting structures shall be supplied.

The degree of protection of the junction box shall be IP54.

Secondary Terminal Blocks

Terminal blocks shall be provided both for the terminal box and the common secondary junction box for terminating the secondary winding terminals and external cables.

The terminal blocks shall be rated for 600VAC, 30A, shorting type and must be capable of handling a maximum of two 8mm^2 conductors per terminal. It shall be provided with white marking strip without covers. The white marking strips shall be marked with a circuit designation which will identify the circuit. The designation shall be related to the wiring schematic and connection diagrams.

All internal wiring shall be supplied with wire designation sleeves marked to conform with the terminal blocks and equipment drawings. These sleeves shall be machine stamped or engraved.

All wires terminated on the terminal blocks shall be furnished with crimped or ring type connectors. Extra terminals shall be provided for grounding cable shields and future modifications.

Insulators

Insulators used for the free standing current transformer shall have an adequate mechanical and electrical strength. Porcelain housings shall be wet process, homogenous and free from blisters, burrs and other defects and shall be well vitrified, tough and impervious to moisture. Composite insulators, if required in the Technical Data Sheets, shall be 100% silicone rubber.

The porcelain insulators shall be so designed that there will be no undue stress on any parts due to temperature change. Fittings made of steel shall be galvanized or made of stainless steel.

Mechanical Strength

The free standing current transformer shall be designed to withstand the mechanical stresses which can arise as a result of forces on the primary terminals in accordance with the Technical Data Sheets.

Transient Performance

The secondary cores for use with transmission line protective relay systems shall be furnished with gaps to reduce the remanence, and designed with a low enough secondary time constant such that the maximum instantaneous error during current flow after circuit breaker reclosing is less than the value specified on the Technical Data Sheets.

The design of secondary cores for use with transmission line protective relay systems shall be satisfactory for the conditions specified in the Technical Data Sheets including the specified circuit breaker reclosing operation. They shall permit one cycle of accurate, undistorted output prior to any saturation for a full asymmetrical short circuit condition.

Supporting Structures

Supporting structures for the free standing CT's if specified in the Technical Data Sheets, shall be hot-dip galvanized after fabrication in accordance with ASTM designation A123 and A153.

All necessary galvanized bolts, nuts and washers to complete the erection shall be furnished including embedded anchor bolts for securing the supporting structures to the concrete foundation.

All individual pieces of the supporting structure shall be marked with the correct designations shown on the approved shop drawings. Marking shall be done by die stamping the marks into the metal before galvanizing and shall be clearly legible after galvanizing. The number and letter shall be a minimum of 12mm in height and 8mm wide.

Finished materials shall be dipped into the solution of dichromate after galvanizing for white rust protection.

EW-8.1.3.4 Other Technical Requirements for the Current Transformer

Other features for the current transformer, if required by the NPC, are stated in the Technical Data Sheets which must be complied, provided or furnished by the Contractor.

EW-8.1.4 INSTALLATION

Installation will be by Contractor unless specified otherwise in Section B.1.0 of the Technical Data Sheets.

When the installation is by Contractor, such as for turn-key contracts complete details of proper handling, transport and storage, installation, testing, commissioning, performance guarantees, etc. shall be provided for NPC's review and approval.

EW-8.1.5 TESTS

EW-8.1.5.1 General

The Contractor shall carry out at his own expense all tests necessary to ensure the satisfactory design and manufacture of the current transformer in accordance with ANSI C57.13 or equivalent IEC Standards and the present specifications.

Each current transformer shall be completely assembled and adjusted at the factory and given the manufacturer's Routine Shop Tests and also other test as specified hereunder in Section EW-8.1.5.3. All parts shall be properly marked for ease of assembly in the field. All tests required in Section EW-8.1.5.3 shall be witnessed by the NPC or his authorized representative unless waived in writing, and no equipment shall be shipped until released for shipment by the NPC or his authorized representative.

The Contractor shall make all preparation for tests and provide the test apparatus and personnel and shall notify the NPC the date of the test forty-five (45) days in advance.

Design tests in accordance with Section EW-8.1.5.2 are always required when the current transformer type and rating is Contractor's new design or Contractor's previous design with significant design changes (i.e. prototype).

If current transformer is not a prototype and if design tests are not specified in the Technical Data Sheets, certified test reports of duplicated production type are acceptable if so specified in the same section.

If tests are required, the Contractor shall submit the test procedures the Contractor intends to use. Actual test procedures to be used shall be subject to the NPC's acceptance.

All applicable production tests in accordance with ANSI C57.13 or IEC equivalent shall be performed on each current transformers and reports are required.

The Contractor shall submit the test procedure of routine tests and actual design tests to NPC for approval. The test procedure shall consist of procedures, applied voltage, current and criteria to justify the result of the tests.

Additional tests, if specified in the Technical Data Sheets, are required by NPC.

EW-8.1.5.2 Design Test

One unit of each type and model of current transformer shall be subject to the test specified below. Previous design test records for an identical unit witnessed or inspected by a third party, maybe furnished instead of performing an actual design test, unless otherwise specified in the Technical Data Sheets.

The tests shall be performed in accordance with the latest ANSI/IEEE C57.13 or equivalent IEC Standards. These tests shall include, but not limited to the following:

a. Short time mechanical current rating test

b. Short time thermal current rating test

c. Temperature rise test at maximum rated current (of continuous thermal current rating factor)

d. Power frequency withstand voltage (wet) test

e. Impulse voltage withstand test

f. Wet and dry switching impulse voltage withstand test, 1175kV crest minimum, 250 x 2500 us positive and negative waves per ANSI/IEEE C37.09 for the 500kV current transformers.

g. Transient performance test

h. RIV test in accordance with NEMA Publication No. 107.

i. Measurement of open-circuit voltage test

j. Creepage distance measurement. The actual test shall be performed on the CT being supplied.

k. Chopped wave impulse reliability test, only for inverted type (top core). Twelve (12) sets of 50 negative chopped wave impulse (total of 600 chopped wave impulse) shall be performed and increase of dissolved gas in the oil shall be measured.

EW-8.1.5.3 Routine Tests

Each current transformer shall be completely assembled at the factory and tested in accordance with the applicable requirements of ANSI C57.13 or equivalent IEC Standards.

The following routine tests, but not limited to the following shall be witnessed by the NPC or his authorized representative(s) unless otherwise waived in writing:

a. Applied voltage test

b. Induced voltage test

c. Accuracy test for each ratio of all winding (including excitation curve of one unit of each item for relaying class)

d. Polarity check

e. Winding resistance measurement for maximum ratio of all winding but one unit of each item shall be performed for each ratio of all winding.

f. Insulation resistance measurement or insulation power factor measurement.

g. Partial discharge measurement

h. Dissolved gas analysis test.

EW-8.1.6 DATA AND DOCUMENTATION REQUIREMENTS

EW-8.1.6.1 General

Contractor-furnished data and information shall be the guaranteed performance data, predicted performance interface requirements and construction features of all Contractor's furnished equipment. The accuracy of such information and its compatibility with overall performance requirements specified by NPC are the sole responsibility of the Contractor.

All information submitted as part of Proposal Data will become part of contract data for successful bidder. Any deviation from such data requires NPC's approval.

EW-8.1.6.2 Data and Information to be Submitted During Post Qualification

Contractor shall furnish during post qualification the filled-in Section B.8.1 of the Technical Data Sheets.

EW-8.1.6.3 Data and Information to be Submitted After Award of Contract

The following items shall be submitted before the final shipment of the equipment.

a. Brochures and catalogues to support the filled-in Technical Data Sheets and to allow NPC to evaluate the equipment/materials being offered;

b. Outline drawings of each current transformer and supporting structure, showing:

1. Overall dimensions;
2. Mounting dimensions including location and size of anchor bolt holes, including base drilling plan;
3. Grounding pad and ground terminal location and details;
4. Recommended minimum clearance;
5. Total net weight of current transformer and supporting structure;
6. Center of gravity of complete assembly;
7. Elevations and sectional views with component parts identification by description and/or catalogue number;
8. Rating and identification nameplate location. The nameplate shall also include the creepage distance and cantilever strength of insulator column;
9. Line terminal location and dimensional data including hole size and spacing;

c. Support and/or foundation drawings for current transformer;

d. Individual terminal boxes, common terminal box and terminal blocks details and schematic diagram;

e. For SF_6 insulated CTs, details of SF6 gas density/leakage monitor;

f. Complete instruction manual covering installation, operation and maintenance;

g. Detailed QA Program based on ISO 9001 Certification;

a. ISO 9001 Certification of the proposed manufacturer;

h. Routine Test Reports; and

i. Field Tests Reports to be performed and Field Test Reports duly signed and witnessed by NPC's representative(s);

The Contractor shall furnish in the manner, number of copies and within the time set forth in the contract, instruction manuals in accordance with Section GW-2.9 of the General Works.

EW-8.2 VOLTAGE TRANSFORMER

EW-8.2.1 SCOPE

EW-8.2.1.1 General

This specification covers the technical and associated requirements for voltage transformers rated 69kV and above for use in electric power generating station, switchyard and substation. The high voltage system is effectively grounded.

It is not NPC's intent to specify all technical requirements nor to set forth those requirements adequately covered by applicable codes and standards. The Contractor shall furnish high quality voltage transformer meeting the requirements of these specification and industry standards.

The Contractor shall bear full responsibility that the equipment has been designed and fabricated in accordance with all codes, standards, and applicable governmental regulations and performs under the conditions and to the standards specified herein.

No departure shall be made from these specification and standards unless waived or modified in writing by NPC. The Contractor shall obtain from its subcontractors a statement as to the compliance with this specification without exception and/or if there are any exceptions, these shall be described in detail and included in the Contractor's proposal. The Contractor shall add a statement that no other exceptions are taken to this specification.

EW-8.2.1.2 Works to be Provided by the Contractor

The Contractor shall provide the equipment, accessories and services delineated in Section B.1.0 of the Technical Data Sheets.

EW-8.2.1.3 Works to be Provided by NPC

NPC shall provide the materials (if any) and services listed in Section B.1.0 of the Technical Data Sheets.

EW-8.2.2 CODES AND STANDARDS

EW-8.2.2.1 General

The voltage transformer furnished shall be in accordance with, but not limited to, the latest issues of the following applicable standards, including all addenda, in effect at time of purchase order unless otherwise stated in this specification.

ANSI/IEEE	**American National Standards Institute and/or Institute of Electrical & Electronic Engineers**
C57.13	Standard Requirements for Instrument Transformers
C93.1	Coupling Capacitor and Capacitor Dividers
C93.2	Capacitor Voltage Transformers
IEC	**International Electro-Technical Commission**
60044-2	Inductive Voltage Transformers
60060-1	High Voltage Test Techniques – Part 1: General Definitions and Test Requirements
60071-1	Insulation Coordination
60085	Thermal Evaluation and Classification of Electrical Insulation

60186	Voltage Transformers, Chapter IV: Requirements for Capacitive Voltage Transformers
60358	Coupling Capacitors and Capacitor Dividers
60567	Guide for Sampling of gases and of Oil from Oil-filled Electrical Equipment and for the Analysis of Free and Dissolved Gases
60815	Guide for the Selection of Insulators in Respect of Polluted Conditions
ISO	**International Standards Organization**
9001	Quality System Model for Quality Assurance in Design/Development, Manufacture and Testing
9002	Quality System Model for Quality Assurance in Production, Installation and Servicing

These codes and standards set forth minimum requirements which may be exceeded by Contractor if, in Contractor's judgment and with NPC's acceptance, superior or more economic designs or materials are available for successful and continuous operation of Contractor's equipment as required in this specification.

EW-8.2.3 TECHNICAL REQUIREMENTS

EW-8.2.3.1 Description of Services

The voltage transformer(s) covered by this specification is (are) for use in a generating station and/or a substation. The application details are in the Technical Data Sheets.

All materials and parts which are not specifically mentioned herein but are or the proper erection, assembly and safe operation of the voltage transformer shall be furnished at no increase in cost to the NPC.

EW-8.2.3.2 Design Requirements

The voltage transformer shall be single-phase, connected between phase and earth and suitable for outdoor installation.

Depending on the requirement, it can either be an inductive or a capacitive voltage transformer or a mixture of two types with the insulating medium either oil-immersed, self-cooled or SF6 gas as specified in the Technical Data Sheets.

Voltage transformer shall be hermetically sealed. Inner insulation shall be satisfactorily and permanently protected against moisture. Associated gaskets shall be resistant to sun, air, oil and water.

Accuracy shall be maintained even when pollution is such that the external leakage or creepage current down the insulator body reaches a value greater than what is allowed.

The metallic lower part of the voltage transformer shall be provided with at least one earthing clamp suited for sizes of 60mm^2 to 120mm^2 copper conductor.

EW-8.2.3.3 Design and Construction Features

General

Tanks for hermetically sealed, oil filled VT's shall have an oil level gauge or indicator readable from ground level, which shows that the hermetic sealing remains intact.

Oil-filled transformers shall be provided with appropriately located fill and drain plugs.

The core of an inductive or magnetic type VT shall have an interleave yokes and limb lamination made of high grade silicon stamping. These shall be insulated with insulated bolts. The high voltage coils shall be assembled to obtain a uniform distribution of the voltage gradients during impulse voltage conditions avoiding weak points in the insulation.

The capacitor elements of CVTs shall consist of a certain number of individual sections in series. Each section shall be made of an assembly of special paper and foil, non-inductive wound and impregnated. It shall be placed in the insulator housing in order to assure that all the capacitor elements have always the same temperature and to reduce measuring errors on the capacitive potential device during period changes of external temperature. The insulator housing can either be porcelain or composite type of insulator as required in the Technical Data Sheets.

The arrangement of a capacitor voltage transformer shall be such that the capacitive voltage divider and the intermediate voltage transformer are assembled together in one unit. No other arrangement will be accepted.

The neutral end of the primary winding shall not be earthed to the tank but brought out to a bushing. The neutral terminal bushing shall be able to withstand a test voltage of 2kV rms for one minute.

When the CVTs are specified for revenue metering, the capacitors shall be mixed dielectric type (film and paper impregnated with synthetic oil) to guarantee the best possible stability over a wide temperature range and a long service life.

The accuracy for each winding shall be fulfilled in one step without any reconnection or use of external burdens. The accuracy shall be able to be adjusted externally.

Temperature Rise

The temperature rise of the voltage transformer under conditions specified in ANSI C57.13 or equivalent IEC Standards shall be based on a 55°C rise.

Primary Terminals

The primary terminals shall be suitable for connection of copper or aluminum conductors without the use of bimetal inserts.

The terminal pads shall be provided with four 14.3 mm (9/16 inch) diameter holes with 45 mm (1-3/4 inch) spacing between the centers of each hole in accordance with the standard NEMA 4 holes arrangement.

The terminal pads shall be of high conductivity bronze or copper and shall be plated with hot flowed electro-tin to a thickness of not less than 0.127 mm (0.005 inch) or an aluminum alloy with hardness Hb minimum of 750 N/mm^2. Whenever large terminal pads are required for higher current rating, the mounting holes shall conform to NEMA Standards, and details of the mounting holes shall be submitted for approval.

The static forces (horizontal and vertical forces) that it can withstand when applied at the outermost point of the terminals including the greatest static and dynamic forces permitted shall be specified by Contractor.

Secondary Terminals

Secondary terminals shall be fixed studs mounted in a weather proof terminal box in the side of the transformer.

Terminal clamps for secondary windings and earthing clamps shall be designed for the connection of one or two conductors of stranded type up to 8 mm^2 and be so constructed that the conductors, without damage can be connected without the cable lugs.

All coupling capacitor voltage transformers and coupling capacitors completed with carrier accessories shall be equipped with carrier terminal connectors suitable for 12-24 mm^2 copper cable and located inside of secondary terminal box for easy access of connection. The cable hole with cable gland suitable for 20 mm outside diameter cable shall be provided at the bottom of secondary terminal box. The insulation level of carrier terminal shall be the same as carrier drain coil as specified in the Technical Data Sheets.

Secondary Terminal Box

The box shall be weatherproof and corrosion-proof and shall have top and bottom hub plates drilled and tapped for standard type of rigid conduit of the following size:

Secondary winding having two or three windings	3 - 62 mm (2-inch hole)

The secondary terminal box shall have protection degree of IP54.

Interconnecting conduits including accessories, necessary to run the cables secondary terminal box of the individual and the common terminal box or junction box shall be provided by the Contractor as part of the supply for voltage transformer.

The terminal box shall be spacious enough to allow connection of necessary connecting leads to be performed comfortably.

Protective Devices

The secondary circuits shall be protected by miniature circuit breakers (MCCB's) of adequate characteristics. Each MCCB shall have thermal and instantaneous magnetic trip devices for overload and short circuit protection and shall be provided with suitable number of auxiliary contacts for local and remote annunciation to interface tripping with the main control board or with the Microprocessor Based Substation Control (MBSC) System if the substation control is through the MBSC.

For coupling capacitor voltage transformer, a potential grounding switch shall be provided.

Earth Terminals

Size of earth terminals shall be suitable to the ground conductors specified in the Technical Data Sheets.

Terminal connector shall be made of high conductivity material and shall be completed with corrosion resistance bolts, nuts and lock washers.

Secondary Terminal Junction Box

For interconnection of the voltage transformers on the secondary side, common terminal box or junction box shall be provided and mounted on the supporting structure. Junction boxes if specified in the Technical Data Sheets, shall be rigid, weather proof, rain tight type complete with ring tongue terminal blocks suitable for termination of the secondary circuit connections, consisting of two conductors of 8 mm^2 size.

It shall be made of metal which will resist corrosion on both inside and outside surfaces, otherwise they shall be suitably protected by galvanizing (hot-dip) or painting.

Surface preparation and coatings of the common interconnecting junction box shall conform to the provision of Section EW-1.12 of the General Technical Requirements.

Cover of the junction box shall be of the hinge door type complete with sealing gaskets and door handle.

In case the junction box is made of steel sheet, the thickness of such steel sheet shall be at least 3mm.

Junction boxes shall be sized and arranged to provide easy access for external cables, with adequate space for internal wiring and installed equipment.

For each junction box type, installed equipment provisions of 5 knockout type holes 62 mm diameter size shall be provided.

Each junction box shall be provided with 2-spare miniature circuit breakers of each circuit breaker rating and the spare miniature circuit breakers shall be properly kept in the junction box.

The mounting accessories of junction boxes on supporting structures shall be supplied.

The degree of protection of the junction box shall be IP54.

Secondary Terminal Blocks

Terminal blocks shall be provided both for the terminal box and the common secondary junction box for terminating the secondary winding terminals and external cables.

The terminal blocks shall be rated for 600VAC, 30A and must be capable of handling a maximum of two 8mm^2 conductors per terminal. It shall be provided with white marking strip without covers. The white marking strips shall be marked with a circuit designation which will identify the circuit. The designation shall be related to the wiring schematic and connection diagrams.

All internal wiring shall be supplied with wire designation sleeves marked to conform with the terminal blocks and equipment drawings. These sleeve markings shall be machine stamped or engraved.

All wires terminated on the terminal blocks shall be furnished with crimped or ring type connectors. Extra terminals shall be provided for grounding cable shields and future modifications.

Terminal connectors suitable for 16mm^2 - 25mm^2 copper cable shall also be provided for the RF carrier leads when the voltage transformers are specified with carrier accessories.

Insulators

Insulator used for the voltage transformer shall have an adequate mechanical and electrical strength. Porcelain housings shall be wet process, homogenous and free from blisters, burrs and other defects. Composite insulators, if required in the Technical Data Sheets shall be 100% silicone rubber.

The porcelain used for capacitor voltage divider of the CVT shall be so designed as to give sufficient safety margins for normal wind loads and line conductor forces. For special applications, the CVT shall be designed to allow for the mounting of a line trap in the top, if required in the Technical Data Sheets.

Mechanical Strength

The voltage transformer shall be designed to withstand the mechanical stresses which can arise as a result of forces on the primary terminals mentioned in this section.

Ferro-resonance

For coupling capacitor potential device, the design shall be incorporated with sufficient suppression of ferro-resonance conditions, adequate damping of transient phenomena and assurance of high accuracy with high burden and insurance against frequency variation. This device shall be independent of the size of the connected burden and shall protect the transformers without connection to any external burdens.

The device shall be accessible for control measurement of the damping circuit components.

Corona Rings

Corona rings shall be supplied, if required in the Technical Data Sheets to meet specified RIV levels.

Supporting Structures

Supporting structures, if specified in the Technical Data Sheets, shall be hot-dip galvanized after fabrication in accordance with ASTM designation A123 and A153.

All necessary galvanized bolts, nuts and washers to complete the erection shall be furnished including embedded anchor bolts for securing the supporting structures to the concrete foundation.

All individual pieces of the supporting structure shall be marked with the correct designations shown on the approved shop drawings. Marking shall be done by die stamping the marks into the metal before galvanizing and shall be clearly legible after galvanizing. The number and letter shall be minimum of 12 mm in height and 8 mm wide.

Finished materials shall be dipped into the solution of dichromate after galvanizing for white rust protection.

EW-8.2.3.4 Other Technical Requirements

Other features for the voltage transformer, if required by the NPC, are stated in the Technical Data Sheets, which must be complied, provided or furnished by the Contractor.

EW-8.2.4 INSTALLATION

Installation will be by Contractor unless specified otherwise in Section B.1.0 of the Technical Data Sheets.

When the installation is by Contractor, such as for turnkey contracts complete details of proper handling, transport and storage, installation, testing, commissioning, performance guarantees, etc. shall be provided for NPC's review and approval.

EW-8.2.5 TESTS

EW-8.2.5.1 General

The Contractor shall carry out at his own expense all tests necessary to ensure the satisfactory design and manufacture of the voltage transformer in accordance with ANSI C57.13 or equivalent IEC Standard and this specification.

Each voltage transformer shall be completely assembled and adjusted at the factory and given the manufacturer's routine Shop Tests and also other tests as specified hereunder in Section EW-8.2.5.2. All parts shall be properly marked for ease of assembly in the field. All tests required in EW-8.2.5.2, Item "b", shall be witnessed by the NPC or his authorized representative unless waived in writing, and no equipment shall be shipped until released for shipment by the NPC or his authorized representative.

The Contractor shall make all preparations for tests and provide the test apparatus and personnel and shall notify the NPC the date of the test forty-five (45) days in advance.

Design tests in accordance with Section EW-8.2.5.2 are always required when the voltage transformer type and rating is Contractor's new design or Contractor's previous design with significant design changes (i.e. prototype).

If voltage transformer is not a prototype and if design tests are not specified in the Technical Data Sheets, certified test reports of duplicated production type are acceptable if so specified in the same section.

If tests are required, the Contractor shall submit the test procedures the Contractor intends to use. Actual test procedures to be used shall be subject to NPC's acceptance.

All applicable production test in accordance with ANSI C57.13 or IEC equivalent shall be performed on each voltage transformer and reports are required.

Additional tests, if specified in the Technical Data Sheets, are required by NPC.

EW-8.2.5.2 Tests at Workshop

Each voltage transformer shall be completely assembled at the factory and tested in accordance with the applicable requirements of ANSI C57.13 and ANSI C93.2 or equivalent IEC Standards for the CVTs.

a. Previous design test records for an identical unit witnessed or inspected by a third party, maybe furnished instead of performing an actual design test, unless otherwise specified in the Technical Data Sheets. The design tests shall include but not limited to the following:

1. For magnetic type voltage transformers:

   i. Short time mechanical rating test
   ii. Short circuit thermal capability test
   iii. Temperature rise test at thermal burden rating
   iv. Power frequency voltage withstand (wet) test
   v. Impulse voltage withstand test
   vi. Creepage distance measurement. The actual test shall be performed on VT being supplied.

2. For Coupling Capacitor Voltage Transformer (CCVT)

   i. Power frequency withstand voltage (wet) test
   ii. Impulse test
   iii. Radio-influence voltage test
   iv. Accuracy test
   v. Short-time overvoltage test
   vi. Thermal burden test
   vii. Short circuit test
   viii. Ferroresonance test. The actual test shall be performed on CCVT being supplied. The oscillographic records of test performed shall be submitted.
   ix. Transient response test. The actual test shall be performed on CCVT being supplied. The peak value of any transient oscillation of the secondary output voltage shall decay within one cycle of rated frequency, to a value of less than 10% of the peak value before short circuit. The oscillographic records of the test performed shall be submitted.
   x. Carrier frequency insertion loss
   xi. Carrier drain coil rated frequency voltage drop and insulation level tests
   xii. Low voltage terminal stray capacitance and stray inductance tests
   xiii. Carrier frequency capacitance and dissipation factor tests
   xiv. Mechanical tests (cantilever test)
   xv. Low voltage terminal insulation level test
   xvi. Creepage distance measurement. The actual test shall be performed on CCVT being supplied.

3. For Coupling Capacitor. Tests shall be performed in accordance with the latest ANSI C93.1.

   i. Power frequency withstand (wet) test
   ii. Impulse test
   iii. Radio influence voltage test
   iv. Low voltage terminal stray capacitance and stray conductance tests
   v. Carrier drain coil insertion loss rated frequency voltage drop, and insulation level tests
   vi. Carrier frequency capacitance and dissipation factor test

vii. Mechanical test (cantilever test)
viii. Low voltage terminal insulation level test
ix. Creepage distance measurement. The actual test shall be performed on Coupling Capacitor being supplied

b. In addition, each voltage transformer shall be subjected to the following routine tests, to be witnessed by the NPC or his authorized representative/s unless otherwise waived in writing:

1. For magnetic voltage transformer

i. Applied voltage test
ii. Induced voltage tests
iii. Accuracy test
iv. Polarity check
v. Winding resistance measurement for each ratio of all windings
vi. Insulation resistance measurement or insulation power factor measurement
vii. Partial discharge measurement

2. For CCVT

i. On the capacitor divider

- Capacitance and dissipation factor measurement before and after power frequency withstand voltage (dry) test
- Power frequency withstand voltage (dry) test
- Partial discharge measurement

ii. On the electromagnetic unit

- Induced potential test on the primary circuit
- Applied potential test on the secondary circuit

iii. On the complete CCVT

- Accuracy test
- Polarity check
- Protective-gap setting

3. For coupling capacitor

Tests to be performed will be same as in Item "2.i".

EW-8.2.5.3 Other Tests

In addition to the tests mentioned above, the other equipment attached as an accessory to the voltage transformer shall be tested in accordance with the test mentioned on the applicable provisions for the accessory equipment.

EW-8.2.6 DATA AND DOCUMENTATION REQUIREMENTS

EW-8.2.6.1 General

Contractor-furnished data and information shall be the guaranteed performance data, predicted performance interface requirements and construction features of all Contractor's furnished equipment. The accuracy of such information and its compatibility with overall performance requirements specified by NPC are the sole responsibility of the Contractor.

All information submitted as part of Proposal Data will become part of contract data for successful bidder. Any deviation from such data requires NPC's approval.

EW-8.2.6.2 Data and Information to be Submitted During Post Qualification

Contractor shall furnish during post qualification the filled-in Section B.8.2 of the Technical Data Sheets.

EW-8.2.6.3 Data and Information to be Submitted After Award of Contract

The following items shall be submitted before the final shipment of the equipment:

a. Brochures and catalogues to support the filled-in Technical Data Sheets and to allow NPC to evaluate the equipment/materials being offered;

b. Outline drawings of each voltage transformer and supporting structure, showing:

    1. Overall dimensions;
    2. Mounting dimensions including location and size of anchor bolt holes, including base drilling plan;
    3. Grounding pad and ground terminal location and details;
    4. Recommended minimum clearance;
    5. Total net weight of voltage transformer and supporting structure;
    6. Center of gravity of complete assembly;
    7. Shipping dimensions and weight of component parts;
    8. Net weight of each part to be assembled in the field;
    9. Elevations and sectional views with component parts identification by description and/or catalogue number;
    10. Rating and identification nameplate location. The nameplate shall also include the creepage distance and cantilever strength of insulator column;
    11. Line terminal location and dimensional data including hole size and spacing;
    12. Support and/or foundation drawings for voltage transformer.

c. Support and/or foundation drawings for voltage transformer;

d. Individual terminal boxes, common terminal box and terminal blocks details and schematic diagram;

e. For SF_6 insulated VT's, details of SF6 gas density/leakage monitor;

f. Complete Instruction manuals covering installation, operation and maintenance;

g. Detailed QA Program based on ISO 9001 Certification;

h. Routine Test Reports;

i. ISO 9001 Certification of the proposed manufacturer;

j. Field Tests to be performed and Field Test Reports duly signed and witnessed by NPC's representative(s); and

k. As- built drawings as finally approved.

The Contractor shall furnish in the manner, number of copies and within the time set forth in the contract, instruction manuals in accordance with Section GW-2.9 of the General Works.

EW-9.0 POWER, CONTROL AND INSTRUMENTATION CABLES

EW-9.1 SCOPE

EW-9.1.1 General

This specification covers the technical and associated requirements of 600 V power, control and instrumentation cables, and medium voltage power cable for use in switchyards and substations.

It is not NPC's intent to specify all technical requirements nor to set forth those requirements adequately covered by applicable codes and standards. Contractor shall furnish high quality power and control cables meeting the requirements of these specification and industry standards.

Contractor shall bear full responsibility that the cables have been designed and fabricated in accordance with all codes, standards, and applicable governmental regulations and performs under the condition and to the standards specified herein.

No departure shall be made from these specification and standards unless waived or modified in writing by NPC. The Contractor shall obtain from its subcontractors a statement as to the compliance with this specification without exception and/or if there are any exceptions, these shall be described in detail and included in the Contractor's proposal. The Contractor shall add a statement that no other exceptions are taken to this specification.

EW-9.1.2 Works to be Provided by the Contractor

The work to be provided by Contractor shall include, but not necessarily be limited to, supplying the cables and services delineated in Section B.1.0 of the Technical Data Sheets.

EW-9.1.3 Works to be Provided by NPC

NPC shall provide the materials (if any) and services listed in Section B.1.0 of the Technical Data Sheets.

EW-9.2 CODES AND STANDARDS

EW-9.2.1 General

The cables to be furnished shall be manufactured in accordance with, but not limited to the latest issues of the following codes and standards including all addenda, in effect at time of purchase order unless otherwise stated in this specification.

ASTM	**American Society for Testing and Materials**
B3	Specification for Soft or Annealed Copper Wire
B8	Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft

B33	Specification for Tinned Soft or Annealed Copper Wire for Electrical Purposes
B189	Specification for Lead-Coated and Lead-Alloy-Coated Soft Copper Wire for Electrical Purposes
D1248	Specification for Polyethylene Plastics Molding and Extrusion Materials
IEC	**International Electrotechnical Commission**
60028	International Standard of Resistance for Copper
60060	High Voltage Test Techniques
60093	Methods of Test for Volume Resistivity and Surface Resistivity of Solid Electrical Insulating Materials
60183	Guide to selection H.V. cables
60189	Low frequency cables and wires with PVC insulation
60227	Specification for Cables and Flexible Cords for Electric Power and Lighting
60228	Conductors of insulated cables
60229	Tests on Cable Over-Sheaths, which have a special protective function and are applied by extrusion
60230	Impulse test on cables and their accessories
60270	Partial Discharge Measurements
60287	Calculation of the current rating
60331	Fire Resistant Test
60332	Tests on Electric Cables Under Fire Conditions
60364	Continuous Transmission Capacity
60446	Color code for conductors
60502	Extruded solid dielectric insulated power cables for rated voltages from 1 to 30 kV
60538	Test methods for PE insulation and sheaths
60540	Test methods for elastomeric and thermoplastic compounds
60708	Low frequency cables with polyolefin insulation
60754	Halogen Content Test
60811	Common Test Methods for Insulating and Sheating Materials of Electric Cables
60885-2	Electrical Test Methods of Electric Cables Partial Discharge Tests
60949	Calculation of Thermally Permissible Short circuit currents, Taking into Account Non-adiabatic Heating Effects
60986	Guide to short circuit temperature limits of electric cables with a rated voltage from 1.8/3(3.6) kV to 18/30(36) kV
1034	Smoke emission tests
ISO	**International Standards Organization**
9001	Quality System Model for Quality Assurance in Design/Development, Manufacture and Testing
9002	Quality System Model for Quality Assurance in Production, Installation and Servicing
NEC	**National Electrical Code**
PEC	**Philippine Electrical Code, Part I**

These codes and standards set forth minimum requirements which may be exceeded by Contractor if, in Contractor's judgment and with NPC's acceptance, superior or more economic designs or materials are available for successful and continuous operation of Contractor's equipment required by this specification.

EW-9.3 TECHNICAL REQUIREMENTS

EW-9.3.1 General

The cables shall be designed for trouble-free service for the highest system voltage.

All cables and their accessories to be supplied shall have insulation levels able to withstand any voltage surges which are normally expected to occur in the power system in which the cable is to be employed, due to switching operations, sudden load variations, faults etc.

All cables shall be selected to withstand without distress any short-circuit currents in the conductor and sheath related to the existing fault levels.

The cables and its accessories shall be constructed to fulfill the requirements when operating with full load or at any load factor.

The cable shall be suitable for use in ducts, trays and for direct burial in ground.

EW-9.3.2 Conductor

Copper conductors for power, control and instrumentation cables shall be concentric-lay-stranded, bare, or coated in accordance with ASTM B3, ASTM B8, or ASTM B33 or equivalent IEC Standards.

EW-9.3.3 Insulation

Insulation shall be of the type specified in the Technical Data Sheets. Insulation type shall be in accordance with National Electrical Code Designation or equivalent IEC Standards.

EW-9.3.4 Jacket

A tough, ozone, low chlorine, heat, flame and moisture-resistant PVC or HDPE jacket capable of providing protection against sunlight, acids, alkalis and oils shall be furnished for all cables. Jacket materials shall meet the requirements of applicable IEC Standards.

EW-9.3.5 Grounding Conductor

Copper grounding conductors shall be furnished within-multi-conductor 600 V power cables. Total cross-sectional area of the grounding conductors shall be in accordance with the National Electrical Code requirements or equivalent IEC Standards. Grounding conductors shall be bare.

EW-9.3.6 Assembly

All multi-conductor cables shall be bundled together with non-hygroscopic fillers to assure a smooth circular assembly. A lapped core binding tape shall be applied over the assembly.

EW-9.3.7 Technical Requirements for Control and Instrumentation Cable

For Instrumentation Cables, the following additional criteria shall apply:

Drain Wire

Class B, 7 strands, annealed, tinned copper drain wire (not less than two AWG sizes smaller than the insulated conductor but not smaller than 20 AWG), to be laid spirally with the same direction and lay as the twisted pair.

Shielding Tape

Type of shielding tape, if not specified in the Technical Data Sheets shall be a 100 percent coverage of a minimum of 2.0 mil Aluminum/polyester tape with metallic face of tape in continuous positive contact with the drain wire. Minimum overlap of shielding tape shall be not less than 20% of its width. The twisted pairs shall have their shields isolated from one another.

The semi conducting thermosetting compound screen layer shall be able to be peeled off easily, without leaving any residue on the insulation.

Cabling

Pairs are to be cabled with fillers, if required, and binder tape which are flame resistant and non-hygroscopic.

EW-9.3.8 Technical Requirements for Medium Voltage Power Cables

For medium voltage power cables, the following criteria, in addition to Section EW-9.3.1 thru EW-9.3.4 shall apply:

Strand Shield

Extruded layer of semiconducting thermosetting compound compatible with the insulation. It shall be continuous, with a minimum thickness of 0.5 mm, with no rough surfaces and keeping close contact with the insulation. The semi-conducting screen shall withstand the temperature in the conductor and the admissible mechanical forces in the insulation, and shall have no detrimental effect on the conductor or the insulation. The insulation semi-conducting screen shall be directly applied upon the insulation and shall make a perfect continuous and discharge free contact, with a minimum thickness of 0.1 mm.

Insulation Shield

Extruded layer of semiconducting thermosetting compound compatible with the insulation. Average thickness of the insulation shall be not less than the nominal value specified in IPCEA or IEC 60502. The maximum thickness in any particular point shall not be greater than 25% of the nominal value specified.

Metal Tape

Annealed copper tape over insulation shielding per ICEA S-19-81, Paragraph 4.1.1.2, with a minimum overlap of 12%. The construction of the metallic screen shall guarantee a perfect contact with insulation semi-conducting screen to constitute an equipotential system. The dimensional characteristics shall be calculated in such a way as to ensure a permissible short circuit current specified in the Technical Data Sheets during 3 sec., without causing overheating in the close layers.

Oversheath or Outer Jacket

The oversheath shall consist of a compound applied by an extrusion process, adequate to the rated cable temperatures, if one of the following alternatives to be specified by the Contractor.

a. Sheath of polyvinyl chloride (PVC) colored black, with anti-termite repellant, non-poisoning type adequate for termite type “ODONTERMUS FORMASANUS” and “COPTERMES FRENCHI”.

b. Black sheath of high-density polyethylene (HPDE), with characteristics according to IEC 60811, ST4 type or equivalent IPCEA or ASTM Standards.

The nominal thickness shall be 0.3 mm and the maximum thickness in any particular point shall not be greater than 25% of the nominal value.

Maximum Conductor Temperature

The insulating material shall be able to withstand the maximum permissible temperature for conductor, as stated below:

Continuous	:	90°C
After short circuit	:	250°C

EW-9.3.9 Application

All cables shall be suitable for installation in cable tray (NEC type TC), conduit, trench, underground duct in wet and dry locations, and above ground raceway in damp and dry locations.

EW-9.3.10 Accessories

Each end of each cable shall be hermetically sealed with a heat shrinkable elastomeric cap fitting or other suitable means, to protect against the entrance of moisture.

EW-9.3.11 Cable and Cable Reel Marking

Cable shall be identified by surface printing of the jacket indicating: manufacturer, conductor metal (thermocouple cable only), size, insulation type, voltage rating, number of conductors, and sequential meter marker and date of manufacture.

Each cable reel shall be marked on both sides with indelible lettering as indicated in the Technical Data Sheets.

EW-9.3.12 Color Coding

All three conductor power cables shall be color coded in accordance with method 4 of the ICEA standard unless otherwise amended in the Technical Data Sheets.

All control cables shall be color coded in accordance with the K2 sequence as specified in the ICEA standard unless otherwise amended in the Technical Data Sheets.

Instrumentation cable shall have individual pairs colored Black/White. On multi pair construction, the pairs shall be numbered unless otherwise amended in the Technical Data Sheets.

For thermocouple extension cable type E the positive conductor (chromel) shall be purple, and the negative conductor (constantin) shall be red.

EW-9.4 INSTALLATION

Installation will be by Contractor, unless specified in Section B.1.0 of the Technical Data Sheets.

When the installation is by Contractor, such as for turnkey contracts complete details of proper handling, transport and storage, installation, testing, commissioning, performance guarantees, etc. shall be provided for NPC's review and approval.

EW-9.5 TESTS

EW-9.5.1 Factory (Production) Tests

EW-9.5.1.1 General

Cables shall be tested at the factory in accordance with applicable standards to determine their compliance with the requirements of this specification. Tests shall be conducted on samples and on the entire length of cables in accordance with the applicable standards.

The costs of all tests and test reports shall be borne by the Contractor.

EW-9.5.1.2 Design Tests

Cable and materials shall be subjected to the design (or type) tests, if specified in accordance with the test standards specified herein. Design test can be omitted if a design test record of the same cables can be submitted. In general, the following test shall be performed as a minimum:

a. Conductor Tests. Tests shall be performed on selected samples of the conductors before the application of any covering. These tests shall include as a minimum:

1. Tensile strength test
2. Elongation test
3. Conductor resistivity test
4. Dimension measurement
5. Surface finish inspection
6. Water and saline absorption test
7. Shrinkage test
8. Water penetration test

b. Physical and Aging Tests on the Cable, Insulation and Jacket. Tests shall be performed on selected samples of the cable insulation and jackets. These tests shall include as a minimum:

1. Thickness measurement
2. Tensile strength test
3. Elongation test
4. Aging test
5. Head distortion test

EW-9.5.1.3 Routine Tests

As part of routine testing at least the following test and measurements shall be carried out as a minimum:

a. Checking of the conductor, insulation and oversheath dimensions

b. Conductor resistance measurements

c. Dielectric tests

Additionally, for the high voltage cables, the following tests shall also be performed:

a. Partial discharge test
b. Impulse voltage test 1.54 x BIL at +20 °C, each 3 negative and positive impulses (followed by power frequency test) on one sample of each cable type to be supplied.
c. Capacitance test
d. Insulation resistance test
e. Test on outer sheath (IEC 229)
f. Water penetration test

EW-9.6 DATA AND DOCUMENTATION REQUIREMENTS

EW-9.6.1 General

Contractor furnished data and information shall be the guaranteed performance data, and construction features of all Contractors' furnished materials. The accuracy of such information and its compatibility with overall performance requirements specified by NPC are the sole responsibility of the Contractor.

All information submitted as part of Proposal Data will become part of contract data for successful bidder. Any deviation from such data require NPC approval.

EW-9.6.2 Data and Information to be Submitted During Post Qualification

Contractor shall furnish during post qualification the filled-in Section B.9.0 of the Technical Data Sheets.

EW-9.6.3 Data and Information to be Submitted After Award of Contract

Contractor shall furnish the following information for each type of cable:

a. Brochures and catalogues to support the filled-in Technical Data Sheets and to allow NPC to evaluate the equipment/materials being offered;

b. Complete description of technical characteristics of each type of cables;

c. Design (Type) Test Reports;

d. Cross-section and details of power, control, and instrumentation cables;

e. Cable rating calculations;

f. Make of each cable and cable reel;

g. Installation procedure and splicing methods for high voltage cable;

h. Description of High Voltage cable terminations and sealing ends;

i. Description of cable supporting structures, cable tray, cable rack, cable fixing method, cable connection, cable spacer, cable clamps, bending radius, etc.;

j. Power, control and instrumentation cable routing plan;

k. Cable schedule, including cable numbers, identification, sizes, etc.;

l. Routine Tests Reports; and

m. Field Tests to be performed and Field Test Reports duly signed by NPC's representative(s).

The Contractor shall furnish in the manner, number of copies and within the time set forth in the contract, instruction manuals in accordance with Section GW-2.9 of the General Works.

EW-10.0 SUBSTATION STEEL STRUCTURES

EW-10.1 SCOPE

EW-10.1.1 General

This specification covers the technical and associated requirements for substation steel structures used in electric power transmission rated 13.8kV and above. The structures shall be supplied complete, i.e., structural steel work, bolts, nuts, washers and miscellaneous fittings.

It is not NPC's intent of this specification to outline all the technical requirements nor to set forth those requirements adequately covered by applicable codes and standards. Contractor shall furnish high quality work and materials meeting the requirements of these specification and industry standards.

The Contractor shall bear full responsibility that the steel structures and materials have been designed and fabricated in accordance with all codes, standards, and applicable governmental regulations and performs under the conditions and to the standards specified herein.

No departure shall be made from these specification and standards unless waived or modified in writing by NPC. The Contractor shall obtain from its subcontractors a statement as to compliance with this specification without exception and/or if there are any exceptions, these shall be described in detail and included in Contractor's proposal. The Contractor shall add a statement that no other exceptions are taken to this specification.

The substation structure/tower design shall belong exclusively to the NPC. In this connection, the Contractor shall furnish the NPC with complete reproducible fabrication/shop drawings that will permit others, on order of the NPC, to extend and modify the substation structures to conform with the requirements of the substation configuration.

EW-10.1.2 Works to be Provided by the Contractor

The Contractor shall provide the materials, work and services listed in Section B.1.0 of the Technical Data Sheets.

EW-10.1.3 Works to be Provided by NPC

NPC shall provide the materials (if any) and services listed in Section B.1.0 of the Technical Data Sheets.

EW-10.2 CODES AND STANDARDS

EW-10.2.1 General

The specified material and services shall be furnished in accordance with, but not limited to, the following codes and standards or to applicable equivalent standards of the country of the manufacturer, including all addenda, in effect at the time of purchase order, unless otherwise stated in this specification.

AISC **American Institute of Steel Construction**

Specification for Structural Steel Buildings (June 1. 1989)

Code of Standard Practice for Steel Buildings and Bridges (September 1, 1992)

ASTM **American Society for Testing and Materials**

A36-92	Standard Specification for Structural Steel
A123-89	Standard Specification for Zinc (Hot-Galvanized) Coatings on Products Fabricated from Rolled, Pressed, and Forge Steel, Plates, Bars and Strips
A143-89	Recommended Practice for Safeguarding Against Embrittlement of Hot-Dip Galvanized Structural Steel Product and Procedure for Detecting Embrittlement
A153-82	Specification for Zinc Coating
A239-89	Standard Test Method for Locating the Thinnest Spot in a Zinc (galvanized) Coating of Iron or Steel Articles by the Preece Test (Copper Sulfate Dip)
A325-93	Standard Specification for High-Strength Bolts for Structural Steel Joints, including Suitable Nuts and Plain Washers
A384-80	Recommended Practice for Safeguarding against Warpage and Distortion during Hot-dip Galvanizing of Steel Assemblies
A394-93	Standard Specification for Galvanized Steel Transmission Tower Bolts and Nuts
A563-93	Standard Specification for Carbon and Alloy Steel Nuts
F436-9-82	Standard Specification for Hardened Steel Washers

AWS **American Welding Society**

D1.1-92	Structural Welding Code-Steel
A5.1-91	Specification for Carbon Steel Covered Arc-Welding Electrodes
A5.17-89	Specification for Carbon Steel Electrodes and Fluxes for Submerged Arc-Welding

AZI **American Zinc Institute**

Inspection Manual for Hot-Dip Galvanized Products (Latest Edition)

ASCE **American Society of Civil Engineers**

Design of Latticed Steel Transmission Structures, (ANSI/ASCE October 1990, ANSI Approved December 9, 1991)

ISO	**International Standards Organization**
9001	Quality System Model for Quality Assurance in Design/Development, Manufacture and Testing
9002	Quality System Model for Quality Assurance in Production, Installation and Servicing

These codes and standards set forth the minimum requirements which may be exceeded by Contractor if, in Contractor's judgment and with NPC's acceptance, superior or more economical designs and materials are available for successful and continuous operation of Contractor's equipment as required by this specification.

EW-10.3 TECHNICAL REQUIREMENTS

EW-10.3.1 General

Supports of substation equipment, filters, shunt banks, etc., shall consist of steel structures bolted to concrete foundations.

All structural steel works below ground and up to at least 300 mm above final ground level shall be protected by a minimum of 100 mm concrete cover.

The height of concrete foundation over finished ground level (exclusive of gravel surfacing) shall be 300 mm.

The substation steel works, conductors, overhead ground wires, connections and busbars shall be so installed and supported as to be capable of withstanding the loads to which they may be exposed under the specified loading conditions and safety factors, including those due to short circuit conditions.

All structures for receiving the installation materials and overhead conductors and grounding materials shall be equipped with U-bolts, gusset plates or corresponding devices of approved design, for attaching the insulator strings and earth wire clamps. Holes for the clamps intended for the electrical connection to the earth wires and the counterpoise shall be provided where required.

Structures shall be designed to maintain the specified clearances.

EW-10.3.2 Structural Steel

Unless otherwise specified on NPC's design drawings and/or Technical Data Sheets, structural steel members shall be fabricated from hot-rolled steel shapes with structural grade ASTM A36 or ASTM A572 latest edition, and shall be detailed and fabricated in accordance with the AISC "Code of Standard Practice for Steel Buildings and Bridges," and the AISC "Specification for Structural Steel for Buildings". Flat bars and rods shall not be used as tower members.

In order to reduce the risk of confusion regarding material, only two strength classes maybe used. Suitable classes are a low strength steel with yield point of 220-260 N/mm^2 and a high strength steel with a yield point of 300-350 N/mm^2.

Where high-strength steel is specified to be furnished on NPC's design drawings and/or Technical Data Sheets, precautions shall be taken by Contractor to ensure that the identity of high-strength steel is maintained throughout fabrication to avoid the possible substitution of mild steel for the designated high-strength members.

If the Contractor intends to use two qualities of steel, he will be required to take every precaution, to the satisfaction of the NPC, against any possible intermixing of different qualities during transport, storing, handling, manufacture and installation.

Properties for structural steel shapes shall be furnished by the Contractor. All structural members shall conform to a standard dimensioning practice.

The total weight of structural steel shall be calculated in accordance with Section 9 of the AISC Code.

EW-10.3.3 Bolts, Nuts and Washers

All connections shall be secured by bolts, nuts and washers of standard design. The minimum diameter of bolts shall be 16 mm for mild steel bolts and 12 mm for high tensile steel bolts. Bolts, nuts and washers shall be galvanized. Bolts shall be galvanized in such a manner that the spelter on the threads will not interfere with the application of the nuts. Nuts shall be tapped after galvanizing and the threads of the nuts left bare and greased.

The quality of standard steel bolts and nuts shall be equivalent to ASTM Specification A394 or A325. All bolts shall have full length shanks, shall be furnished with regular hexagon heads and nuts with Class 2A threads and dimensions before galvanizing, shall conform to ANSI Specifications B18.2.1 for bolts and B18.2.2 for nuts and shall be complete with one standard spring lock washer to ANSI Specification B27.1 1965. Nuts for A325 bolts shall be in accordance with ASTM-A563.

All U-bolts and suitable attachment fittings for mounting all equipment shall be provided.

All bolts shall be furnished with the lock nut. The spring lock washer shall not be accepted as the locking device.

EW-10.3.4 Design Requirements

EW-10.3.4.1 General

All designs are to be made in accordance with the information provided herein and on the accompanying outline drawings. All outline dimensions are fixed but where no dimensions are given, the framing may be modified to suit the Contractor's design, subject to compliance with all the requirements of the specification.

The Contractor should aim at keeping the number of members to a minimum and the number of like members to a maximum consistent with reasonable economy. Opposite faces of the towers shall be identical but adjacent faces may be dissimilar.

Only two (2) diameters of connection bolts and two (2) thickness of washers shall be used on any one type of tower and such sizes shall be maintained in all towers of the same type. All bolts of like diameter in the contract shall be of the same quality. Connections shall be design for bearing and shear in the plane of the threads, not friction.

The Contractor, at the NPC's request, shall explain and provide all the necessary information pertaining to the design of any or all elements of the structure. In the event that the Contractor fails to provide satisfactory explanations of any assumptions made in the designs, all modifications which in the opinion of the NPC are deemed necessary shall be made at no extra cost to NPC.

The tower structure components including embedded parts, shall withstand the ultimate loadings based on the yield stress of steel for tension and flexural members, the ultimate shearing and bearing stresses for bolts and equivalent concrete stresses.

EW-10.3.4.2 Clearance

The structural framing shall be such as to maintain the clearances between conductor and steel as shown on the drawings. The path of the conductors and jumpers should be accounted for when checking these clearances.

EW-10.3.4.3 Design Loadings

For the calculation of sag and tension, the following temperatures of conductors and overhead ground wires shall apply:

- Minimum temperature of air, conductors and OHGW +5 °C
- Maximum temperature of air +40 °C
- Maximum temperature of conductors +90 °C
- Maximum temperature of OHGW +55 °C

The incoming and outgoing lines will be dead ended on towers outside the substation and connected to the line bays at low mechanical conductor tension.

All columns and beams shall be designed to withstand full one-sided unbalanced conductor and overhead ground wire pull, i.e. no relief pull from conductors and overhead ground wires in adjacent bays shall be considered.

The steel structures shall be designed to withstand the following working loads, which shall be multiplied by an overhead factor of 1.5 to obtain ultimate loads:

Apparatus Loads including conductors consisting of:

a. Static Loads

1. Weight of apparatus and equipment;
2. Conductor and overhead ground wire weights. Weights shall be taken on the basis of 100 meters horizontal span for externally connected conductors and wires.

b. Operating and Dynamic Loads

1. Friction forces, moments and torques due to mechanical operation of apparatus such as disconnecting switches and fused disconnecting switches;
2. Dynamic forces, moments and torques due to accelerating loads of high-speed circuit interrupting devices.
3. Magnetic forces due to short-circuit current.

Dead Loads consisting of:

a. Weight of structures;

b. Internal strained conductors and wires. Minimum tension due to each conductor shall be taken to be 1,500 kg for aluminum conductor with sizes of 850 mm^2 to 1250 mm^2 and 1,000 kg for aluminum conductor with sizes of 240 mm^2 to 660 mm^2 both for spans over 30 meters. Minimum tensions due to each conductor with spans less than 30 meters shall be taken to be 600 kg. Tension due to each overhead ground wire shall be 500 kg.

c. External strained conductors and wires. Tension due to each conductor shall be taken to be 1000 kg. Tension due to each overhead ground wire shall be 500 kg. Direction of tension shall be assumed to range from 0° to 20° from normal to the face of the structure for conductors and 0° to 45° for overhead ground wire.

Wind loads

a. Wind load on the vertical projection of the structural members and other flat surfaces shall be as stated in the Technical Data Sheets. For beams, lattice box columns and trusses, the exposed area shall be assumed as 1-1/2 times the exposed area of the members of one face.

b. Wind load on round surfaces such as conductors, ground wires, insulators, etc. shall be as stated in the Technical Data sheets. Wind load on incoming transmission lines may be assumed to be on the basis of 100 m horizontal span insofar as it will affect the structure loading.

Maintenance Load

a. Simultaneously in combination with the specified loads, all members placed horizontally or inclined not greater than 30 degrees shall be designed for maintenance load of 120 kg multiplied by an overload factor of 1.5 placed at the point which will produce the greatest stress in the member.

Loads due to Seismic Loading

a. All structures shall be able to withstand the stresses to which they may be subjected during earthquake. For earthquake conditions, see the Technical Data Sheets.

Other Specified Loads

a. These loads shall consist of conductor vibrational forces and forces caused by thermal expansion and contraction.

EW-10.3.4.4 Design of Members and Connections

Unless specified herein, design of tower members and connections shall comply to the requirements of the latest issue of ASCE Design of Latticed Steel Transmission Structures.

EW-10.3.4.5 Design of Anchor Bolts in Concrete

Steel structures shall be provided with anchorage which shall be designed in accordance with the requirements stated under Clause 9.6.1 – "Anchor Bolts with base Plate on Concrete or Grout of the ASCE Design of Latticed Steel Transmission Structure".

EW-10.3.4.6 Deflections

When apparatus and strained conductor loads are considered, the size of the members may be determined by deflection limits rather than stress limits. This is to be done in order that deflections which might be detrimental to the operation of steel structured mounted disconnect switches and cause undesirable stresses and vibrations in bus supports or equipment will not occur.

Under working loads, vertical deflections shall be limited to a maximum of 1/300 of span and horizontal deflection to 1/200 of span. Members of trusses subject to rotational forces shall be given special consideration.

EW-10.3.4.7 Minimum Sizes

Minimum thickness, before galvanizing, shall be:

		(mm)	(in)
a.	Structural members		
	- Tower legs, compression members in cross arms and ground wire peak	6	1/4
	- Members normally embedded in concrete foundation	8	5/16
	- All others	5	3/16
b.	Washers	4	5/32

Minimum thickness of gusset plates shall be 6 mm or 1/4".

The minimum diameter of connection bolt shall be 12 mm (1/2") for high tensile steel bolts and 16 mm (5/8") for mild steel bolts. Twelve (12) mm (1/2") diameter bolts shall be of ASTM A325 quality.

The width to thickness ratio, b/t, of any angle leg shall in no case exceed twenty to one (20:1) in which b is the longest leg measured from the end of the root fillet to the extreme fiber and t is the nominal leg thickness.

The minimum width of the connected leg of an angle shall be related to the diameter of the bolt being used and shall be twice the diameter plus 12 mm (1/2").

EW-10.3.5 Detailing and Fabrication

EW-10.3.5.1 General

Fabrication shall conform to the AISC Code of Standard Practice for Steel Building and Bridges and the following additional requirements:

Deformed or bent material will not be accepted. Material that is deformed or bent to a minor degree shall not be used unless straightened by methods acceptable to NPC.

All copes, blocks, and other re-entrant cuts shall have 1/2-inch minimum radius fillets.

Shearing shall be to gage, with clean cut edges and no variation in length beyond that noted on the shop detail drawings. All bevel cutting shall be accurate, and a variation of more than 1/16 inch shall be caused for rejection.

Punching shall be to gage to ensure the accuracy demanded for this type of work. Only sharp dies and punches shall be used, and burrs caused by worn dies or punches will be caused for rejection. The center to center distance between the end holes of a piece shall not vary by more than 2 mm (1/16").

Where bending of members is required, it shall be moderately sharp and true to the shop detail drawings.

When applicable, galvanizing assemblies shall conform to the recommended practices of ASTM A384.

EW-10.3.5.2 Framing

Ease of assembling in the field is of utmost importance. All details shall be based on this consideration wherever practicable.

Eccentric connections shall be avoided whenever possible. Where the configuration of the bus structures makes it impossible to eliminate eccentricities, due consideration should be given to the additional stresses introduced.

Redundant and mutual support systems utilized to provide joint restraints or reduced the unsupported lengths of the members shall be framed in such a manner so that no reliance on the flexural rigidity of any member shall be required.

Structures shall be designed and detailed to allow for the future extensions shown on the drawings.

EW-10.3.5.3 Splices and Bolted Connections

Minimum bolt spacing, end and edge distances shall be as specified in the ASCE Design of Latticed Steel Transmission Structures.

All field connections shall be bolted and the shank of all bolts shall extend full size completely through the connected members. Use of gusset plates should be kept to a minimum. The length of the bolts and threads shall be such that bearing is upon the shank and not upon the thread. However, design shall be for shear in the plane of threads.

Sloping leg members of templates or structures, if applicable, shall lap on the outside of stub angles to facilitate template removal and setting of pre-assembled structures.

When angles are lap-spliced, the heel of the inside angle shall be chamfered to clear the fillet of the outside angle.

The minimum bolt pitch shall be twice the diameter plus 10 mm (2/8").

The minimum edge distance measured from the center of the bolt hole to any edge shall not be less than the following:

Bolt Diameter	Rolled Edge	Sheared Edge	Flame Cut Edge
12 mm (1/2")	20 mm (3/4")	20 mm (3/4")	25 mm (1")
16 mm (5/8")	22 mm (7/8")	24 mm (15/16")	30 mm (1-3/16")
20 mm (3/4")	25 mm (1")	28 mm (1-1/8")	35 mm (1-3/8")
22 mm (7/8")	28 mm (1-1/8")	33 mm (1-5/16")	40 mm (1-9/16")
25 mm (1")	32 mm (1-1/4")	38 mm (1-1/2")	44 mm (1-3/4")

For plates and members carrying tensile loads, the distance from the center of the end bolt to the end of the member shall not be less than the values for edge distance given above or the following quantity:

$$e = \frac{0.87\ P}{Fy\ .\ t} + 0.38\ D$$

where:

e	=	end distance
P	=	ultimate load on the bolt
Fy	=	yield stress of the member material
t	=	thickness of the member
D	=	nominal diameter of the bolt

Splices shall develop the maximum stresses in members with no credit given for abutting joints. The number of splices shall be the minimum practicable.

End connection of angle members shall be detailed in such a manner that blocking or flattening the outstanding leg is not required.
Splices shall be as close as possible to a node point. In sloping or vertical members, lap splices shall be above the closest node point.

The minimum length of lap splice from the leading to trailing bolt in angle lap splice shall be one and one-half times the flange width of the smaller lapped member. The location of the bolts in lap splices shall be such that the center of gravity of the bolt group is as close as practicable to the center of gravity of the combined member in the splice.

Butt splice length on one side shall conform with the same requirement for lap splice as mentioned above.

All bolts, nuts, ring fills and lock washers shall be furnished in excess of the actual number required in quantity sufficient to compensate for normal field losses. The excess quantities shall be at least five percent (5%) greater than the actual requirements.

EW-10.3.5.4 Drilling and Punching

Drilled or punched holes are acceptable for materials up to 12 mm or 1/2" thickness. Materials over 12 mm thickness shall be drilled or sub-punched and reamed. All burrs left by the drill or punch shall be removed completely.

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

Holes shall be accurately placed so that, except for tension members, no drifting will be necessary at site to enable assembly.

Before galvanizing steel members, bolt holes shall not be more than 2 mm (1/16") larger in diameter than the diameter of the bolts.

EW-10.3.5.5 Bending

All bending of pieces shall be done cold. However, hot bending where advisable, shall be specified on the drawings. Any hot bending shall be done in such a manner that the full section shall be maintained and so that the physical properties of the steel will not be impaired.

Bending of cross arm hanger bars is not permitted.

EW-10.3.5.6 Anchor Bolt Setting Templates

The anchor bolt setting templates to be furnished under this specification shall be made of galvanized structural steel of the same quality as those of the latticed steel structures. The Contractor shall provide the necessary setting templates required for setting the anchor bolt system for each type of steel structure to be furnished. The required number of setting templates per type of structure per substation project site shall be as follows:

a.	1 – 4 structures	1 – anchor bolt setting templates
b.	5 – 8 structures	2 – anchor bolt setting templates
c.	9 – 12 structures	4 – anchor bolt setting templates
d.	>12 structures	5 – anchor bolt setting templates

EW-10.3.5.7 Double-Angle Members

All double-angle members shall be connected at intervals between and connections by stitch bolts. The spacing of stitch bolts shall not be more than 915 mm (3 ft.) for tension members. For compression members, the spacing shall be such that the L/R ratio of one angle between stitch bolts shall not be greater than the L/R ratio of the whole member and not more than 610 mm (2 ft.). All double-angle members shall be connected in at least 2 points between panel points. Angles with connected legs longer than 100 mm (4") shall be connected with 2 stitch bolts and filler plate at each point (one bolt on each gauge line). Angles with connected legs 100 mm (4") or smaller shall be connected at each point by one bolt and fillers which shall be placed on the inner gauge line.

EW-10.3.5.8 Long Tension Member

Tension members shall be detailed shorter than the theoretical required length. Members 3048 mm (10 ft.) or less shall be detailed 3 mm (1/8") short. Members more than 3048 mm (10 ft.) long shall be detailed 3 mm (1/8") short and an additional 2 mm (1/16") short for additional 3048 mm (10 ft.) or fraction thereof to a maximum of 6 mm (1/4").

EW-10.3.5.9 Welding

When necessary, welding of steel shall be carried out before galvanizing in accordance with the AWS "Code for Arc and Gas Welding in Building Construction". The shield-arc welding process shall be used.

EW-10.3.5.10 Excess

All bolts, nuts, ring fills, and lock washers shall be furnished, in excess of the actual number required, in quantity sufficient to compensate for normal field losses. The excess quantities shall be at least five percent (5%) greater than the actual requirements.

EW-10.3.6 Galvanizing

Unless otherwise specified in the Technical Data Sheets, all structural steel shall be hot-dip galvanized after fabrication in accordance with ASTM A123.

Fabrication and preparation of material for galvanizing shall conform with the requirements of ASTM A143. When specified in the Technical Data Sheets, embrittlement tests of designated galvanized material shall be performed in accordance with ASTM A143.

Bolts, nuts and washers shall be galvanized in accordance with ASTM A153. Bolts and nuts shall be assembled after galvanizing and shall fit with finger pressure only and nuts shall be interchangeable on any bolt without shake. Wrench tightness or spinning fit shall be caused for rejection.

Only virgin zinc shall be used in galvanizing, and the use of remelted zinc is prohibited. Inspection of the galvanizing shall follow the procedures of the AZI Inspection Manual.

Heavy runs or lumps of excess zinc will not be acceptable in any area where they will interfere with bolt hole alignment (such as the "drip end" of punched angle braces, etc.), with matching flat surfaces which are to be bolted together, or are of such size and location that normal handling or erection may cause them to be dislodged. Sharp, pointed, "stickers" of zinc which could cause injuries in handling shall be removed.

Straightening of steel after galvanizing shall be accomplished without the use of heat. Steel so straightened shall be inspected to assure no delamination of galvanizing layer.

The zinc coating shall withstand the minimum number of dips of the Preece Test, according to ASTM Specifications A239.

Bolts shall be spun-galvanized and rechasing of bolts threads after galvanizing shall not be permitted. Nut threads shall be tapped after galvanizing but not to cause appreciable recking of the nuts to the bolts.

All steel works shall be dipped into the solution of dichromate after galvanizing for white rust protection. Pipe, tubing or box sections shall not be double-dipped.

All materials shall be cleaned and washed after galvanizing to remove traces of flux, flux inclusions, preflux salts, acid ash, dross or other extraneous materials. The presence of wet storage stain (White Rust) shall be caused for rejection.

Small areas of damage to the galvanizing may be repaired with the acceptance of NPC. The repair shall be made by thoroughly cleaning the damaged area and then applying a stick of powder type zinc repair compound such as Galv-Weld or alternate acceptable to NPC in accordance with the manufacturer's instructions.

EW-10.3.7 Foundations

All foundations shall be of reinforced concrete. Foundation shall be of the anchor bolt type. All anchor bolts and base plates and angles shall be shipped to the NPC ahead of the other structural members, the timing of such shipment being as specified elsewhere in this specification.

The design of the foundation will be the responsibility of the NPC unless otherwise indicated in Section B.1.0 of the Technical Data Sheets. If by Contractor, design of foundation will be subject to the approval of the NPC.

Anchor bolts should be designed to provide resistance to all conditions of tension and shear at the bases of the columns, including the net tensile components of any bending moments which may result from fixation or partial fixation of column.

EW-10.3.8 Attachments

EW-10.3.8.1 Conductor and Shield Wire Attachments

For the attachment of each suspension insulator string, a 20 mm minimum, 22 mm maximum diameter U-bolt of sufficient strength, in line with the conductor suitable shackle or hanger, permitted to swing longitudinally through 180 degrees with 21 mm diameter hole shall be supplied.

For the attachment of each shield wire suspension clamp, a 16 mm minimum diameter U-bolt of sufficient strength in line with the wire, or suitable shackle, permitted to swing longitudinally through 180 degrees, shall be supplied.

For the attachment of each strain insulator string and shield wire strain clamp, a suitable uneven leg shackle permitted to swing vertically, shall be supplied.

The conductor and shield wire strain attachments shall have a minimum strength horizontally and along the direction of the line equivalent to the ultimate tensile strength of the conductor and the overhead shield wire respectively.

EW-10.3.8.2 Step Bolts

Each tower structure shall be provided with step bolts on one of the legs from approximately 1.0 meter above ground level to the ground wire peak. Step bolts shall be furnished in an amount of 25% of the step bolt holes. These bolts shall not be less than 16 mm diameter, double nut type, 18 cm long with 35 mm diameter, symmetrical head, two hexagon nuts and spring washers, spaced not more than 45 cm apart.

Each bolt shall withstand without permanent deformation a vertical load of at least 137 kg applied at the bolt head.

EW-10.3.8.3 Phase Indication Plates

For phase indication of the incoming and outgoing lines/feeders of the substation, the Contractor shall furnish phase indication plates as part of the supply for the steel structures.

The indication plates shall be made of steel plate with 3 mm thickness zinc galvanized and colored with enamel twice painting and baking, or more durable method. Indicating numbers and letters shall be painted with directional light reflexion material. The surfaces of the plate shall be free from scratches, cracks, flaws, spots and rust and shall be smooth surfaced and non-sharp corner.

The dimension of plates for each voltage class shall be as follows:

- 500 kV 600 mm x 600 mm
- 230 kV 500 mm x 500 mm
- 138 kV 400 mm x 400 mm
- 115 kV 400 mm x 400 mm
- 69 kV 300 mm x 300 mm

EW-10.3.8.4 Lightning Rod/Air Terminal

The structure with overhead ground wire as shown on the bid drawing shall be equipped with three (3) meters height lightning rod made of copper pipe more than 25 mm in diameter with terminal suitable for 100 mm^2 HDCC conductor terminal. The upper point of the lightning rod shall be sharp and chrome plated.

EW-10.3.8.5 Earthing Points

Each steel structure and column shall be provided with means for the attachment of a permanent connection to the substation grounding system.

EW-10.3.9 Shop Assembly and Inspection

All built-up assemblies shall be shop bolted complete with washers, after galvanizing, and shipped as a unit. When specified in the Technical Data

Sheets, Contractor shall completely assemble in the presence of NPC or his authorized representative(s) one (1) complete bay structure of each voltage rating before the shipment of such structures. Any errors in the shop detail drawings or shop work shown by this assembly shall be immediately corrected. Contractor's proposal shall include the work required for these shop assemblies.

Any material rejected by NPC for failure to conform with this specification or the Technical Data Sheets shall be corrected or replaced by the Contractor. The fact that material has been inspected, or NPC has waived the right to inspect any material, shall not prevent rejection of the material if it is found not to be in proper condition or to have fabrication inaccuracies preventing proper assembly.

EW-10.3.10 Marking

All pieces shall be distinctively marked with erection marks clearly visible after galvanizing, corresponding to those on the erection drawings. Additionally, all tower structure members shall be marked with "NPC" to identify the same as the property of National Power Corporation. Steel stamping dies, minimum 16 mm, shall be used and special care shall be taken to see that all erection marks are made in such a manner as not to be obliterated in transit, or in any way damage the galvanizing or impair the strength of the member.

In marking the members, each marking shall be prefixed by letters, which indicate the tower post number or the beam structure number.

In addition, the members shall be marked with water-proof ink stencil 25 mm height after galvanizing to facilitate in yarding the members and erecting the towers.

The diameter and the length of the bolt shall be marked on each bolt end so as to be visible after galvanizing.

An additional Contractor identification mark shall be stamped immediately in front of the piece identification marks. This Contractor identification mark shall be submitted to NPC for acceptance and registration prior to first use.

When a piece is fabricated from steel other than ASTM A36, the applicable suffix from the list below shall be added to the piece mark.

"H" = 42-50 ksi yield point
"X" = 51-69 ksi yield point
"T" = 70-100 ksi yield point

Identification marks shall be located conspicuously to permit easy reading. Marking of like pieces shall be identical in location, and pieces over 3.0 meters in length shall be marked at both ends.

EW-10.3.11 Other Technical Requirements

Other features for the steel structures, if required by the NPC, are stated in the Technical Data Sheets.

EW-10.4 INSTALLATION

Installation will be by Contractor, unless specified in Section B.1.0 of the Technical Data Sheets.

When the installation is by Contractor, such as for turnkey contracts complete details of proper handling, transport and storage, installation, testing, performance guarantees, etc. shall be provided for NPC's review and approval.

EW-10.5 TESTS

EW-10.5.1 General

Tests shall be carried out by the Contractor to the satisfaction of the NPC before shipment of the steel structure materials.

EW-10.5.2 Material Tests

Contractor shall furnish five (5) copies of certified mill test reports covering chemical and mechanical properties of the structural steel. Stock material may be used with NPC's concurrence where Contractor's stock can be satisfactorily identified with the specified ASTM specification.

EW-10.5.3 Shop Tests

Contractor shall furnish six (6) copies of shop test reports for NPC's review and records showing the results of all tests made during fabrication.

EW-10.5.4 Mechanical Tests

Mechanical Tests on the material used in the fabrication of the structures shall include ultimate tensile strength and elongation. Mill certificates, if available, may be supplied in lieu of these tests.

EW-10.5.5 Galvanizing Tests

Galvanizing tests shall be carried out according to the latest ASTM Specifications A123, A143, A153 and A239 on the structural shapes, bolts, nuts and other small miscellaneous hardwares.

EW-10.5.6 Trial Assembly of Prototype Structures

A trial assembly of one complete bay section or the whole structure system shall be made in horizontal position on the ground, if required in the Technical Data Sheets.

EW-10.6 DATA AND DOCUMENTATION REQUIREMENTS

EW-10.6.1 General

Contractor-furnished data and information shall be the performance data, predicted performance, interface requirements and construction features of all

Contractor's furnished equipment and materials. The accuracy of such information and its compatibility with overall performance requirements specified by the NPC are the sole responsibility of the Contractor.

All information submitted as part of Proposal Data will become part of contract data for successful bidder. Any deviation from such data requires NPC's approval.

EW-10.6.2 Data and Information to be Submitted During Post Qualification

Contractor shall furnish during post qualification the filled-in Section B.10.0 of the Technical Data Sheets.

EW-10.6.3 Data and Information to be Submitted After Award of Contract

The following shall be submitted before final shipment of materials:

a. Brochures and catalogues to support the filled-in Technical Data Sheets and to allow NPC to evaluate the equipment /materials being offered;

b. Design drawings showing structure dimensions, conductor clearance diagrams and schedule of member sizes, bolts sizes and material specifications;

c. Erection drawings showing each individual member with its identification mark, location and position of outstanding leg of angles, with number, diameter and length of bolts for connection and typical details to large scale where a number of members frame together;

d. A complete Bill of Material for each structure showing the number, kind, size, length, weight and identification mark for each member including all bolts.

e. Certified test data;

f. Detailed QA Program based on ISO 9001;

g. ISO 9001 Certification of the proposed manufacturer;

h. Complete instruction manuals for Installation, operation and maintenance; and

i. As- built drawings as finally approved.

The Contractor shall furnish in the manner, number of copies and within the time set forth in the contract, instruction manuals in accordance with Section GW-2.9 of the General Works.

EW-11.0 INSTALLATION MATERIALS

EW-11.1 BUS CONDUCTORS AND HARDWARES

EW-11.1.1 SCOPE

EW-11.1.1.1 General

This specification covers the technical and associated requirements for stranded aluminum bus conductors and tubular aluminum bus conductors for use in electric power switchyards and substations.

It is not NPC's intent to specify all technical requirements nor to set forth those requirements adequately covered by applicable codes and standards. Contractor shall furnish high quality materials meeting the requirements of this specification and industry standards.

The Contractor shall bear full responsibility that the conductors and hardware have been designed and fabricated in accordance with all codes, standards and applicable governmental regulations and performs under the conditions and to the standards specified herein.

No departure shall be made from these specification and standards unless waived or modified in writing by NPC. The Contractor shall obtain from its subcontractors a statement as to compliance with this specification without exception and/or if there are any exception, these shall be described in detail and included in Contractor's proposal. The Contractor shall add a statement that no other exceptions are taken to this specification.

EW-11.1.1.2 Works to be Provided by the Contractor

The Contractor shall provide the equipment, accessories and services delineated in Section B.1.0 of the Technical Data Sheets.

EW-11.1.1.3 Works to be Provided by NPC

NPC shall provide the materials (if any) and services listed in Section B.1.0 of the Technical Data Sheets.

EW-11.1.2 CODES AND STANDARDS

EW-11.1.2.1 General

The conductors furnished shall be in accordance with, but not limited to, the latest issues of the following applicable standards, including all addenda, in effect at time of purchase order unless otherwise stated in this specification.

ASTM	**American Society for Testing Materials**
B230	Aluminum Wire, 1350-H19 for Electrical Purposes
B231	Aluminum Conductors, Concentric-Lay-Stranded
B232	Aluminum Conductors, Concentric-Lay-Stranded Steel Reinforced (ACSR)

B241	Aluminum Alloy Seamless Pipe External Tube
B341	Aluminum-Coated (Aluminized) Steel Core Wire for Aluminum Conductors, Steel Reinforced
B498	Zinc Coated (Galvanized) Steel Core Wire for Aluminum Conductors, Steel Reinforced (ACSR)
B549	Aluminum Conductor, Aluminum-Clad Steel Reinforced (ACSR)
E-139	Conducting Creep, Creep-Rupture, and Stress-Rupture Tests of Metallic Materials

IEC	**International Electrotechnical Commission (all parts of listed Standards apply)**
60888	Zinc-Coated Steel Wires for Stranded Conductors
60889	Hard-Drawn Aluminum Wire for Overhead Lines
1089	Round Wire Concentric Lay Overhead Electrical Stranded Conductors

ISO	**International Standards Organization**
9001	Quality System Model for Quality Assurance in Design/Development, Manufacture and Testing
9002	Quality System Model for Quality Assurance in Production, Installation and Servicing

These codes and standards set forth minimum requirements which may be exceeded by Contractor if, in Contractor's judgment and with NPC's acceptance, superior or more economic designs or materials are available for successful and continuous operation of Contractor's furnished conductors and hardware as required in this specification.

EW-11.1.3 TECHNICAL REQUIREMENTS

EW-11.1.3.1 General Requirements

<u>General</u>

The type(s) of conductor(s) to be furnished and their detailed characteristics are specified in the Technical Data Sheets. The standard design requirement for the basic conductor types are:

a. Stranded Conductors following ASTM Standards

ACSR/GB	ACSR conductor with outer layer(s) of hard-drawn aluminum wire type 1350-H19 per ASTM B230 and core layer(s) of Class B zinc-coated (galvanized) steel wires per ASTM B498, fabricated according to ASTM B232.
ACSR/AZ	ACSR conductor using aluminum coated (aluminized) steel core wire
ACSR/AW	Aluminum Conductor, Aluminum Clad Steel Reinforced fabricated according to ASTM B549
AAC/TAL	All aluminum conductors (Class AA) or thermally upgraded aluminum alloy fabricated according to ASTM

	B231, Specification for Aluminum Conductors, Concentric-Lay-Stranded
TACSR	Thermo-Resistant Aluminum Alloy Conductor Steel Reinforced

b. Stranded Conductors following IEC Standards

A1/S1B	ACSR conductor with outer layer(s) of hard-drawn aluminum wire type A1 per IEC 60889 and core layer(s) of regular strength, class B zinc-coated steel wires per IEC 60888, fabricated to meet IEC 1089 requirements.
TAL	High Conductivity Thermo-Resistant Aluminum Alloy Conductor

c. Tubular Conductor Following US Standards

6063-T6	Aluminum alloy extruded pipe fabricated to meet ASTM B241 requirements

EW-11.1.3.2 Manufacturing Requirements

Stranding for Conductor

All wires of the stranded conductor shall be concentrically stranded. The wires in each layer shall be evenly and closely stranded around the underlying wire(s). The tension in individual wires in a layer shall be sufficient to hold each wire firmly in place with only enough strand separation to prevent crowding at the time of stranding and during installation. All steel and aluminum wires shall lie naturally in their position in the stranded conductor and, when the core and/or the aluminum wires are cut, the wire ends shall remain in position or be readily replaced by hand and then remain approximately in position.

Conductor Characteristics

The aluminum shall be of the higher purity commercially obtainable which shall not be less than 99.5%. The Contractor shall submit certificate of analysis giving the percentage and nature of any impurities in the metal out of which the wires were made. There shall be no joints in the individual wires of the outer layer.

The type of conductor to be supplied shall be as stated in the Technical Data Sheets and shall be manufactured according to applicable ASTM or equivalent IEC Standards.

Tubular Bus

Bare aluminum tubular bus conductors shall be provided where indicated in the bid drawings.

The aluminum tube shall be made of 6063-T6, UNI 3569-T6 or Alcan 50 S-T6, first melting aluminum alloy ANSI Standard Schedule 40 standard pipe size. This extruded seamless tubing shall be manufactured in accordance with ASTM Specification No. B241.

The electrical characteristics for the aluminum tube if applied for the substation shall be as indicated in the Technical Data Sheets.

The bus tubing shall be furnished with identification marking which shall include the following:

a. Manufacturer's Name

b. Specification Number

c. Alloy and temper

d. Size

Corona bells shall be furnished for the ends of all tubular buses.

Surface Condition

The completed conductor shall be smooth, free from nick, burrs, aluminum or steel particles, dirt and excessive die grease. The conductor shall be absolutely free of copper dust and copper particles. If so specified, the outer conductor surface shall receive an additional treatment to make it non-specular (non-reflective).

Conductor Hardware

Bus Support Clamps (For Tubular Bus)

a. All bus support clamps shall be cast of first melting aluminum alloy equivalent to 356-T6. Each clamp shall be adjustable for alignment with the insulator and furnished with four galvanized steel mounting bolts and lockwashers.

b. Bolted type bus support clamp, if used, shall be furnished complete with bolts, nuts and washers and shall be finished with anodic coating and lubricated. The clamps for tubing shall have dimensions and section suitable for splicing two pieces of tubing in the clamp.

c. Welded type non-expansion clamps shall be suitable for use either as a welded fixed clamp or as an unwelded slip clamp.

d. Flexible elements of expansion bus support clamps, where required, shall utilize a laminated aluminum strap which has current capacity equivalent to the tube. Expansion bus support clamps for 500kV installation shall be furnished with corona rings to minimize corona.

Connectors

a. Connectors for aluminum shall be first melting cast aluminum alloy equivalent to 356-T6. All terminal pad drilling holes shall conform to NEMA CC1 and shall be furnished with stainless steel bolts, nuts, flat washers and Belleville washers.

b. Bolted type connectors, if supplied, shall be a multi-grip type and furnished from first melting aluminum alloy equal to 356-T6 with bolts, nuts and washers and finished with anodic coating and lubricated.

c. Threads shall be coarse series, class 2A for bolts and class 2B for nuts.

d. Welded type connectors, if required shall be designed for filler welds or chamfered for butt welds.

e. All EHV terminal connectors for 500 kV shall be furnished with pad caps or shall be protected with corona rings or shields to prevent corona when bolting terminal connectors to flat pads. All terminal pad drilling holes shall conform to NEMA-CC1 and shall be furnished with stainless steel bolts, nuts, flat washers and belleville washers.

f. All terminal connectors shall have a smooth surface free from burrs and edges and fillet and shall be rounded to minimize corona concentration and radio interference. As much as possible, connectors shall be corona-free at highest voltage of equipment.

g. Angle and T-connectors shall be of streamlined, welded or bolted type as specified in the Technical Data Sheets and shall be made of first melting cast aluminum alloy 356-T6. Tap element sockets shall be deep enough to allow for error in cut-off.

h. The connectors shall be able to carry the continuous currents as specified for the conductors and equipment, without the constant temperature of the connectors exceeding the temperature of the weakest connecting point from the current carrying aspect. Connectors shall withstand the forces from the drawing conductors, vibrations and short-circuit.

i. The component for connection shall be adopted to the design size of conductor.

j. Couplers shall be of welded or bolted type as specified in the Technical Data Sheets and shall be made of first melting cast aluminum alloy 356-T6.

   For 500kV, all couplers shall be of the internal fit, welded type to give maximum strength, streamlined appearance and minimum corona. This includes all straight and angle couplers and bus terminal connectors.

k. Corona bells shall be streamline internal type and cast from first melting aluminum alloy 356-T6.

All 500kV corona bells shall be the bolted type for ease in expansion, future reuse and to eliminate possibilities of nicks and scratches.

Compression Connectors

a. Compression Dead End. The compression dead end, if used, shall be of tubular, compression type with non-adjustable clevis and made of first melting aluminum alloy equal to 1100 or Alcan D1S. They shall be designed to grip both steel core and the aluminum strands and must have an ultimate strength of the conductor specified in the Technical Data Sheets. Dead ends shall be equipped with galvanized steel clevis, bolts, nuts and stainless steel cotter pins with NEMA-CC1 tap pad.

Clamps

a. Aluminum Strain/Suspension Clamps. Aluminum strain clamps and suspension clamps for aluminum conductor, if required in the Technical Data Sheets, shall have its clamp bodies and keeper pieces, made of high strength and heat treated cast aluminum alloy. Cotter bolts, U-bolts, nuts, and lockwashers shall be hot dip galvanized steel. Cotter pins shall be made of stainless steel. Slip strength of the strain clamp shall be not less than 85% of the rated ultimate strength of the conductor.

b. Parallel Groove Clamp. The parallel groove clamp shall be made of aluminum alloy and be used for connecting the jumper conductor to the main conductor. The parallel groove clamp shall be bolted type and must be suitable for the specified conductor size and type. The slip strength of the clamp must not be less than fifteen percent (15%) of the ultimate breaking strength of the conductors being connected.

c. Wedge Pressure Clamps. Wedge pressure clamp if used, shall be of high strength aluminum alloy that is power driven between the run and the tap cable locking them into "C" shaped tampered aluminum spring body. The clamp shall maintain the pressure throughout the life of the connection to ensure reliability during severe electrical and climactic condition. The clamp shall provide superior contact integrity.

Conductor Spacer

a. Conductor spacer, when required by the number of conductor arrangement and ampacity ratings shall be furnished and shall consist of an interlinking body and clamps for gripping the conductors.

b. The spacer body frame shall be made of aluminum alloy and the clamps of the line spacers shall be hinged-type made also of aluminum alloy.

c. Clamp fastener shall be aluminum alloy break-away bolt.

d. The conductor spacer shall not be deformed due to electromagnetic attraction of short circuit current through the bundle conductors as specified in the Technical Data Sheets.

e. The corona noise from the conductor spacers shall not exceed that of the bundle conductors.

Galvanizing

All ferrous metal as described in this specification shall be galvanized by hot-dip process. The minimum quantity of zinc coating shall comply to the requirement of ASTM A153 and the degree of contamination specified in the Section B.1.0 of the Technical Data Sheets. Bolts and nuts shall be galvanized after being threaded and excessive zinc shall be removed, and the nuts shall run freely (by hand) over the entire length of the thread. The bolts and nuts shall not be re-tapped after galvanizing.

Finished materials shall be dipped into the solution of dichromate after galvanizing for white rust protection.

Oxide Inhibitor

When so specified in the Technical Data Sheets, the conductors and all aluminum connectors shall be protected by a high melting point (e.g. dropping point of approximately 380^{0}F), neutral, organic inhibitor.

EW-11.1.4 INSTALLATION

Installation will be by Contractor unless specified otherwise in Section B.1.0 of the Technical Data Sheets.

When the installation is by Contractor, such as for turnkey contracts complete details of proper handling, transport and storage, installation, testing, performance, guarantees, etc. shall be provided for NPC's review and approval.

EW-11.1.5 TESTS

EW-11.1.5.1 General

All materials shall comply with test criteria, and NPC's acceptance of the conductors and accessories shall not relieve the Contractor of his responsibility for meeting all the requirements of this specification.

The Contractor shall carry out his own expense all tests necessary to ensure the satisfactory design and manufacture of conductors in accordance with ASTM or equivalent IEC Standards.

Conductors, bus fittings, connectors and hardware shall be given the manufacturer's routine shop tests and quality conformance tests and shall be witnessed by the NPC or his authorized representative unless waived in writing. No conductors, bus fittings, connectors and hardware shall be shipped until released for shipment by the NPC of his authorized representative.

The Contractor shall make all preparation for tests and provide the test apparatus and personnel and shall notify the NPC the date of the tests to be witnessed forty-five (45) days in advance.

EW-11.1.5.2 Shop Tests

Cables and materials shall be subjected to the design (or Type) tests, if specified, and quality conformance (or Sample) tests in accordance with the test standards specified herein. Design tests can be omitted if a design test record of the same materials can be submitted. Even though NPC or his representative performs or witnesses the required tests and the cables and materials meet the acceptance criteria, Contractor shall not be relieved of the responsibility of providing cable conforming to all requirements of the specification.

In general, the following routine tests shall be performed as a minimum:

a. For Tubular Conductor (If supplied)

The tests shall be performed in accordance with ASTM B241. The routine test shall be performed by selecting the samples from each lot of equipment. The number of samples required for the test shall be 3 for each size;

1. General inspection
2. Dimension and weight measurement
3. Tensile strength and elongation test
4. Chemical composition or certified report of aluminum alloy from the original manufacturer
5. Surface finish inspection

b. For Stranded Conductors

The following tests shall be performed as a minimum in accordance with the applicable ASTM or equivalent IEC standards.

1. Construction test
2. Tensile strength test
3. Conductor sensitivity test
4. Dimension measurement
5. Surface finish inspection
6. Weight of conductor

c. For Bus Fittings

The tests shall be performed in accordance with NEMA CCI. The routine test shall be performed by selecting the samples from each lot of equipment. The number of samples required for the tests shall be: all for 1-3 sets; 3 for 4-30 sets; and 10% for over 30 sets.

1. General inspection
2. Dimension measurement
3. Chemical composition of aluminum alloy or certified report of the aluminum alloy characteristics from the original manufacturer

d. For Connectors

The tests shall be performed in accordance with the NEMA CC1. The routine test shall be performed by selecting the samples from each lot of equipment. The number of sample required for the tests shall be; all for 1-3 sets; 3 for 4-30 sets; and 10% for over 30 sets.

e. For Miscellaneous Hardwares

The test shall be performed in accordance with ASTM B153 and the manufacturer standard. The routine tests shall be performed by selecting the samples from each lot of equipment. The number of samples required for the tests shall be: all for 1-3 sets; 3 for 4-30 sets; and 10% for over 30 sets.

1. General inspection
2. Measurement of dimensions
3. Tensile tests:
   No. of samples required: 1 for 20-50 sets;
   2 for 51-100 sets; and
   3 for over 100 sets
4. Galvanizing tests

EW-11.1.6 DATA AND DOCUMENTATION REQUIREMENTS

EW-11.1.6.1 General

Contractor-furnished data and information shall be the guaranteed performance data, predicted performance, interface requirements and installation/stringing features of all Contractor's furnished materials. The accuracy of such information and its compatibility with overall performance requirements specified by NPC are the sole responsibility of the Contractor.

All information submitted as part of Proposal Data will become part of contract data for successful bidder. Any deviation from such data requires NPC approval.

EW-11.1.6.2 Data and Information to be Submitted During Post Qualification

Contractor shall furnish during post qualification the filled-in Section B.11.1 of the Technical Data Sheets.

EW-11.1.6.3 Data and Information to be Submitted After Award of Contract

The following shall be submitted before shipment of the bus conductors and hardware's:

a. Brochures and catalogues to support the filled-in Technical Data Sheets and to allow NPC to evaluate the equipment /materials being offered;

b. Drawings, instructions and other reference material for the specified installation tool and materials;

c. Drawings, instructions and other reference material for the stringing/installation of conductors;

d. Sag tension charts for the conductor specified;

e. Outline drawings indicating weight, dimensions, and material composition of hardware and conductors;

f. Field assembly requirements of bus conductors and hardware;

g. List of drawings and its schedule of submittal;

h. Detailed QA Program based on ISO 9001;

i. Detailed Project Progress and Performance Review (PPR) for the bus conductors and hardware;

j. ISO 9001 Certification of the proposed manufacturer;

k. Cable schedule, including cable numbers, identification, sizes, etc.; and

l. As-built drawings as finally approved.

The Contractor shall furnish in the manner, number of copies and within the time set forth in the Contract, instruction manuals in accordance with Section GW-2.9 of the General Works.

EW-11.2 STATION INSULATORS

EW-11.2.1 SCOPE

EW-11.2.1.1 General

This specification covers the technical and associated requirements for wet process porcelain or toughened glass, or composite type suspension insulator units and station post insulator units for use in electric power switchyards and substations.

It is not NPC's intent to specify all technical requirements nor to set forth those requirements adequately covered by applicable codes and standards. Contractor shall furnish high quality wet process porcelain or toughened glass, or composite type suspension insulator units and station post insulator units meeting the requirements of these specification and industry standards.

The Contractor shall bear full responsibility that the station insulators have been designed and fabricated in accordance with all codes, standards and applicable governmental regulations and performs under the conditions and to the standards specified herein.

No departure shall be made from these specification and standards unless waived or modified in writing by NPC. The Contractor shall obtain from its subcontractors a statement as to compliance with this specification without exception and/or if there are any exception, these shall be described in detail and included in Contractor's proposal. The Contractor shall add a statement that no other exceptions are taken to this specification.

EW-11.2.1.2 Works to be Provided by the Contractor

The Contractor shall provide the insulators, works and services delineated in Section B.1.0 of the Technical Data Sheets.

EW-11.2.1.3 Works to be Provided by NPC

NPC shall provide the materials (if any) and services listed in Section B.1.0 of the Technical Data Sheets.

EW-11.2.2 CODES AND STANDARDS

EW-11.2.2.1 General

The insulators furnished shall be in accordance with, but not limited to, the latest issues of the following applicable standards, including all addenda, in effect at time of purchase order unless otherwise stated in this specification.

ANSI/IEEE	**American National Standards Institute/Institute of Electrical & Electronic Engineers**
C29.1	Electrical Power Insulators – Test Methods
C29.2	Wet Process Porcelain and Toughened Glass – Suspension Type
C29.11	Tests for Composite Insulators for Overhead Transmission Lines
4-78	Standard Technique for High Voltage Testing
957	Guide for Cleaning Insulators
987	Guide for Application of Composite Insulators
ASTM	**American Society for Testing and Materials**
A 153	Specification for Zinc Coating (Hot Dip) on Iron and Steel Hardware
C 151	Test Method for Autoclave Expansion of Portland Cement
IEC	**International Electrotechnical Commission**
60060-1	General Definitions & Test Procedures
60120	Dimensions of Ball and Socket Couplings of String Insulator Units
60168	Tests on Indoor and Outdoor Post Insulators of Ceramic materials or Glass for Systems with Nominal Voltages Greater than 1000V
60273	Characteristics of Indoor and Outdoor Post Insulators for Systems with Nominal Voltages greater than 1000V
60305	Characteristics of String Insulator Units of the Cap and Pin Type
60372	Locking Devices for Ball and Socket Couplings of String Insulators

60383	Tests on Insulators of Ceramic Material or Glass for Overhead Lines with a Nominal Voltage greater than 1000V
60433	Characteristics of String Insulators Units of the Long Rod Type
60437	Radio Interference Test on High Voltage Insulators
60438	Tests and Dimensions for High Voltage D.C. Insulators
60471	Dimensions of Clevis and Tongue Coupling of String Insulator Units
60506	Switching Impulse Tests on High Voltage Insulators
60507	Artificial Pollution Tests on High Voltage Insulators to be used on A.C. Systems
60575	Thermal-mechanical Performance Test and Mechanical Performance Test on String Insulator Units
60591	Sampling Rules and Acceptance Criteria when Applying Statistical Control Methods for Mechanical or Glass for Overhead Lines with a Nominal Voltage Greater than 1000 V
60815	Guide for Selection of Insulators in Respect of Polluted Conditions
1109-92	Composite Insulators for AC Overhead Lines with Nominal Voltage Greater than 1000 volts – Definitions, Test Methods and Acceptance Criteria.
CEA	**Canadian Electrical Association**
LWIWG-01& 2	Design and Type Test Methods for Composite Insulators
ISO	**International Standards Organization**
9001	Quality System Model for Quality Assurance in Design/Development, Manufacture and Testing
9002	Quality System Model for Quality Assurance in Production, Installation and Servicing

EW-11.2.3 TECHNICAL REQUIREMENTS

EW-11.2.3.1 Description of Services

Wet process porcelain (or toughened glass) and/or composite type suspension insulator units and station post insulator units covered by this specification will be used in switchyards and substations. The type of insulators to be used shall be as stated in the Technical Data Sheets.

EW-11.2.3.2 Design Requirements

Porcelain Type Insulators

The insulator design, fabrication and resultant characteristics shall be in accordance with the codes and other particular requirements specified herein.

Insulators shall not be affected by weather or sudden change in temperature and salt laden atmosphere in an area subject to intense lightning storms at certain periods of the year. The entire porcelain surface of the insulator that will be exposed after assembly shall be glazed and shall be relatively free from imperfections.

Suspension insulator shells shall be made of commercial quality wet process porcelain or of toughened glass in accordance with ANSI C29.2. The color of toughened glass shells shall be manufacturer's standard color. The color of the glaze of porcelain shells shall be as specified in the Technical Data Sheets. When units are coupled together there shall be no contact between the shell of one unit and the metal parts of the next adjacent unit when strings are in their service position.

Station post insulators shall be made of dense, wet process porcelain, homogeneous and completely vitrified, in accordance with ANSI C29.9. The station post insulators shall be furnished complete with all mounting hardware including fittings, nuts, bolts, spring washer. The post insulators shall have the characteristics required in the Technical Data Sheets.

<u>Metal Parts</u>

a. Pins and caps shall be designed to transmit the mechanical stresses to the shell by compression and to develop uniform mechanical strength of the insulator. The metal parts shall retain their rated mechanical strength even when the porcelain or glass skirts are partially or completely broken off.

b. Pins shall be made of drop-forged, upset-forged, or machined-steel. The insulator pins, if specified in the Technical Data Sheets, shall be protected against electrolytic corrosion by the use of a sleeve of pure zinc, zinc alloy or a corrosion intercepting sleeve. The sleeve shall be fused to the pin so that no gap exists between pin and sleeve and shall be so positioned on the pin as to intercept the cement line.

c. Caps shall be of copper-bearing drop-forged steel or heat-treated malleable iron. The hole for the cotter key in a socket type cap shall be on the side of the cap opposite the socket opening. The hole shall be counter-sunk in such a manner that the eye of the cotter key when in the locked position maybe engaged by a hot-line key puller, to provide for disengagement of insulator units under energized conditions.

d. All ferrous parts, except stainless steel, shall be galvanized in accordance with ASTM A153.

e. Insulator units shall be furnished with the size and type of connection specified in the Technical Data Sheets. The dimensions and tolerances of ANSI/IEC type ball and socket connections and tongue-clevis connections shall be in accordance with ANSI C29.2 or IEC 60120. The dimensions and tolerances of ANSI/IEC type station post insulators shall be in accordance with ANSI C29.9 or equivalent IEC equivalent standard.

f. Insulator units' ball-socket connection shall be furnished with a locking device of the split cotter key type installed in the socket hole of the insulator cap. The cotter key shall be of such design and size to meet the tests specified herein. The cotter key shall provide positive locking against unintentional disengagement of insulator units during the use and handling to provide easy connection to other units or hardware. Cotter keys shall be made from cold-drawn bronze, brass or stainless steel wire of approximately half-round section having the following properties:

1. Stainless steel shall be of American Iron and Steel Institute Type 301, 302 and 304, shall have a minimum elongation of 20 percent in a two-inch gage and shall have a surface hardness of Rockwell B88 to C30.

2. Brass shall contain a minimum of 80 percent copper and have a minimum tensile strength of 80,000 psi.

3. Bronze shall contain 88 percent minimum, 98 percent maximum copper and shall have a minimum tensile strength of 80,000 psi.

g. Pins for tongue-clevis type connection shall be of drop forged, upset-forged or machined steel. Locking device of split cotter key type shall be used to prevent disengagement of insulator units. Cotter keys shall allow easy connection to other units or hardware. Cotter key materials shall comply with Item "f" above.

h. Station post insulators, if made up of several sections, shall be furnished complete with all the necessary hardware for intersection connections.

<u>Assembly</u>

a. Neat Portland cement (in accordance with ASTM C150) or a Portland cement and sand mixture shall be used in making the assembly of porcelain insulators.

b. Neat aluminous cement or an aluminous cement and sand mixture shall be used in making the assembly of toughened glass insulators.

<u>Miscellaneous Hardware</u>

a. <u>String Insulator Hardware's:</u>

1. All string hardwares shall be made of malleable iron, ductile iron or forged steel, hot-dip galvanized. All metals shall be free from rust, burrs, sharp edges, lumps and dross and shall be smooth so that interconnecting parts will fit properly and the part maybe assembled and disassembled easily. All string hardwares must have an ultimate strength of the insulator specified in the Technical Data Sheets.

<u>Galvanizing</u>

a. All ferrous metal shall be galvanized by hot-dip process. The minimum zinc coating shall comply to the requirements of ASTM 153. Bolts and nuts shall be galvanized after being threaded and excessive zinc shall be removed.

Materials and Workmanship

a. Material shall be free of defects or irregularities, of recent manufacture, unused, and the best available considering durability, strength, electrical characteristics and suitability for the intended service and the best engineering practice. Workmanship shall conform to industry standards and practices.

b. Metal caps shall be free from cracks, seams, shrinks, air holes, burrs, and rough edges. Metal pins shall be free from laps, folds, seams, burrs, and rough edges. Surfaces of metal parts shall be smooth with no projecting points or irregularities which may cause corona.

c. Insulator units after assembly shall be concentric and coaxial.

Composite Insulators

General

a. The polymer or composite insulator described in this specification consist of the following components:

1. a fiberglass reinforced resin rod;
2. a chemically bonded polymer sheath to protect the fiberglass rod form hydrolysis;
3. polymer weathersheds to provide adequate leakage distance; and
4. metal end fittings.

Design Requirements

a. The insulator design, fabrication and resultant characteristics shall be in accordance with the codes and standards and other particular requirements specified herein.

b. The reinforced fiberglass core shall be electrical grade epoxy or made with corrosion (acid) resistant glass fibers to achieve maximum tensile strength. The insulator core shall be mechanically and electrically sound, free from voids, foreign substances and manufacturing flaws. The rod shall have a uniform diameter throughout the entire length.

c. A protective polymer material shall be extruded or injection molded on the reinforced fiberglass to a thickness not less than 3.0 mm. The polymer material shall be firmly bonded to the sheath, vulcanized to the sheath or molded as part of the sheath and be seamless and free from imperfections. The strength of the weathershed to sheath interface shall be greater than the tearing strength of the polymer. Weathersheds shall be located at intervals to provide optimum electrical performance. The base polymer shall be 100% silicone rubber prior to the addition of reinforcing fillers.

d. Grading rings shall be provided when system voltages are equal to or greater than 230 kV. The size and placement of the metallic grading rings shall be designed to eliminate dry band arcing in the vicinity of the end fittings and shield the end fittings preventing corona inception at 115% of nominal line-to-ground voltage.

e. The design of the grading rings shall be such that the ring can only be mounted with its orientation towards the weathersheds for maximum RIV and corona control. Grading rings shall be capable of installation and removal with hot line tools without disassembling any other part of the insulator assembly.

f. The sheath material shall be continuous and shall extend inside the end fitting collar. No joints shall be permitted for greater assurance against the formation of electrical discharge or stress erosion points.

g. The full insulator string unit shall contain equal leakage distance as that of an electrically equivalent standard string of porcelain insulators. Insulator having reduced leakage design will not be accepted.

h. The completed insulator shall have a permanent seal at the interface between the metal end fittings and the housing to insure that no moisture or foreign materials shall enter.

i. The polymer insulator shall be of the type specified in the Technical Data Sheets.

Galvanizing

a. All ferrous items, other than stainless steel, shall be galvanized to ASTM A-123 or A 153-82.

b. The insulator's end fittings shall be connected to the rod core by means of a controlled compression technique which provides the required SML.

c. The zinc coating shall be uniform, and adhere to the surface of the base metal. The coating shall be free from blisters, flux, black spots, dross, tear drop edges, flaking zinc, rough appearance and in general shall be smooth, clean and unblemished when received.

Materials and Workmanship

a. Hardware and weathersheds shall be uniform in quality. They shall be clean, sound, smooth, free from gross and defects, of recent manufacture and unused. Workmanship shall conform to industry standards and practices.

b. Assembly of end fittings shall be made in a manner that no rod fracture should occur during assembly process.

EW-11.2.3.3 Insulator Marking

Each insulator unit shall be marked in accordance with ANSI C29.2 and C29.9. Marking shall be either on the shell or cap prior to galvanizing.

Additional marking, such as production record code, if customarily provided by Contractor, are acceptable.

In addition, all shells of insulator units shall be marked with official NPC logo to identify the same as the property of National Power Corporation. Marking shall be on the opposite side of the usual trademark by the manufacturer of the insulator units.

For composite type of insulator unit, the insulator shall be marked per ANSI C29.11, Section 6, 1988 with additional marking of NPC Logo only at the uppermost and lowest weather shed of the complete insulator unit.

EW-11.2.4 INSTALLATION

Installation will be by Contractor unless specified otherwise in Section B.1.0 of the Technical Data Sheets.

When the installation is by Contractor, such as for turnkey contracts complete details of proper handling, transport and storage, installation, testing, performance, guarantees, etc. shall be provided for NPC's review and approval.

EW-11.2.5 TESTS

EW-11.2.5.1 General

All materials shall comply with test criteria, and NPC's acceptance of the insulators and accessories shall not relieve the Contractor of his responsibility for meeting all the requirements of this specification.

The Contractor shall carry out, at his own expense, all tests necessary to ensure the satisfactory design and manufacture of insulator in accordance with ANSI or IEC Standards.

All routine tests required in ANSI or equivalent IEC Standards shall be witnessed by the NPC or his authorized representative unless waived in writing, and no insulator units shall be shipped until released for shipment by the NPC or his authorized representative.

The Contractor shall make all preparation for tests and provide the test apparatus and personnel and shall notify the NPC the date of the tests forty-five (45) days in advance.

Actual test procedures to be used shall be subject to NPC's acceptance and approval.

EW-11.2.5.2 Shop Tests

Insulator units shall be subjected to the design, quality conformance, and routine tests in accordance with ANSI C29.2, C29.9, C29.1 (IEC 60383) and C29.11. Even though Contractor performs the required tests and the insulators meet the acceptance criteria, Contractor shall not be relieved of the responsibility of providing insulators conforming to all requirements of the specification.

EW-11.2.5.3 Design Tests

Contractor shall provide design test report for the insulator type(s) he proposes to furnish if so required in the Technical Data Sheets. All insulator units shall comply with all the Design Test in accordance with ANSI C29.2 and C29.9 or equivalent IEC Tests Standards.

Design tests may be omitted if a design test record of the same insulator units described in the specification and in the Technical Data Sheets can be submitted.

As a minimum, the following tests shall be performed:

a. For Station Post Insulators

1. Low-frequency wet withstand voltage test
2. Critical impulse flashover voltage test, positive
3. Impulse withstand voltage test
4. Radio-Influence voltage test (RIV)
5. Thermal shock test
6. Compression strength test
7. Torsional strength test
8. Creepage distance measurement. One unit of each rating and type shall be subject to this test. The test shall be performed in insulators being supplied.

b. For Porcelain and /or Toughened Glass Suspension Insulators

1. Low-frequency dry flashover voltage test
2. Low-frequency wet flashover voltage test
3. Critical impulse flashover voltage tests – positive and negative
4. Radio-Influence Voltage test (RIV)
5. Time-loading test
6. Thermal shock test
7. Residual-strength test
8. Impact test
9. Cotter key set
10. Creepage distance measurement. One unit of each rating and type shall be subject to this test. The test shall be performed in insulators being supplied.

c. For Composite Insulators

The insulator unit to be supplied shall comply with all design tests specified in ANSI C29.11 and the following additional tests:

1. Water Penetration Test in accordance with CEA-LWIWG-01 and/or CEA-LWIWG-02.
2. Power Arc Test in accordance with CEA-LWIWG-01 and/or IEEE 1024.

3. Tracking Wheel Test in accordance with CEA-LWIWG-01 and/or IEEE 1024
4. Ageing Test for 5000 hours, climatic conditions in accordance with IEC 1109.
5. Cantilever Bending in accordance with CEA-LWIWG-01
6. Thermal Mechanical, in accordance with IEC 1109.

EW-11.2.5.4 Routine and Quality Conformance Tests

Routine and quality conformance tests shall be witnessed by the NPC unless otherwise waived in writing and shall be in accordance with ANSI C29.2, C29.9 and C29.11or equivalent IEC test standards.

Test reports are required if so indicated in the Technical Data Sheets. The following routine and quality conformance tests shall be performed as a minimum:

a. Routine Tests:

1. For Station Post Insulators
   i. Flashover voltage test (Hollow-core insulator only)
   ii. Mechanical proof

2. For Porcelain and/or Toughened Glass Suspension Insulators
   i. Tension-proof test
   ii. Flashover voltage test

3. For Composite Insulator
   i. Per ANSI C29.11

b. Quality Conformance Test

1. For Station Post Insulators
   i. Visual and dimension check
   ii. Porosity check
   iii. Galvanizing test for associated hardwares
   iv. Tensile strength test

2. For Porcelain and/or Toughened Glass Suspension Insulators
   i. Visual and dimension check
   ii. Porosity check
   iii. Galvanizing test
   iv. Combined mechanical and electrical strength test
   v. Puncture test

3. For Composite Insulator
   ii. Per ANSI C29.11

EW-11.2.6 DATA AND DOCUMENTATION REQUIREMENTS

EW-11.2.6.1 General

Contractor-furnished data and information shall be the performance data, predicted performance and installation features of all Contractor's furnished materials. The accuracy of such information and its compatibility with overall performance requirements specified by NPC are the sole responsibility of the Contractor.

All information submitted as part of Proposal Data will become part of contract data for successful bidder. Any deviation from such data requires NPC's approval.

EW-11.2.6.2 Data and Information to be Submitted During Post Qualification

Contractor shall furnish during post qualification the filled-in Section B.11.2 of the Technical Data Sheets.

EW-11.2.6.3 Data and Information to be Submitted After Award of Contract

The following shall be submitted before shipment of insulator units:

a. Brochures and catalogues to support the filled-in Technical Data Sheets and to allow NPC to evaluate the equipment /materials being offered;

b. Certified Quality Conformance and Routine Test Reports, if so indicated in the Technical Data Sheets;

c. Installation procedures;

d. Detailed outline drawing of each insulator unit including a cross-sectional view of the insulator shell, and the following information:

   1. Type designation in accordance with Standard (e.g., ANSI or IEC) used, if applicable
   2. Shell diameter and unit spacing with manufacturing tolerances
   3. Leakage distance, total and shielded portions
   4. Mechanical and electrical characteristics
   5. Size of ball and socket or tongue-clevis parts
   6. Materials
   7. Unit weight
   8. Identification marking
   9. Manufacturer's catalogue number
   10. Each drawing shall be identified by a drawing number

e. Descriptive material brochures, drawings, instructions and other reference material for the specified station insulators;

f. Field assembly requirements of station insulators;

g. ISO 9001 Certification of the proposed manufacturer;

h. Detailed QA Program based on ISO 9001 for the station and suspension insulators and either ISO 9001 or 9002 for the associated hardware; and

i. Final drawings as approved.

The Contractor shall furnish in the manner, number of copies and within the time set forth in the Contract, instruction manuals in accordance with Section GW-2.9 of the General Works.

EW-12.0 GROUNDING SYSTEM

EW-12.1 SCOPE

EW-12.1.1 General

This specification covers the technical and associated requirements for the entire grounding system in one or more substations and/or switchyards, required to protect persons and equipment, to reduce electromagnetic interference (EMI) and to allow safe service and maintenance of the installations. The grounding system includes overhead ground wires and the underground grid, ground rods and connections. The extent of the scope for the subject project (design and/or supply and/or installation) is specifically indicated in the Technical Data Sheets.

It is not NPC's intent to specify all technical requirements nor to set forth those requirements adequately covered by applicable codes and standards. The Contractor shall furnish high quality grounding system materials meeting the requirements of these specification and industry standards.

The Contractor shall bear full responsibility that the grounding system materials have been designed and fabricated in accordance with all codes and standards and that they perform under the conditions and to the standards specified herein.

No departure shall be made from these specification and standards unless waived or modified in writing by NPC. The Contractor shall obtain from its subcontractors a statement as to compliance with this specification without exception and/or if there are any exception, these shall be described in detail and included in Contractor's proposal. The Contractor shall add a statement that no other exceptions are taken to this Specifications.

EW-12.1.2 Works to be Provided by the Contractor

The Contractor shall provide the grounding system materials, accessories and services delineated in Section B.1.0 of the Technical Data Sheets.

EW-12.1.3 Works to be Provided by NPC

NPC shall provide the materials (if any) and services listed in Section B.1.0 of the Technical Data Sheets.

EW-12.2 CODES AND STANDARDS

EW-12.2.1 General

The materials and services of this specification shall be furnished in accordance with, but not limited to the latest issues of the following applicable codes and standards, including all addenda, in effect at time of purchase order unless otherwise stated in this specification:

For Grounding System Design:

IEEE Std. 80-1986	Guide for Safety in Substation Grounding
IEEE Publication 86	EH0253-5-PWR – Practical Applications of ANSI/IEEE Standard 80-1986, IEEE Guide for Safety

For Materials:

ASTM B3	Specification for Soft or Annealed Copper Wire
ASTM B8	Specification for Concentric-Lay, Stranded Copper Conductors
ASTM A363	Specification for Zinc-Coated (Galvanized Steel) Overhead Ground Wire Strand
ASTM A474	Specification for Aluminum-Coated Steel Wire Strand
ASTM A475	Specification for Zinc-Coated Steel Wire Strand
ASTM A415	Specification for Hard-Drawn Aluminum-Clad Steel Wire
ASTM A416	Specification for Concentric-Lay, Stranded Aluminum-Clad Steel Conductors
ISO	International Standards Organization
9001	Quality System Model for Quality Assurance in Design/Development, Manufacture and Testing
9002	Quality System Model for Quality Assurance in Production, Installation and Servicing

These codes and standards, as applicable to the specified material, equipment and services, set forth the minimum requirements which may be exceeded by Contractor if, in Contractor's judgement and with NPC's acceptance, superior or more economic designs and/or materials are available for successful maintenance and continuous operation of Contractor's grounding system as required by this specification.

EW-12.3 TECHNICAL REQUIREMENTS

EW-12.3.1 Description of Services

The materials, equipment and services covered by this specification are for use in one or more substation(s) and/or switchyard(s). Specific technical characteristics and requirements for the subject project are shown in Technical Data Sheets.

All materials and parts which are not specifically mentioned herein but are necessary for the safety of operating personnel and safe operation of the substation shall be furnished and determined by the Contractor at no increase in cost to the NPC.

The Contractor shall connect all metallic parts, such as structures, electrical equipment, cable trays, control boards, fences, metallic doors and fences, etc. within the substation area to the grounding system.

All connections of the earth grid to equipment at the grid end and the connection between the earth grid and earth rods shall be made by welding or pressure clamps.

Bolted connections will be permitted only above ground for connection to the fence or to equipment. All bolted connections shall be coated with corrosion inhibiting grease.

EW-12.3.2 Design Requirements

EW-12.3.2.1 General

The ruling criteria in the design of the grounding grid shall be the safety of personnel and the proper operation of the electrical equipment during normal operation and during transient disturbances such as short circuits in the electric power system and during lightning discharges.

The design of the grounding grid shall be based on the data provided in the Technical Data Sheets which is valid for future stage, and shall be such that the maximum permissible mesh and touch voltages are not exceeded. (See Guide IEEE Std. 80, equations (3) and (4) in Clause 6).

The Contractor shall carry out earth resistivity measurement for the substation site. Based on the result of this measurement and the system parameter, the appropriate design and the calculation will be determined whether impermissible touch and step voltages occur at any place inside substation area and at any place 10 m. outside of the substation boundary line which may be endangered. These calculations will decide on the provisions for grounding to be made with the relevant part of the civil works related to foundations. If the calculations proved after the application of all engineering possibility that touch and step voltages are still higher than permitted and consequently the Contractor managed to design the earthing and grounding grid in such a way to obtain the lowest touch and step voltage value, all documents including limitation and justification shall be provided to the NPC for approval. Only calculations built up on computer generated design program shall be accepted. A special software for providing detailed analysis of the actual step and touch voltages likely to be generated has to be used. Hand calculated shall not be accepted.

In order to minimize the effect of seasonal variations of the earth resistance and the interruption of the overhead ground wire, the grounding system shall be designed for the worst condition, i.e. the overhead ground wire connection shall not be considered, etc.

If in case the actual measured resistance of the Contractor-designed and installed ground grid is higher than specified in the Technical Data Sheets, the Contractor shall install, at no extra cost to the NPC, additional grounding rods, mats, grounding electrodes, etc., until the field-measured resistance is equal to or less than the specified value.

The ground grid shall be composed of a system of copper conductors buried approximately 50 cm. beneath the surface of the earth, excluding crushed rock surfacing. The grid system shall cover the entire fenced substation area and shall extend 0.50 m outside of the substation fence. Driven ground rods shall be installed at regular intervals and connected to the grounding conductor at grid nodes. A minimum of four (4) of the specified ground rods must be installed (one at each corner of the ground grid). The Contractor shall determine the spacing of ground grid conductors and the total number and location of ground rods and their lengths (single or two or more coupled sections).

Grid conductors shall be arranged in parallel lines along the rows of structures or equipment, at intervals meeting the requirements of IEEE 80.

A second set of parallel conductors shall be laid perpendicular to the grid conductors. These conductors shall also meet the spacing requirements of IEEE 80. Suitable connection, either thermoweld or compression as required in the Technical Data Sheets, shall be used at all conductor intersections.

At the corner of the grid, the meshes shall be sub-divided into smaller squares to prevent the higher potential gradients which would otherwise occur in these area.

The following shall also be considered in the design of grounding grid for the substation:

a. At each gate opening, the ground grid shall be installed to include an area 1 meter beyond the swing gate.

b. Grid conductor(s) shall be run in the cable trenches attach to the cable tray support. The conductor shall be connected to the substation ground grid at every intersection with a ground grid conductor, or at intervals not to exceed 25 meters.

When a substation is located adjacent to another substation or generating station, the ground systems of the existing facility and (the new one) of the subject project shall be connected at spacing of not more than 5 meters by two or more copper conductors appropriately sized for mechanical strength and the specified fault current with minimum conductor size to be $\geq$100 mm^2.

The transmission line incoming overhead ground wires shall be insulated from the substation take-off towers by suspension-type strain insulators. Jumpers shall be used to connect the incoming ground wires to the towers (bolted connection) to permit isolating the transmission line overhead ground wires from the substation grounding system while making substation ground grid resistance measurements.

The substation overhead ground wires shall be connected directly to the substation take-off towers.

The material for earthing and grounding in particular for jointing shall be selected to prevent corrosion at the connection points as well as the earthing and grounding material itself, both underground and exposed to air.

It is advisable to measure the grounding resistance values at different stages over the erection to decide at an early stage, if additional grounding measures have to be taken, e.g. by addition of further ground rods or grading rings whenever deemed necessary during and after completion of the relevant work.

The Contractor has to provide sufficient portable earth for the attachment of portable safety earthing and grounding devices maintenance of HV equipment.

EW-12.3.2.2 Working Stresses

The design of all components, particularly those subject to shock or stress reversal, shall incorporate reasonable factors of safety in all cases. Applied design stresses (tension) shall not be more than 40% of rated tensile strength (RTS) for extreme mechanical loading conditions and not more than 20% of RTS for every day stress.

EW-12.3.2.3 Service Condition

The equipment and materials shall be suitable for outdoor installation and use at service conditions specified in Section B.1.0 of the Technical Data Sheets without corrosion, deterioration or degradation of performance characteristics.

EW-12.3.3 Equipment and Materials Requirements

EW-12.3.3.1 Grounding Cables

Grounding cables shall be copper conductor of soft drawn or hard drawn concentric stranding bare copper conductor in accordance with the latest revision of ASTM B3 and manufactured in accordance with ASTM Specification B8 (class B). The copper conductor shall have the characteristics specified in the Technical Data Sheets.

Ground leads running down from the lightning rod or air terminal rods shall be hard drawn concentric stranding copper PVC-insulated (600 V class) and shall be provided with the required clamp supports mounted on the steel structure at approximately 1.5 m intervals.

EW-12.3.3.2 Ground Rods

The ground rod shall be copper-covered steel of circular cross section, with a nominal diameter of 19 mm and a nominal length of 3 meters.

Each ground rod shall have a conical swaged point at one end and shall have a continuous smooth copper covering of at least 0.254 mm thickness molten-welded or copper bonded (electro-deposit) to a steel core. The copper clad or pressed type will not be accepted.

EW-12.3.3.3 Overhead Ground Wire

Overhead ground wire shall be of the type specified in the Technical Data Sheets.

All wires of the overhead ground wires shall be concentrically stranded. The wires in each layer shall be evenly and closely stranded around the underlying wire(s). The tension in individual wire in a layer shall be sufficient to hold each wire firmly in place with only enough strand separation to prevent crowding at the time of stranding and during installation.

The completed overhead ground wire shall be smooth, free from nick, burrs, aluminum, zinc or steel particles, dirt and excessive die grease. The wire shall be absolutely free of copper dust and copper particles.

EW-12.3.3.4 Exothermic Welding Materials (If Exothermic Process is Required)

The Contractor shall supply exothermic welding materials for cable-to-cable, cable-to-ground rod and cable-to-steel structure grounding connections. These materials shall be Cadweld or approved equal. If the Contractor proposes to supply an exothermic process other than Cadweld, detailed information describing the proposed process shall be included with his proposal.

The exothermic welding materials shall include removable clamp type molds, handle, flint gun, exothermic power cartridges, metal discs and other devices required to complete the grounding connection.

The exothermic powder cartridges shall be designed to provide an installed connection having a current capacity equal to conductor being welded. The ignition powder shall be packed in the bottom of the cartridge to permit the ignition powder to fall on top of the welding powder when dumped into the mold. The powder cartridges shall be complemented with metal discs.

The molds shall be designed to withstand the high temperature associated with the welding operation and shall provide a minimum of 50 acceptable connections without maintenance or replacement.

EW-12.3.3.5 Grounding Hardware

<u>Terminal Lugs</u>

Terminal lugs shall be one hole, socket type, rounded edge lug, cast of high strength corrosion resistant copper alloy.

Machine screws, nuts, and washers used with the lugs shall be bronze.

<u>Flexible Copper Braids</u>

All flexible copper braids shall be made of flat, extra-flexible copper braid which has been tinned before weaving. Both ends shall be encased in a seamless copper ferrule drilled in accordance with NEMA Standard or equivalent. Ferrules shall be formed under high pressure ensuring dependable contact.

EW-12.3.3.6 Accessories for Shield Wire

<u>Suspension Ground Wire Materials</u>

The hardware for the overhead ground wire shall consist of a free-center suspension clamp, a link, a U-clevis and preformed armor rods as shown in the attached drawings for this specification.

The characteristics of the clamp for suspension ground wire assemblies shall be as indicated in the Technical Data Sheets.

Tension Ground Wire Materials

The tension assembly for the overhead ground wire shall consist of a tension device and a jumper clamp as shown in the attached drawing for this specification.

The tension assembly shall consist of a wedge type tension clamp, a link and two U-clevises as shown in the attached drawing for this specification.

The characteristics of the clamp for the tension assembly shall be as stated in the Technical Data Sheets.

The jumper clamp, if used, for the tension ground wire assembly shall be used for fastening the jumper of ground wire at the tower top and shall have the same material properties as the tension clamp. The characteristics of the jumper clamp shall be as stated in the Technical Data Sheets.

Wedge Pressure Clamp for Ground Wire

The wedge pressure clamp, where required, shall be used for connecting the jumper wires of ground wires.

The wedge clamp shall be suitable for the type of ground wire to be used.

The slip strength of the clamp after connecting the wires must not be less than 15 percent of the ultimate breaking strength of the wires being connected.

Corrosion Inhibitor

When so specified in the Technical Data Sheets, the overhead ground wire shall be protected by a high melting point (e.g. dropping point of approximately 380^{0}F), neutral, organic inhibitor.

EW-12.3.3.7 Steel Structure Grounding

Every steel structure that carries insulators or apparatuses shall be connected to the earthing grid.

All substation metal parts such as structures, equipment, cable trays, fence, etc. except the disconnecting switch operating platform shall be connected to the ground grid by suitable ground connections specified in the Technical Data Sheets.

Steel structures with more than one leg should have two legs connected to the grid, with one riser to each leg. Those legs which have a great spacing between them shall be chosen. In case of steel structures (for example gantries) are covering more than one bay, each leg of those structures have to be earthed by separate riser at two different points

If there is any possibility for a conductor to fall down on a steel structure, this structure must be connected to the grid with a connection able to sustain the earth fault current.

EW-12.3.3.8 Equipment Earthing

Transformer/Reactor Earthing

An earthing grid of sufficient size, defined by grounding calculations and consisting of tinned, annealed hard drawn copper conductor with a maximum mesh size of 3 x 3 m shall be installed in the transformer foundation.

Power transformer/reactor tanks shall be earthed at two points diagonally opposite each other. These connections shall be made from two different points of the earthing grid.

Transformer/reactor earthing neutrals shall be earthed to two different points of the earthing grid. The transformer earthing strip shall be $\geq$ 100 mm^2 in copper.

Circuit Breaker

Circuit breakers shall be earthed by two connections at diagonal corners of the breaker supporting structures. These connections must be from separate points of the earthing grid. One $\geq$ 100 mm^2 connection strip shall be extended to the breaker operating mechanism.

Disconnect/Earthing Switches

Connections between any type of earthing device, e.g. earthing switch, and risers from the earthing grid shall be made through a copper wire connected between the earth contact of the earthing device and a riser. This wire should be properly clamped to the steel structure at both ends and laid in close contact to the steel works along the way.

The housing of isolator and earthing switch operating mechanism shall be earthed at a point as near to the operating handle as possible. Earthing strips of a size $\geq$ 100 mm^2 shall connect the base of each switch from two separate points of the earthing grid. Each earthing b;lade shall be connected to the earthing cable with flexible braid.

To give increased protection to operators, an earthing mat shall be laid beneath the operator's place. This mat should consist of 35 mm^2 copper wire laid down in a spiral of about 1 m diameter with about 0.2 m distance between wires, and with one end connected to the operating mechanism. The mat shall be buried at a depth of about 0.5 m (or to be laid out above the normal earthing grid).

If the three earthing device in one group are mounted on the same structure, then an extra copper wire shall be connected to the shortest way between the three devices.

Lightning Arrester

Lightning arresters shall be connected to the earthing grid with one $\geq$ 100 mm^2 PVC insulated copper connection. For 500 kV arrester, connection to the earthing grid shall be made from two (2) separate points in its supporting structure.

Power Cables

The lead sheath or armor (shield) of a three-core MV power cables shall be earthed by connecting a flexible braid to the shield. This shall be done at both ends of each cable.

The copper wire shield of single-core MV power cables shall be earthed by connecting a flexible braid to the shield. This shall be done at both ends of each cable, if the cable is longer than 700 m, else arresters have to be installed.

Cable end boxes shall be earthed with copper cable connection on one of the mounting bolts.

Instrument Transformer

Voltage and current transformers shall have their metal cases earthed by one $\geq$ 100 mm^2 copper connection to the earthing grid. The earthed leg of voltage transformers shall be connected with $\geq$ 100 mm^2 copper wire to the earthing system. Secondary connections of voltage and current transformers can be earthed by 16 mm^2 copper solid wire connected to one centrally located $\geq$ 100 mm^2 copper connection.

Overhead Ground Wire

The transmission line overhead ground wires shall be connected to the exposed base of the supporting structure and the station earth grid with one PVC insulated $\geq$ 100 mm^2 tin annealed copper cable.

Transmission Line Tower Earthing

Transmission line towers located inside the station yard shall be connected to the station earthing grid.

Lighting Poles

Poles for lighting shall be connected to the earthing grid via a 35 mm^2 tin annealed copper conductor with one connection for each item.

Other Metal Structures

Other types of metal structures within the substation area, not mentioned hitherto, shall be connected to the earthing grid by copper ground conductor $\geq$35 mm^2 with one connection for each item. The only exception is radio antennas, the earthing of which follows other principles not stated herein.

Each metal-enclosed HV or MV equipment or compartment shall feature the connection of a readily installed short circuit device or special earthing bolts or screws allowing for application of earthing clips of approved design with flexible cables to be clamped into phase conductors by means of insulated earthing poles for subsequent earthing.

High voltage equipment shall be equipped with at least two terminal bolt M 16 in diameter or suitable grounding pads of adequate size to accommodate at least two fixing screws for proper connection to the earthing system.

EW-12.3.3.9 Control Building Earthing

For potential equalizing of the building, an earthing grid of suitable corrosion protected copper conductor $\geq$ 100 mm^2 shall be cast into the surface concrete of all floors (see Tender Drawings). The connection points shall be exothermic welding. The mesh size shall not be greater than 3 x 3 m. Suitable connection points shall be brought out of the concrete to allow connection to the main earthing grid and to all parts of the equipment and building to be earthed. The part of these connecting points which protrudes from the concrete shall be tinned. The earthing grids of the different levels shall be connected at 8 to 10 m. on the periphery distributed locations.

At least two potential equalizing bars in all electrical rooms shall be provided. The potential equalizing bar shall be of 50 x 50 mm tinned copper bar protected by stainless steel cover.

To ensure that reinforcement grid is made electrical continuous, a sufficient number of connection points shall be brought out of the concrete. Together with the detailed civil engineering drawings, the earthing design is to be checked before releasing for construction.

The connections to these parts should be of soft drawn tinned copper of adequate cross section of at least 70 mm^2. Further similar connection points shall be installed at a number of places for the connection of portable earthing equipment when working in the station. All iron parts of the building and the reinforcement shall be connected to this common earthing installation.

Generally, each electrical device inside the control building must be equipped with an earthing screw of sufficient diameter for connection to the earthing system. The same applies to all metallic parts such as panels, metal windows, doors, etc. are effectively connected by earth conductors.

Control panels and desks, switchboards, etc. consisting of several individual sections or compartments shall each be connected to a common tinned copper earth bar unless all panels are solidly welded together, or other approved means are applied ensuring solid earthing connections. In such a case, provisions for earthing must be made at one end at least.

EW-12.3.3.10 Fence Earthing

Steel fences around the switchyard or station can be connected to a separate earthing system outside the fence at every second fence pole and at all corners and gate posts.

For earthing of the fence and of the gate, the original optional solution in respect of touch and step voltages shall be designed by the Supplier/Contractor to be approved by the Purchaser.

In case of separate fence earthing, the ground cable shall encircle the outside of the fence at a depth of 50 cm depending on the soil quality and at a distance of about 50 – 80 cm from the fence. Earthing rods have to be connected wherever necessary to meet the requirements in respect of the earthing resistance.

EW-12.3.3.11 Pipe Earthing

All piping shall be earthed at all service points in an approved manner.

EW-12.3.3.12 Cable Tray Earthing

Cable trays and ladders shall be connected to the earthing system at every ten (10) meters interval.

EW-12.3.3.13 Ground Rods

Ground rods required in the switchyard shall be determined by the Contractor. However, the following minimum requirement for ground rods must be met:

a. Near each ground lead from surge arresters.
b. Near each transformer or reactor neutral (if any) ground lead.
c. Every 5 meters along the grid square which enclose a power transformer and reactor, if any.
d. Every 30 meters along the fence.
e. Ground rods shall be driven to a depth such that the top of each rod is at the same elevation as the ground grid and shall be bonded to the ground grid conductors by suitable exothermic connections.

EW-12.3.4 Grounding Equipment

To meet the safety regulations before any maintenance or repair works are started on the EHV/HV/LV power equipment, the disconnected "live" parts of the equipment shall be grounded by means of permanent grounding switches and/or portable or mobile grounding sets. The portable or mobile grounding sets (Substation Grounding Sets) shall be supplied by the Contractor and included in the cost for grounding system. The current-carrying components of the grounding set shall have a fault current rating (magnitude and duration) as specified in the Technical Data Sheets.

These devices shall consist of, but not limited to those listed in the Technical Data Sheets.

In addition, guides permanently mounted to disconnect switch structures for use with portable grounding rods shall be provided.

EW-12.3.5 Other Technical Requirements for the Grounding System

Other features for the grounding system if required by the NPC are stated in the Technical Data Sheets.

EW-12.4 INSTALLATION

Installation will be by Contractor, unless otherwise specified in Section B.1.0 of the Technical Data Sheets.

When the installation is by Contractor, such as for turnkey contracts complete details of proper handling, transport and storage, installation, testing, performance guarantees, etc. shall be provided for NPC's review and approval.

EW-12.5 TESTS

EW-12.5.1 General

The Contractor shall carry out at his own expense all tests necessary to ensure the satisfactory design and manufacture of all grounding equipment and materials in accordance with ASTM or equivalent IEC Standard.

EW-12.5.2 Design Tests

Cables, hardwares and materials shall be subjected to the design (or type) tests in accordance with applicable ASTM or equivalent IEC standards. Even though NPC or his representatives performs or witnesses the required tests and the cables, hardwares and materials meet the acceptance criteria, Contractor shall not be relieved of the responsibility of providing cables, hardwares and materials conforming to all the requirements of the specification.

EW-12.5.3 Quality Conformance and Routine Test

These tests are intended to eliminate defective materials and fittings. They are to be made on all materials and fittings of the type to which they are applicable, per applicable standards and/or per Contractor's quality assurance methods if accepted by NPC.

<u>Overhead Ground Wire</u>

The tests shall be performed in accordance with ASTM A363, A474 and B416 and shall include, but not limited to the following:

a. Construction check

b. Tensile strength tests

c. Weight of coating

d. Elongation

e. Weight of conductor

Grounding Cables

The tests shall be performed in accordance with ASTM B3 and ASTM B8 and shall include, but not limited to the following:

a. Tensile strength tests

b. Elongation tests

c. Conductor resistivity tests
d. Dimension measurement

e. Surface finish inspection

f. Weight of conductor

For Miscellaneous Hardwares

The test shall be performed in accordance with ASTM B153 and the manufacturer standard. The routine tests shall be performed by selecting the samples from each lot of equipment. The number of samples required for the tests shall be: all for 1-3 sets; 3 for 4-30 sets; and 10% for over 30 sets.

a. General inspection
b. Measurement of dimensions
c. Tensile tests:
   No. of samples required: 1 for 20-50 sets; 2 for 51-100 sets; and 3 for over 100 sets
d. Galvanizing tests

Grounding Materials

Quality conformance tests are required to verify the quality of materials and workmanship. They are to be made on fittings taken on random from the various lots offered for acceptance.

EW-12.6 DATA AND DOCUMENTATION REQUIREMENTS

EW-12.6.1 General

Contractor furnished data and information shall be the performance data, predicted performance interface requirements and construction features of all Contractor's furnished equipment and materials. The accuracy of such information and its compatibility with overall performance requirements specified by NPC are the sole responsibility of the Contractor.

All information submitted as part of Proposal Data will become part of contract data for successful bidder. Any deviation from such data requires NPC's approval.

EW-12.6.2 Data and Information to be Submitted During Post Qualification

Contractor shall furnish during post qualification the filled-in Section B.12.0 of the Technical Data Sheets.

EW-12.6.3 Data and Information to be Submitted After Award of Contract

The following shall be submitted by the Contractor as a minimum for NPC's review and approval:

a. Brochures and catalogues to support the filled-in Technical Data Sheets and to allow NPC to evaluate the equipment /materials being offered;

b. Results of soil characteristics investigations;

c. Computer based design of the grounding system;

d. Computer based calculation of the grounding system resistance, grid potential rise and step/touch voltages (IEEE Std. 80) based on Contractor's soil resistivity measurements;

e. Computer based step and touch potential contour drawing of each floor;

f. Computer based layout of substation grounding system;

g. Rating of the conductors and grid layout;

h. Lightning protection system detail design drawings and calculations;

i. Detail lists of grounding materials necessary for the whole switchyard/substation and other related structures;

j. Descriptive material brochures, drawings, instructions and other reference material for the specified grounding materials;

k. Detailed outline drawings of all grounding materials;

l. ISO 9001 Certification of the proposed manufacturer;

m. Detailed QA Program based on ISO 9001 and/or 9002; and

n. As-built drawings as finally approved.

The Contractor shall furnish in the manner, number of copies and within the time set forth in the Contract, instruction manuals in accordance with Section GW-2.9 of the General Works.

EW-13.0 AC & DC STATION AUXILIARY SWITCHBOARD

EW-13.1 SCOPE

EW-13.1.1 General

This specification covers the technical and associated requirements for AC and DC Auxiliary Switchboards for use in electric power switchyard and substations.

It is not NPC's intent to specify all technical requirements nor to set forth those requirements adequately covered by applicable codes and standards. The Contractor shall furnish high quality metal-clad switchgear and accessories meeting the requirements of these specification and industry standards.

The Contractor shall bear full responsibility that the equipment has been designed and fabricated in accordance with all codes, standards, and applicable governmental regulations and performs under the conditions and to the standards specified herein.

No departure shall be made from these specification and standards unless waived or modified in writing by NPC. The Contractor shall obtain from its subcontractors a statement as to compliance with this specification without exception and/or if there are any exceptions, these shall be described in detail and included in Contractor's proposal. The Contractor shall add a statement that no other exemptions are taken to this specification.

EW-13.1.2 Works to be Provided by the Contractor

The Contractor shall provide the equipment, accessories and services delineated in Section B.1.0 of the Technical Data Sheets.

EW-13.1.3 Works to be Provided by NPC

NPC shall provide the materials (if any) and services listed in Section B.1.0 of the Technical Data Sheets.

EW-13.2 CODES AND STANDARDS

EW-13.2.1 General

The AC and DC auxiliary system shall be in accordance with, but not limited to, the latest issues of the following codes and standards, including all addenda, in effect at time of NPC order unless otherwise stated in this specification:

ANSI/IEEE	**American National Standards Institute and/or Institute of Electrical & Electronic Engineers**
C37.20	Switchgear Assemblies, Including Metal Enclosed Bus, Including Supplement C37.02c
C2	National Electrical Safety Code

C37.51	Dry Type Distribution Transformers, 500kVA and Smaller
C57.12.91	Test Code for Dry-Type Distribution and Power Transformers
C62.41	Guide for Surge Voltages in Low Voltage AC Power
C62.45	Guide on Surge Testing for Equipment Connected to Low Voltage AC Power
IEC	**International Electro-Technical Commission**
60144(529)	Degree of Protection of enclosure for L. V. Switchgear
60057	L. V. Switchgear and control gear
60439	Factory Built Assemblies of L. V. Switchgear
60664	Insulation Coordination within Low Voltage System
60686(478)	Stabilized Power Supplies with AC (DC) output
60715	Dimension of L. V. Switchgear
60726	Dry Type Transformers
ISO	**International Standards Organization**
9001	Quality System Model for Quality Assurance in Design/Development, Manufacture and Testing
9002	Quality System Model for Quality Assurance in Production, Installation & Servicing
NEMA	**National Electrical Manufacturers Association**
AB1	Molded Case Circuit Breakers and Switches
PB1	Panelboards
KS1	Enclosed Switches
FU1	Low Voltage Cartridge Fuses
ST20	Dry Type Transformers for General Application
Publ 250	Enclosure for Electrical Equipment (1000 volts maximum)
NEC	**National Electrical Code**
SSPC	**Steel Structure Painting Council**
SP1	Solvent Cleaning
SP3	Power Tools Cleaning
PA1	Shop, Field and Maintenance Painting
PA2	Measurement of Dry Paint Thickness with Magnetic Gages
UL	**Underwriters Laboratories, Inc. (all parts apply)**
44	Rubber-Insulated Wires and Cables
PEC	**Philippine Electrical Code**

These codes and standards set forth the minimum requirements which may be exceeded by the Contractor, if, in Contractor's judgment and with NPC's acceptance, superior or more economical designs or materials are available for successful and continuous operation of Contractor's equipment as required by this specification.

EW-13.3 TECHNICAL REQUIREMENTS

EW-13.3.1 Description of Services

The auxiliary switchboards covered by this specification is for use generally in substation or switchyard. The equipment will be intended to supply the required station auxiliary service of a substation or switchyard. The application details are in Technical Data Sheets.

All materials and parts which are not specifically mentioned herein but are necessary for the proper erection, assembly and safe operation of the auxiliary switchboards shall be identified and furnished by the Contractor and included in the price for the auxiliary switchboard.

EW-13.3.2 Design Requirements

The equipment shall be designed to perform in accordance with the standards and as specified herein, when operating under the environmental and operating conditions given in the Section B.1.0 of the Technical Data Sheets.

In all respects, equipment shall incorporate the highest quality of modern engineering, design and workmanship. It is not the intent to specify all details of design and construction; therefore, equipment shall be fabricated and equipped with accessories in accordance with Contractor's standard practices when such practices do not conflict with this specification.

The auxiliary switchboard shall be supplied complete with all equipment, instruments, meters, indicators, control switches or push-buttons, annunciators, indicating lamps, terminal blocks, wiring and miscellaneous devices as called for by this specification, or indicated in the Bid drawings.

EW-13.3.3 AC Auxiliary System

EW-13.3.3.1 General

The low voltage AC system shall consist of a star-connected, solidly earthed, four wire system designed for power and a star-connected system for lighting and other essential loads.

The station auxiliary system shall be designed to fulfill the following requirements:

- with loss of the entire AC auxiliary power system, automatically controlled shut-down of the converters shall take place. Immediately after recovery of the auxiliary power supply, start-up of the converters shall be possible.

The low voltage AC system shall compose any of the following sources as required in the Technical Data Sheets:

a. 460V, 60 Hz, 3-phase, 4-wire for power supply

b. 230V, 60 Hz, 3-phase and/or 1-phase (depending on the requirement), 4-wire and/or 2-wire for lighting, outlets, etc.

c. 120V, 60 Hz, 1-phase, 2-wire

Where there are two or more incoming feeders connected to the main board, these shall be connected to an automatic change-over device with circuit breakers. Simultaneous feeding from more than one source is not permitted. The automatic change-over device shall be fed from the DC system for power and control. The main board shall be equipped with transient voltage surge suppressors.

EW-13.3.3.2 Power Source

The source of the power supply for the AC auxiliary system shall be as stated in the Technical Data Sheets. It can be taken from: (depending on the requirement or as stated in the Technical Data Sheets)

a. An auxiliary station service transformer connected to the tertiary or secondary voltage terminal of the main transformer; or

b. From two auxiliary station service transformers connected to the tertiary or secondary voltage terminals of the two main transformer; or

c. A combination of an auxiliary station service transformer and a stand-by diesel generator set.

EW-13.3.3.3 AC Distribution

If required in the Technical Data Sheets and/or drawings, distribution to the different equipment and installations shall be performed via sub-distribution boards connected to the main board. The connections between main board and sub-distribution boards shall be made by cables running along trench or conduits.

The distribution boards shall be installed outdoor or indoor as required in the drawings or in the Technical Data Sheets.

The basic principle design for the AC power supply shall be as indicated in the Bid Drawings.

EW-13.3.3.4 Automatic Change-Over Device (If required)

General

The auxiliary power supply is of great importance and must remain in duty as long as possible. If required in the Technical Data Sheets and/or in Bid Drawings, this automatic device will make sure that a voltage is always available. At loss of voltage, the automatic device will change-over to another supply. The change-over shall be indicated on the alarm panel.

There must be a time delay in the change-over operation between the two supplies. Connections between the two supply systems shall be prevented by an interlocking system.

The secondary circuit breakers of the two main power supplies feeding the main 460volt switchboard shall have selector switch with two positions:

Position 1: off duty
Position 2: automatic

Any tripping from sub-distribution protection as well as a manual trip, shall block the automatic change-over system. The blocking shall be indicated visually.

Automatic and manual interlocking scheme shall be provided between the two main circuit breakers to prevent parallel operation of the two main circuit breakers.

Voltage Measuring

A three-phase voltage relay, which measures each phase independently, shall be furnished. The voltage level has to be 80-85% of the rated voltage in order to prevent a false indication caused by remaining voltage at lost phase. Provisions shall be made such that actuation of the voltage relay will automatically transfer all the bus loads with faulty power source to the other power source.

In case of voltage dip beneath 70% of the rated voltage, the motors in operation on distribution board connected on a faulty power source shall be switched-off automatically. If the voltage recovers in a preset time variable between 0.5-3 sec as a result of change-over device activation or restoration of normal power supply, the motor starters (contactors) will be switched-on automatically again in pre-selected time steps so that the starting current drawn by the starting motors does not cause a voltage drop more than 20% on the motor terminals.

There shall be a time delay (1-10 sec) of voltage indication to prevent the change-over device from working at auto-reclosure.

If measuring relays are placed in a control cubicle, they must be connected via voltage transformers.

Measuring points are:

- Before breaker on secondary side of transformer
- On busbars

Supervision

Trip and close circuit supervision shall be implemented. Fault signals shall lead to an alternative power supply and block further operations of a faulty unit.

Fault signals shall be connected to the alarm system.

Provision shall be made such that the monitoring and supervision of the AC auxiliary system can be made through the microprocessor-based substation control system (MBSC), if required in the Technical Data Sheets.

EW-13.3.4 DC Auxiliary System

EW-13.3.4.1 General

The function of the DC Auxiliary System is to supply auxiliary and operating power to control equipment and to DC dependent devices. The DC power is normally supplied from the AC system across rectifier/charger, but if the AC supply is lost, the batteries take over the power supply without interruption.

The DC system shall compose any of the following sources as required in the Technical Data Sheets:

a. 125 VDC system
b. 48 VDC system (if needed)
c. 24 VDC system (if needed)

EW-13.3.4.2 System Design

The fundamental demand on a DC system is that, it must be robust, simple and clearly arranged.

The batteries and rectifiers shall be dimensioned to supply the substation with direct current both present and future additional requirements.

The battery distribution boards shall be furnished with equipment necessary for the future stage.

The DC system design shall be based on the following principles:

- High selectivity
- Main distribution located adjacent to the battery room
- No common main automatic circuit breaker for the battery
- An installation which is free from the risk of short circuit between the battery and the main distribution board.

The DC system shall be earthed across a high-resistance resistor, so that simple earth faults will not cause tripping of the system.

The DC system shall be designed to allow unloading tests, boost charging and maintenance of each battery to be carried out during normal operation.

This implies that provision shall be made for isolating the battery and the associated rectifier from the load.

EW-13.3.4.3 Battery Connection

The first automatic circuit breaker seen from the battery shall be located as close as possible to the battery and shall be contained in separate enclosures for the positive and negative poles, respectively. The enclosure shall be made of insulating materials.

The connections between the battery system and the automatic circuit breakers shall be laid in such a way that they are protected from physical damage.

Each battery system is connected through its own battery distribution board to the main boards, and every battery system shall have its own supervisory equipment to indicate and alarm for the maximum and minimum voltage levels on float charging and earth fault.

EW-13.3.4.4 Connection of the Charging Equipment

The charging rectifier shall be connected as close as possible to the battery and shall be sized for charging the battery plus the base loads including future base loads. Every permanently installed battery system shall have its own rectifier/charger.

The charging rectifiers shall be controlled by the battery terminal voltage and not by the rectifier output voltage. The control voltage shall, therefore, be obtained at the battery via separate automatic circuit breakers and control cables.

EW-13.3.4.5 Short Circuit Protection

The DC system shall be provided with short circuit protection. These shall provide absolute and safe selectivity, so that tripping is confined to a minimum.

Only circuit breakers shall be used and shall consist of the series 5-15-20-30-50-60-100A, etc. two steps between every circuit breakers shall be of the UL listed type or equivalent and shall be used for protection of all feeders.

EW-13.3.4.6 Batteries

Technical Requirements

The requirements shall be as stated in the Technical Specifications and Technical Data Sheets.

EW-13.3.4.7 Charger/Rectifier

Technical Requirements

The requirements shall be as stated in the Technical Specifications and Technical Data Sheets.

EW-13.3.4.8 Supervision

Trip and close supervision shall be implemented. Fault signals shall lead to an alternative power supply and block further operations of a faulty unit.

Fault signals shall be connected to the alarm system.

Provision shall be made such that the monitoring and supervision of the DC auxiliary system can be made through the microprocessor-based substation control system (MBSC), if required in the Technical Data Sheets.

EW-13.3.5 AC and DC Panelboards

EW-13.3.5.1 General

The station auxiliary switchboard (both AC and DC) shall be supplied complete with all instruments, meters, indicators, control switches, push buttons, indicating lamps, terminal blocks, wire-in glands and other miscellaneous devices as called for by this specification or indicated in the bid drawings. All boards shall have circuit breakers instead of fuses to protect outgoing cables in feeders from short circuit and overcurrent. The continuous and short-time/short-circuit rating of the AC/DC panel shall be designed in accordance with the specified transformer rating and the expected short circuit rating.

The station auxiliary board shall include required auxiliary and accessory devices such as auxiliary current and potential transformer, phase shifters, auxiliary relays, resistors, etc. whether or not expressly called for or indicated on the bid drawings. All instrument scales, relay coils, contacts and other features shall be suitable for the apparatus controlled or for the purpose intended.

A large number of cables will be brought in through the bottom of the auxiliary switchboard and adequate provisions shall be made to accommodately support and terminate these cables on the terminal blocks. Appropriate cable fixing and sealing glands shall be provided.

The station auxiliary switchboard shall be designed and wired with relays and devices adequate to supply auxiliary power not only the equipment supplied under this contract but also the future equipment shown in the single line diagram or in the substation layout.

The boards shall have Cu busbars for phases, neutral (N) and protective earth (PE). The neutral busbar shall also have full insulation against earth and shall be connected to earth with one link in the board only. The earth busbar shall preferably be located near the outgoing cable terminals.

All boards except battery boards shall be connected to the main earth wire system by a separate earth conductor.

The battery distribution boards shall be made of insulating material and shall be designed for complete pole separation with positive and negative circuit breakers in separated cubicles. Mounting plates shall be of plastic-covered steel. The battery distribution boards shall not be earthed and the shields of the cables entering the battery distribution boards shall, therefore, insulated.

The Contractor shall ensure that all equipment will allow sufficient room for operation, maintenance, future additions and possible future replacement of defective components. In all boards, there shall be at least 25% spare terminals for power auxiliary circuits.

EW-13.3.5.2 Panel Construction

The main distribution boards and sub-distribution boards shall be of the factory-built assembly (FBA) low voltage switchgear type, modularized, free-standing and totally enclosed and to conform to the protection class specified in the Technical Data Sheets.

The main distribution board shall be constructed out of folded or pressed steel panels of not less than 3 mm thickness with edges bent to 6 mm radius, securely fixed to structural members and suitable for bolting to each other and to the floor through sheet steel channels. The panel shall comprise modules for withdrawable, removable and/or fixed group of modules. In the same cubicle or panel, withdrawable, removable and/or fixed group of modules can be mixed.

The sub-distribution boards shall be made of smooth sheet steel panels with angle or channel frame and with edges bent to 6.0 mm radius, seam-welded at corners and ground smooth. The panels shall be bolted at the bottom to suitable steel channel sills to be furnished as part of this supply. Suitable grouting and anchor bolt holes shall be provided in the channel sills. Butt joints on outside surfaces shall not be permitted.

Outside panels shall not be drilled or welded for attaching wires, resistors or other devices where such holes or fastening will be visible from the front of the panel. All screws and bolts used for assembling members and panels and for mounting wire cleats and devices shall be provided with lock washers or other locking devices. Vertical edges of panels shall be formed and bolted together in such a manner that no part of edge are exposed to view.

The panels shall not deviate more than 1.6 mm from the true plane. To prevent warping of panels, all heavy devices shall be adequately supported by means of rear mounted brackets or straps.

The panels, trim, doors and frames shall match and shall present a neat appearance when assembled. Electrical clearance shall be provided without cutting away the adjacent steel framework. Vents and louvers shall be provided, where required, to give adequate ventilation. All ventilation openings and all opening in the floor shall be provided with screens to prevent entrance of insects and rodents.

Thermostically controlled heaters with switches both for indoor and outdoor switchboards shall be furnished suitable to a voltage source specified in the Technical Data Sheets.

Each assembled indoor panelboard shall be anchored to floor embedded channel members. Each assembled outdoor panelboard shall be anchored to a concrete foundation or shall have a steel supporting structure.

Power cables shall enter both indoor and outdoor panel boards from below and shall be connected directly to the buses or circuit breakers.

Unit structural steel members, buses, bus supports, etc. shall not obstruct bus and circuit breaker cable termination.

The dimensions of the single panel shall be manufacturer's standard but in no case shall exceed the height of 2200 mm.

The main lugs of the panelboards shall be capable of accepting the size of two cables with size ranging from 14 mm^2 to 150 mm^2.

Polyvinyl chloride, asbestos or hydroscopic insulation shall not be used in any equipment or component, porcelain or glass polyester insulation shall be used or NPC approved equal.

Bolts and associated hardware shall be of non-magnetic and corrosion-resistant material.

Application of insulating tapes shall be avoided whenever possible, the Contractor shall inform NPC of any areas where insulating tape is required.

EW-13.3.5.3 Buses and Bus Supports

All buses shall be copper with sufficient ampacity for the intended service. AC and DC main buses and AC neutral buses shall have minimum ampacities as shown in the bid drawings or as stated in the Technical Data Sheets.

All buses shall be adequately braced to withstand the stresses created by fault currents and in the event of an internal (arcing) fault on a load circuit, that circuit shall be the only one damaged. Buses shall be arranged to provide consecutive alternate phasing of branch circuit connection.

Each bus shall be provided with a clamp type pressure connector capable of accepting stranded copper conductor of the size shown on the accompanying drawings or as indicated in the Technical Data Sheets.

Sufficient binding head screw or pressure type neutral bus terminals shall be furnished to accommodate each circuit neutral lead.

Each AC neutral bus shall have a clamp type pressure connector suitable for accepting a stranded copper ground cable specified in the Technical Data Sheets. This connection point shall be identified by a grounding symbol.

Buses, including neutral buses, shall be fastened securely to insulated bus supports and shall not be supported by the circuit breakers.

Bus supports shall be high dielectric strength, low moisture absorption, high impact strength, and low surface capacitance molded compound.

EW-13.3.5.4 Grounding

A 25 mm wide x 6 mm thick bare copper ground bus bolted solidly to the panelboard structure shall be provided at the bottom of both the outdoor and the indoor panelboard for grounding control and power cable shields and the secondary circuits of current and voltage transformers.

Each ground bus shall have sufficient 4 mm drilled and tapped holes to accommodate all required ground bus connections. The holes shall be spaced on 20 mm center-lines minimum. A 10 mm long binding head screw or screw with bronze spring washer shall be provided in each hole. A maximum of two connections shall be made to each ground bus terminal.

A clamp type pressure connector suitable for accepting a stranded copper grounding cable specified in the Technical Data Sheets shall be provided at one end of each ground bus. Each connection point shall be identified with a protective grounding symbol.

Each control and power cable shield shall be connected to the ground bus via a 6 mm^2 wire soldered to the shield and having a crimp type ring tongue terminal for the ground bus connection.

EW-13.3.5.5 Nameplates

A unit identification nameplate shall be furnished at the top front of each panelboard. An identification nameplate shall be provided for each device including circuit breakers and fuse blocks (if required). Each circuit breaker nameplate shall be mounted adjacent to the associated circuit breaker. Where applicable, nameplates shall be provided for control and power circuit identification.

All nameplates shall be black satin finish with white core engraved to show white lettering. Nameplate engraving shall be in accordance with the nameplate designations shown on the accompanying drawings.

The Contractor shall submit to NPC for approval his nameplate engraving lists and a sample nameplate showing the proposed style of engraving.

All nameplates shall be attached with non-corroding screws.

EW-13.3.5.6 Terminal Blocks

Terminal blocks for terminating incoming leads shall be molded type with insulating barriers, binding head screw type terminals and removable white circuit designation marker strip, and shall be rated 600V.

Each terminal block shall be capable of accepting 2.5 sq. mm. to 10 sq. mm. wire sizes. A minimum of 10% spare terminal block points shall be provided.

One spare blank white circuit designation marker strip shall be furnished for each terminal block.

EW-13.3.5.7 Wiring

All wiring shall conform to applicable National Electric Safety Code and NEMA Standards. Wire shall conform to the requirements of applicable ANSI and ICEA (IPCEA) standards and shall be stranded, tinned copper, flame retardant, high temperature insulated.

All control wiring shall be flexible switchboard type, except hinge wire which shall be extra-flexible class K stranding and shall be 4 sq. mm. minimum within insulation rated 600V minimum.

Ring tongue crimp type terminals shall be used for all device and terminal block wire connections.

No wire splices shall be permitted.
All wiring shall be neatly run and securely fixed in such a manner that wherever possible, wiring can be easily checked against diagram.

All power circuits, control and protection wiring and low level signal wiring shall be physically separated. Separate laying-way shall be provided for power cables, and the working voltage of each power circuit shall be marked on the associated boards.

Connections for indicating instruments shall use individually shielded wire pairs. One (1) extra terminal per pair of terminals shall be provided to connect this shield to ground.

Each wire shall be identified at each end with a slip-on sleeve bearing a distinctive, permanent, printed wire designation. Adhesive label type wiring markers are unacceptable. Wire marker sleeve designations shall be unaffected by heat, solvents or steam. The Contractor shall furnish approximately 20% spare blank wire marker sleeves.

The distinct wire designation for each wire terminated on a terminal block point shall be engraved, machine-lettered, or stamped or neatly marked with permanent ink on the terminal block removable marker strip.

A wire designation shall not change until the wire continuity is interrupted by a device element such as a contact, coil or resistor.

The distinct designation assigned to each wire shall be shown on both the schematic and wiring diagrams.

EW-13.3.5.8 Panelboard Devices

Circuit Breakers

The main circuit breakers for the station service transformer secondaries shall be as stated in the Technical Data Sheets. It shall be provided with mechanical and electrical interlock if required in the drawings or stated in the Technical Data Sheets and enough number of auxiliary switches for alarm and indication.

480 V circuit breakers with a rating of 800 A and above shall be of the air break type, spring storage device powered by a 125 VDC motor, suitable for hand operation and provided with an appropriate tripping mechanism to be actuated by the protective relays.

Circuit breakers with a rating below 800A shall be of the molded case type and shall have poles, voltage, current, interrupting and frame size ratings and wire terminal lug sizes as shown on the accompanying drawings.

AC three phase and single phase circuit breakers shall be rated 600 V, 60 Hz. DC circuit breakers shall be rated 250 VDC.

Each circuit breaker shall have a thermal-magnetic trip element per pole. The instantaneous magnetic trip element shall operate at approximately 8 to 10 times the current rating of the circuit breaker. Trip elements shall be adjustable type for the 460 V main circuit breakers. The rest of the breakers shall be equipped with non-interchangeable trip units and non-adjustable thermal trip.

Where applicable, circuit breaker derating factors shall be applied to compensate for factors such as ambient temperature, altitude, frequency, duty cycle and enclosure loading.

The circuit breakers shall be installed so as to permit the removal and re-installation or replacement of an individual circuit breaker without requiring the removal of any other circuit breaker or the disconnection of main or branch circuit connectors.

Instrument Transformers

Current transformers shall be single phase, cast resin encapsulated and shall have an insulation class of 1000 V and shall be arranged as shown on the bid drawings. The current transformers shall have ANSI metering accuracy and burden of at least 0.3B0.5. The primary current ratings are as shown on the bid drawings or indicated in the Technical Data Sheets with the secondary current rated at 5A or 1A.

Voltage transformers shall have an insulation class of 1000 V and shall be arranged as shown on the bid drawings. The voltage transformers shall be suitable for 480 VAC, 3-phase, 60 Hz, 4-wire application and 230 VAC, single-phase, 60 Hz, two-wire application. The voltage transformer shall have 115 VAC secondary voltage both suitable for metering and relaying applications. Non-removable cartridge type fuses shall be provided for the primaries and secondaries of the potential transformers. All primary fuses shall be of the current limiting, high interrupting capacity type.

Current transformers shall be able to withstand the mechanical forces consistent with the interrupting rating of the feeder breakers and shall have a 1-sec thermal rating equal to or exceeding the interrupting rating of the feeder breakers. The temperature rise shall be limited to 30^0C over 55^0C ambient.

Indicating Instruments

Indicating instruments shall be back connected, dustproof, switchboard type in dull black finish case for semi-flush mounting on steel panels. The instruments shall have tropical treatment, as required, for use in a tropical climate.

Indicating instruments shall not be larger than 96 mm square with a minimum 90^0 sector scale.

Indicating instrument error shall not exceed ± 1% of full scale range.

Indicating instrument scale plates shall have a permanent white finish with black graduations, numerals and legends. Scale ranges and other details shall be as shown on the accompanying drawings.

DC ammeters shall be furnished complete with shunts and calibrated shunt leads or adjustable lead compensators.

Kilowatthour Demand Meters

Kilowatthour demand meters shall be transformer-connected, polyphase, 3-phase, 4-wire, 60Hz, three-element type with primary reading cyclometer type register having a minimum of 5-digits, with reverse-running stop, and with 30-minute integrating period maximum demand indicator.

The kilowatthour demand meters shall be furnished in dull black finish back-connected, dustproof, switchboard type cases for semi-flush mounting and with tropical treatment, as required, for use in a tropical climate.

Lighting Contactors

Lighting contactors, as required, shall be furnished and installed in the panelboards to satisfy the lighting circuit contact requirements shown on the accompanying drawings.

Each contactor contact shall have a continuous current rating not less than the associated panelboard circuit breaker trip rating and shall be capable of interrupting incandescent, fluorescent or high pressure sodium vapor lamp current of the same magnitude.

Undervoltage Relays

Undervoltage relays for low or loss of voltage shall be furnished and installed in the panelboards where shown on the accompanying drawings.

Each relay shall have a minimum of two electrically separate normally closed alarm contacts wired to terminal block points for remote alarm and sequence of events recorder indication. The relay contacts shall have a minimum continuous current rating of 10 amperes.

The relay shall have the electrical characteristics mentioned in the Technical Data Sheets.

EW-13.3.5.9 Transient Voltage Suppression System

General

The Contractor shall also furnish a transient voltage suppression system (TVSS) as indicated in the drawings for the station auxiliary switchboard system to provide protection against voltage surges and spikes common to low voltage circuits.

Materials and Construction

The circuit configuration of the suppression unit shall be thermal stress reducing, custom parallel, solid state.

The panel suppression unit shall be housed in minimum NEMA 12, 13 enclosure. The suppression circuit shall be totally encapsulated in a thermally conductive chemical compound to enhance transient energy dissipation.

Each complete suppression unit shall be Underwriters Laboratories UL (listed) or equivalent, as a transient voltage surge suppressor per UL 1449, 1987 or equivalent. Each unit shall bear the suppressed voltage rating for all protected modes, i.e., L-L, L-N, L-G.

The design of each model shall be tested in all modes to demonstrate the capability to withstand 1,000 sequential, category B3/C1, 6 kV/3 kA, 8 x 20 us impulses as described in ANSI/IEEE C62.41-1991. The interval between impulses shall not exceed 30 seconds. Other aspects of the tests shall be in accordance with ANSI/IEEE C62.45-1987. The resultant peak let-through voltage of the last impulse shall not vary from the first impulse by more than + 10% or –20%.

No suppression unit shall be supplied that require scheduled preventive maintenance or replacement parts for at least a period of ten (10) years. Suppression unit shall be maintenance free for a period of at least 15-years after its installation.

The suppressor shall conform in performance and design as described in the Technical Data Sheets.

EW-13.3.5.10 Sub-Distribution Transformer

General

A sub-distribution transformer of the type and rating as listed in the Technical Data Sheets shall be supplied, if required, to cater to the single and three phase 230 VAC requirements of the substation. The transformer shall be furnished in accordance with the codes and standards, including all addenda as specified in Section EW-13.2.

<u>Overload Requirement</u>

The short-time overload rating and operation shall be in accordance with applicable ANSI or IEC Standard. The overload capability of any auxiliary equipment shall not be less than the transformer overload rating. If other considerations will limit the overload capability of the transformer, the Contractor shall specify these limitations in his proposal.

<u>Short Circuit Capability</u>

The transformer, including its accessories, shall be capable of withstanding the specified short circuit requirements without mechanical deformation or impairing the electrical capabilities.

The thermal and mechanical capability of the transformer and its accessories shall meet or exceed the requirements listed in ANSI C57.12, Section 7 or IEC 60076.

<u>Audible Sound Level</u>

The average sound level of the transformer shall not exceed the values as specified in the ratings and features when measured in accordance with the conditions outlined in the latest ANSI/IEEE C57.12.90.

EW-13.3.6 Other Technical Requirements for the Auxiliary Switchboard

Other features for the station auxiliary switchboard, if required by the NPC are stated in the Technical Data Sheets.

EW-13.4 INSTALLATION

Installation will be by Contractor unless specified otherwise in Section B.1.0 of the Technical Data Sheets.

When the installation is by Contractor, such as for turnkey contracts complete details of proper handling, transport and storage, installation, testing, commissioning, performance, guarantees, etc. shall be provided for NPC's review and approval.

EW-13.5 FACTORY ASSEMBLY AND TESTS

EW-13.5.1 General

The auxiliary switchboard shall be completely assembled and adjusted at the factory and given the manufacturer's routine shop tests and also other test as specified herein. All parts shall be properly marked for ease of assembly in the field. All routine and quality conformance tests required herein shall be witnessed by the NPC or his authorized representative unless waived in writing, and no equipment shall be shipped until released for shipment by the NPC or his authorized representative.

The test equipment, test methods, measurements and computations shall be in accordance with the latest applicable requirements of ANSI and IEC Standard except in cases where otherwise set forth, and shall be subject to the approval of the NPC.

EW-13.5.2 Shop Tests

Routine, design, quality conformance tests and other tests necessary shall be performed in accordance with ANSI Standard or equivalent IEC Standard.

The Contractor shall make all preparation for tests and provide the test apparatus and personnel and shall notify the NPC the date of the test forty-five (45) days in advance.

The tests noted below shall be performed and maybe witnessed by the NPC or his authorized representative on the equipment covered by the specification at the manufacturer's plant before shipment:

a. For the Station Auxiliary Switchboard:

1. Complete Ringout of All Wiring

   A complete point to point ringout of all wiring against the latest wiring diagram shall be made to ensure that the assembly has been wired in accordance with its wiring diagram and further to ensure that the wiring diagram for any assembly is in accurate representation of that assembly.

2. Check of All Meters and Instruments

   The calibration and internal connection of all meters and instruments are assumed to have been made in the normal production process. However, to establish that the connections between the associated incoming blocks and these instruments and meters are correct it is required that three-phases voltage and current be applied at the terminal blocks with the proper phase angle relationship to check the direction of rotation.

3. Complete Functional Test

   This test is intended to completely check the functional operation of the equipment. The test shall be a check of all the tripping, closing, auxiliary circuits, interlocking, etc., for each panel or unit.

4. 1000 Volts Megger Test

   Each circuit or bus shall be given an individual 1000V megger test with a minimum permissible reading of 6 megohms.

5. Mechanical Inspections

   This shall be a physical inspection of the equipment as a whole to ensure that all components are mechanically sound and that there are no imperfections. Also attention should be given to establishing that all special requirements of the specification have been met.

b. For the Sub-distribution Transformer:

   1. Winding Resistance
   2. Ratio
   3. Polarity
   4. Phase relation
   5. Impedance
   6. Applied Potential
   7. Induced Potential

EW-13.5.3 Type Tests

For all standard equipment, the Contractor shall submit five (5) certified copies of the results of type tests on each type of equipment to be supplied to show the adequacy of its design.

EW-13.5.4 Test Failures

If any equipment fails to pass any test, it shall be repaired, with defective parts replaced, and the equipment shall then be re-tested without additional cost to the NPC and without extension of time.

EW-13.6 DATA AND DOCUMENTATION REQUIREMENTS

EW-13.6.1 General

Contractor-furnished data and information shall be the guaranteed performance data, predicted performance, interface requirements and construction features of all Contractor's furnished equipment. The accuracy of such information and its compatibility with overall performance requirements specified by NPC are the sole responsibility of the Contractor.

All information submitted as part of Proposal Data will become part of contract data for successful bidder.

EW-13.6.2 Data and Information to be Submitted During Post Qualification

Contractor shall furnish during post qualification the filled-in Section B.13.0 of the Technical Data Sheets.

EW-13.6.3 Data and Information to be Submitted After Award of Contract

The following items shall be submitted by the Contractor after award of contract:

a. Brochures and catalogues to support the filled-in Technical Data Sheets and to allow NPC to evaluate the equipment /materials being offered;

b. Outline drawings of AC and DC Boards and accessories showing all critical dimensions and weights, including the following:

    1. Overall dimensions;
    2. Mounting dimensions including location and size of anchor bolt holes, including base drilling plan;
    3. Plans, elevation and sectional views;
    4. Details of AC and DC panelboards;
    5. Control and power cable entrance openings at each panelboard;
    6. Details of main terminals and grounding connections;
    7. Internal equipment layout;

c. Certified test reports, if specified in the Technical Data Sheets;

d. Specifications and brochures of each of the component of the control and instrumentation panel;

e. Detailed material list contained in each panel;

f. Detailed functional diagram, schematic diagram, panel wiring diagram, terminal block diagram and cabling layout including interlocking scheme for both AC and DC boards;

g. General assembly and erection/installation drawings and procedures;

h. Complete design calculations;

i. Detailed test procedures to be followed after installation of the panel and Field Tests Reports duly signed and witnessed by NPC's representative(s);

j. Instruction, maintenance and operation manuals;

k. ISO 9001 Certification of the proposed manufacturer;

l. Detailed QA Program based on ISO 9001; and

m. As-built drawings as approved.

The Contractor shall furnish in the manner, number of copies, and within the time as set forth in the contract, instruction manuals in accordance with Section GW-2.9 of the General Works.

EW-14.0 STORAGE BATTERIES

EW-14.1 SCOPE

EW-14.1.1 General

This specification covers the technical and associated requirements for a storage battery or storage batteries for use in electric power generating stations, switchyard and substations.

It is not NPC's intent to specify all technical requirements nor to set forth those requirements adequately covered by applicable codes and standards. Contractor shall furnish a high quality storage battery or batteries meeting the requirements of these specification and industry standards.

The Contractor shall bear the full responsibility that the equipment has been designed and fabricated in accordance with all codes, standards, and applicable governmental regulations and performs under the conditions and to the standards specified herein.

No departure shall be made from these specification and standards unless waived or modified in writing by NPC. The Contractor shall obtain from its subcontractors a statement as to compliance with this specification without exception and/or if there are any exceptions, these shall be described in detail and included in Contractor's proposal. The Contractor shall add a statement that no other exceptions are taken to this specification.

EW-14.1.2 Works to be Provided by the Contractor

The Contractor shall provide the equipment, accessories and services delineated in Section B.1.0 of the Technical Data Sheets.

EW-14.1.3 Works to be Provided by NPC

NPC shall provide the materials (if any) and services listed in Section B.1.0 of the Technical Data Sheets.

EW-14.2 CODES AND STANDARDS

EW-14.2.1 General

The equipment furnished shall be in accordance with, but not limited to, the latest issues of the following codes and standards, including all addenda, in effect at time of purchase order unless otherwise stated in this specification:

ANSI/IEEE	**American National Standards Institute and/or Institute of Electrical & Electronic Engineers**
C18.1	Specification for Dry Cells and Batteries
Z55.1	Gray Finishes for Industrial Apparatus and Equipment (NO. 61 Light Gray and No. 24 Dark Gray)

450	Recommended Practice for Maintenance, Testing and Replacement of Large Lead Storage Batteries for Generating Stations and Substations
484	Recommended Practice for Installation Design and Installation of Large Lead Storage Batteries for Generating Stations and Substations
485	Recommended Practice for Sizing Large Lead Storage Batteries for Generating Stations and Substations
IEC	**International Electrotechnical Commission (all parts of listed Standards apply)**
60896	Stationary Lead Acid Batteries, General Requirements and methods of Test
ISO	**International Standards Organization**
9001	Quality System Model for Quality Assurance in Design/Development, Manufacture and Testing
9002	Quality System Model for Quality Assurance in Production, Installation and Servicing
NEMA	**National Electrical Manufacturer's Association**
IB 1	Definitions for Lead Acid Storage Batteries
NEPA	**National Fire Protection Association**
70	National Electrical Code - Article No. 480
UL	**Underwriters Laboratories Incorporated**
486A	Wire Connectors and Soldering Lugs for Use with Copper Conductors
UBC	Uniform Building Code of the International Conference of Building Officials, Section 2312 - Earthquake Regulations

These codes and standards set forth minimum requirements which may be exceeded by Contractor if, in Contractor's judgment and with NPC's acceptance, superior or more economic design or materials are available for successful and continuous operation of Contractor's equipment as required by this specification.

EW-14.3 TECHNICAL REQUIREMENTS

EW-14.3.1 Description of Services

The storage batteries covered by this specification will be used to supply dc power under continuous and emergency conditions for the dc power system listed in the Technical Data Sheets. The batteries shall be complete in all respects and shall be furnished with all required accessories.

All materials and parts which are not specifically mentioned herein but are necessary for proper erection, assembly and safe operation of the battery system shall be identified and furnished by the Contractor and included in the price for the battery system.

EW-14.3.2 Design Requirements

Service conditions under which each battery shall operate satisfactorily and deliver the specified capacity are listed in Technical Data Sheets.

The Contractor shall furnish batteries as described in the Technical Data Sheets. The batteries shall comply with Article 480 of NEPA 70.

The batteries are required to supply power in case of emergency, the various substation equipment and auxiliaries as shown in the bid drawings. The batteries must have sufficient AH capacity to supply power to these equipment including future extensions and/or additions to the substations at an hour discharge rate described in the Technical Data Sheets.

The batteries shall be fully charged and stabilized at the open circuit voltage just prior to the commencement of the duty cycle.

Each battery shall perform in accordance with the requirements of its respective duty cycle at any time including the end of its service life. In this context, end of service life is defined as the time at which the battery capacity is 80% of Contractor's initial rating.

De-rating factors for the specified service conditions shall be applied in addition to the aforementioned requirements.

The nominal system voltage for each battery is provided in the Technical Data Sheets. Each battery is for use in an ungrounded system unless otherwise noted in the Technical Data Sheets.

EW-14.3.3 Design and Construction Features

The cell jars shall be of transparent impact-resistant heavy duty polypropylene (PP) material to allow check of electrolyte level through the cell wall.

High and low electrolyte level lines shall be permanently marked on all four sides of cell and/or multicell units.

Sediment space shall be adequate to permit unimpaired operation of the battery despite material accumulation throughout its guaranteed life. Cell design shall accommodate plate growth such that jar will not crack.

Cells shall be vented. The vent plugs shall form a tight seal within the vent opening and prevent electrolytic creepage or dust and foreign matter entrance. The vent plug shall be the explosion resistant type.

Plates shall be supported so that no undue stress is placed on the jar or cover during the life of the battery. Supports shall be bottom supports. Negative and positive plates shall be matched. The life of the negative plate shall be equal to or greater than that of the positive plate. The plates shall be reinforced as needed to retain their shape and shall have the necessary conducting material to maintain low internal resistance to carry the current to or from all parts of the plate under all operating conditions. Separators shall be impervious to the chemical action within the cell. They shall provide proper spacing and insulation between the plates and permit free circulation of electrolyte.

The battery whether wet or dry charged shall be furnished complete with electrolyte. The specific gravity of the electrolyte in the lead-acid batteries at 25degree shall be as specified in the Technical Data Sheets.

The Contractor shall furnish connectors for connecting the cells and tiers of the battery. The connectors and bolts shall be designed for a temperature rise not exceeding 30degree above a rated ambient of 40 degrees when conducting a sustained one hour current equal to the battery one-hour discharge rate and continuous current equal to the battery discharge rate described in the Technical Data Sheets.

All current-carrying parts, such as terminal bolts, links and connections shall be adequately protected to a degree of protection of at least IP20 (IEC 60529 or equivalent ANSI/IEEE Standard) to prevent personnel from coming into contact with the battery system. However, provision shall be made for measuring the cell voltages without removing such protection.

The voltage drop of all connectors in series shall be not be more than one volt while carrying the one-hour discharge current.

Connectors shall meet the requirements of UL 486A.

Intercell connectors shall provide a sufficient spacing between cells for periodic cleaning of cell sidewalls to eliminate traces of acid spillage, etc. The inter-tier connections shall be properly insulated and the arrangement shall be subject to NPC's review.

The terminal cells shall be provided with connectors (essentially, terminal plates, and terminal lugs) for copper cables as specified in the Technical Data Sheets for the Storage Battery. Appropriate size of terminal lugs for the power cable and ground cable for battery rack shall be provided by the Contractor. Sample of terminal lugs shall be furnished for approval by the NPC.

Solid copper connectors, terminal plates, and terminal lugs shall be lead plated for lead-acid batteries.

To allow easy monitoring of the battery cells electrolyte, the Contractor shall furnish staggered design battery racks made of corrosion resistant steel, properly insulated and painted. They shall consist of no more than two (2) steps or as specified in the Technical Data Sheets. The staggered racks shall be complete with all necessary steel frames, fittings, rails and braces, plastic insulating channels, plastic spacers and hardwares. The paint shall resist the corrosive effects of the battery electrolyte. The racks shall be designed to permit the mounting of the batteries as easy as possible. The design shall also consider the easy maintenance of the batteries.

Each rack shall have a grounding pad and a lead plated terminal lug suitable for ground cable specified in the Technical Data Sheets.

If rack are shipped knocked down, all parts shall be numbered or match-marked to facilitate field assembly.

EW-14.3.4 Accessories

The Contractor shall furnish and ship with each battery system any and all accessories which are essential for proper installation, operation and maintenance. The accessories shall include, but are not limited to the following:

a. Vent-plug-mounted hydrometer syringe
b. Portable hydrometer syringe
c. Vent-plug-mounted thermometer
d. Battery cell voltmeter with shunt load resistor (2 percent accuracy with +/-3 volt scale)
e. Goggles
f. Plastic face shield
g. Acid proof gloves
h. Apron
i. Overshoes
j. A quantity of bicarbonate of soda

Contractor shall furnish, as part of the whole supply for the battery system, <u>a wall mounted storage cabinet for the accessories</u>

EW-14.3.5 Other Technical Requirements for the Battery System

Other technical features for the battery system, if required by the NPC are stated in the Technical Data Sheets.

EW-14.4 INSTALLATION

Installation will be by Contractor unless specified otherwise in Section B.1.0 of the Technical Data Sheets.

When the installation is by the Contractor, such as for turnkey contracts, complete details of proper handling, transport and storage, installation, testing, commissioning, performances guarantees, etc. shall be furnished for NPC's review and approval.

EW-14.5 TESTS

EW-14.5.1 Material Tests

All materials shall comply with test criteria, and NPC acceptance of the equipment shall not relieve Contractor of his responsibility for meeting all the requirements of this specification. The Contractor shall carry out at his own expense all tests necessary to ensure the satisfactory design and manufacture of storage battery in accordance with ANSI/IEEE or IEC equivalent.

EW-14.5.2 Shop Test

The weight of each positive and negative plate shall be measured before assembly. The tolerance shall not exceed ± 1.0 percent.

Contractor shall designate the permanent pilot cell on the basis of the test results for each battery's permanent record. If the battery is shipped wet, it shall be the cell with the lowest specific gravity after the battery is installed but not yet charged. If the battery is shipped dry, it shall be the cell indicating the lowest voltage while on charge. In addition, approximately 10 percent of the battery's cells shall be selected at random as permanent sample cells.

The following production tests shall be performed for batteries to be shipped wet:

a. Cell voltage measurement. The tolerance shall not exceed ± 0.01 volts.

b. Electrolyte gravity measurement simultaneously with a. The tolerance shall not exceed ± 0.01.

c. Cell jar leakage test. The cell shall be pressurized with air and for one hour the pressure shall remain constant.

If the battery is shipped dry, the battery test shall be made at the factory. For this test, the Contractor shall produce 5 percent extra cells in the same production run as for the battery and perform the tests on the extra cells.

EW-14.6 DATA AND DOCUMENTATION REQUIREMENTS

EW-14.6.1 General

Contractor furnished data and information shall be the guaranteed performance data, predicted performance, interface requirements and construction features of all Contractor's furnished equipment. The accuracy of such information and its compatibility with overall performance requirements specified by NPC are the sole responsibility of the Contractor.

All information submitted as part of Proposal Data will become part of contract data for successful bidder. Any deviation from such data requires NPC's approval.

EW-14.6.2 Data and Information to be Submitted During Post Qualification

Contractor shall furnish during post qualification the filled-in Section B.14.0 of the Technical Data Sheets.

EW-14.6.3 Data and Information to be Submitted After Award of Contract

After award of the contract, the Contractor shall furnish drawings and data, in quality and quantity as specified herein and in purchase order, for NPC's review and acceptance as follows:

a. Brochures and catalogues to support the filled-in Technical Data Sheets and to allow NPC to evaluate the equipment /materials being offered;

b. Installation drawings showing batteries, interconnections, rack outline, dimensions required for mounting, weight of rack and filled cells, and description of rack finish for each battery system;

c. Cell outline including connector and battery terminal details, electrolyte levels, weight of assembled cell, separate weights of electrolyte, plates and jar;

d. Type, catalogue designation and description of major components furnished by Contractor;

e. Battery arrangement;

f. Complete design calculations;

g. Discharge graph for assumed pre-defined emergency case;

h. Length of time batteries can be stored if shipped dry charged and/or charged wet. Also, Contractor's storage recommendations.

i. Recommendations for tests after delivery including field tests and performance;

j. Instructions covering installation, operation and maintenance;

k. ISO 9001 Certification of the proposed manufacturer;

l. Detailed QA Program based on ISO 9001 or 9002 Certification; and

m. Final Drawings as approved.

The Contractor shall provide in the manner, number of copies, and within the time set forth in the purchase order, Instruction Manuals in accordance with Section GW-2.9 of the General Works.

EW-15.0 BATTERY CHARGER

EW-15.1 SCOPE

EW-15.1.1 General

This specification covers the technical and associated requirements for constant potential battery chargers for use in non-nuclear electric power generating stations, switchyard and substations.

It is not NPC's intent to specify all technical requirements nor to set forth those requirements adequately covered by applicable codes and standards. Contractor shall furnish a high quality battery charger meeting the requirements of these specification and industry standards.

The Contractor shall bear the full responsibility that the equipment has been designed and fabricated in accordance with all codes, standards, and applicable governmental regulations and performs under the conditions and to the standards specified herein.

No departure shall be made from these specification and standards unless waived or modified in writing by NPC. The Contractor shall obtain from its subcontractors a statement as to compliance with this specification without exception and/or if there are any exceptions, these shall be described in detail and included in Contractor's proposal. The Contractor shall add a statement that no other exceptions are taken to this specification.

EW-15.1.2 Work to be Provided by the Contractor

The Contractor shall provide the equipment, accessories and services delineated in Section B.1.0 of the Technical Data Sheets.

EW-15.1.3 Work to be Provided by NPC

NPC shall provide the materials (if any) and services listed in Section B.1.0 of the Technical Data Sheets.

EW-15.2 CODES AND STANDARDS

EW-15.2.1 General

The equipment furnished shall be in accordance with, but not limited to, the latest issues of the following codes and standards, including all addenda, in effect at time of purchase order unless otherwise stated in this specification:

ANSI/IEEE	**American National Standards Institute and/or Institute of Electrical & Electronic Engineers**
C2	National Electric Safety Codes
C34.2	Practices and Requirements for Semiconductor Power Rectifier
Z55.1	Gray Finishes for Industrial Apparatus and Equipment (No. 61 Light Gray and No. 24 Dark Gray)

AWS	**American Welding Society**
A2.4	Symbols for Welding and Non-Destructive Testing Including Brazing
IEC	**International Electrotechnical Commission (all parts of listed Standards apply)**
60255	Electrical Relays and Protection Equipment (All Parts)
ICBO	**International Conference of Building Officials**
UBC	Uniform Building Code, Section 2312, Earthquake Regulations
ISO	**International Standards Organization**
9001	Quality System Model for Quality Assurance in Design/ Development, Manufacture and Testing
9002	Quality System Model for Quality Assurance in Production, Installation and Servicing
NEMA	**National Electrical Manufacturer's Association**
ICS 6	Enclosures for Industrial Controls and Systems
PE 5	Constant Potential Type Electric Utility (Semi- conductor Static Converter) Battery Chargers
Pub'l. 250	Enclosure for Electric Equipment (1000 Volts Maximum)
SSPC	**Steel Structures Painting Council**
SP1	Solvent Cleaning
SP5	White Metal Blast Cleaning
SP6	Commercial Blast Cleaning
SP10	Near - White Blast Cleaning
PA1	Shop, Field and Maintenance Painting
PA2	Measurement of Dry Film Thickness with Magnetic Gauge
UL	**Underwriters Laboratories Incorporated**
44	Rubber Insulated Wires and Cables
PEC	**Philippine Electrical Code Part I & II**

These codes and standards set forth minimum requirements which may be exceeded by Contractor if, in Contractor's judgment and with NPC's acceptance, superior or more economic design or materials are available for successful and continuous operation of Contractor's equipment as required by this specification.

EW-15.3 TECHNICAL REQUIREMENTS

EW-15.3.1 Description of Services

The equipment covered by this specification will be used by an electric utility in a power plant, substation or switchyard for continuous battery floating, equalizing and recharging.

All materials and parts which are not specifically mentioned herein but are necessary for proper erection, assembly and safe operation of the battery charger shall be identified and furnished by the Contractor and included in the price for the battery charger.

EW-15.3.2 Design Requirements

Input to the battery charger shall be as described in the Technical Data Sheets. The Contractor is advised that the ac power system may be subjected to 200 percent voltage surges of microsecond order due to motor starting. Also ground faults on high resistance grounded systems may cause 260 percent voltage surges of milliseconds order. Finally, unfaulted phases may rise to line-to-line potential above ground for a time not exceeding seven days. The battery charger shall be designed to continue operation during these transient conditions. Output from the battery charger shall be as described in Technical Data Sheets.

The battery charger shall be of the automatically regulated type and shall be of the latest technology employing microprocessor based control system of plug-in modules, without use of electronic tubes.

Automatic regulation shall consist of maintaining constant current for equalizing charge and constant voltage for float conditions.

The battery charger shall be self-contained with all accessories as specified herein and as otherwise required to assure proper operation and protection.

The charger shall be switched to the equalizing mode by an adjustable equalizing timer. The timer shall be manually or automatically activated as specified in the Technical Data Sheets and shall automatically return the charger to the floating mode at the end of the pre-selected equalizing period.

The charger output voltage shall be continuously adjustable in the floating and equalizing mode of operation with ranges of adjustment as specified in the Technical Data Sheets.

The steady state floating and equalizing voltage deviation shall not exceed $\pm$ 0.5 percent at any load from no load to full load with ac input power source voltage and frequency variations as specified in the Technical Data Sheets.

The input transformer shall be provided with two 2.5 percent taps above and below the rated voltage.

The charger shall be provided with a current limiting means. The chargers shall be capable of delivering the current limit continuously without damage.

Chargers are for ungrounded (DC output) operation unless otherwise stated in the Technical Data Sheets.

The charger shall be provided with an automatic discharging and charging device.

The charger shall be provided with an electronic control and microprocessor board.

For substation where microprocessor based substation control (MBSC) system is required, the charger shall be provided with an interface board to allow all data available in the charger microprocessor to be transmitted to the MBSC system.

The charger shall be provided with earth-fault monitoring device and anti-condensation heater.

EW-15.3.3 Design and Construction Features

The charger shall be housed in a heavy duty, reinforced steel, freestanding cabinet which requires access only from the front unless otherwise stated in the Technical Data Sheets. It shall be provided with adequate ventilation and means of easy access to the interior. The degree of protection shall be at least IP 42 minimum if not specified in the Technical Data Sheets. Provisions shall be made to allow control and power cables to enter either from the top or bottom of the cabinet or as required in the Technical Data Sheets.

The charger/rectifier and its accessories and/or components shall be adaptable to the batteries with which they are associated.

All plug-in modules, power supply units, etc., shall be inspectable and removable from the front of the cabinet (hinged panel open) without requiring access to the rear of the cabinet.

Cooling shall be either by natural convection or by forced air cooling. Low velocity, permanently lubricated redundant fans and disposable filters shall be provided when forced air cooling system is used.

Relays, meters, switches, indicating lamps, etc., shall be clearly identified functionally by a black background and white multi-layer nameplate with rust-resistant steel, self-tapping screws. The inscription shall describe the function of the device and shall be subject to NPC's acceptance.

Instruments, adjustments and controls shall be operable from the front panel. Fuses, if used shall be accessible by opening front panels. Each instrument shall have one percent accuracy or better.

A copper ground bus, at least 6mm x25mm (¼ in. x 1 in.) shall be provided in the cabinet with compression type connector or type acceptable to NPC for connection of copper grounding cable specified in the Technical Data Sheets.

The same type of compression connectors shall be provided for termination of ac and dc cables described in the Technical Data Sheets.

Each unit shall be provided with suitable lifting devices (e.g., lifting eyebolts).

Pushbuttons, when furnished, shall be heavy-duty type, oil tight type recessed or provided with shroud ring. Control fuses shall be 250 V cartridge type or type accepted to NPC.

Indicating lights shall be extra-long-life lamps.

Means shall be provided for quick and convenient access, preferably by hinged door or panel, to protective devices and control circuit disconnecting devices furnished.

EW-15.3.4 Sound Control

The NPC will review the sound level of equipment covered by this specification with respect to the permissible exposure limits for personnel as defined in applicable codes and regulations. Accordingly, the sound level measured at a distance of 152.40 cm (5 ft.) from the outline of the equipment shall not exceed the allowable limit specified in the Technical Data Sheets.

If Contractor expects the maximum sound level of the equipment to exceed the specified allowable limit at a distance of 152.40 cm (5 ft), the Contractor shall use acoustical treatment features, subject to NPC's review and acceptance, to achieve the sound control design objectives.

If the expected maximum sound level of the equipment exceeds the specified requirements, the following sound level data (both attenuated and unattenuated) at equipment design point and for at least two other operating conditions shall be provided:

a. Maximum sound pressure level as would be measured under "free field" conditions at a distance of five (5) ft from the outerline of equipment shown in decibels, on the "A" scale, at the octave band center frequencies ranging from 31.5 to 8000 Hz.

b. Calculated maximum sound power level of the equipment shown in decibels at octave band center frequencies ranging from 31.5 to 8000 Hz and referred to base of 10^{-12} watts.

EW-15.3.5 Panel/Cubicle Wiring

All wiring shall conform to the requirements of applicable ANSI and ICEA (IPCEA) standards and shall be stranded, tinned copper, flame retardant, high temperature insulated.

All wires for a given circuit, or maximum of twelve wires, shall be in one bundle to facilitate tracing for trouble-shooting or removal for changes.

Wiring shall be free of abrasions and tool marks, including no nicks or fraying from stripping of insulation.

Wiring shall also:

a. Have a minimum bending radius of 6.25 mm (¼ in)

b. Have sufficient surrounding space to avoid jamming near terminal blocks, or between terminal blocks and wireways

c. Be adequately supported to prevent sagging and breakage caused by vibration or shock in transit.

All wires within a panel or unit shall be continuous, that is: no splicing is permitted.

Wire shall be of adequate rating for the current to be carried.

All circuits shall use nothing smaller than 2.0 mm^2 (No. 14 AWG wire). On other circuits where maximum current does not exceed 5 amperes, 1.25 mm^2 (No. 16 AWG) wire may be used.

Wire size and insulation selection shall conform with the following: no overheating of the conductor itself or insulation damage to adjacent conductor shall occur when wires associated with dc and ac control circuits carry 20,000 amperes and 10,000 amperes root-mean-square symmetrical respectively, for 0.025 second.

Where cables must be carried across hinges to devices mounted on doors, extra flexible, ICEA (Insulated Cable Engineers Association) Class D stranding conductors or equivalent IEC Standards shall be used.

The wire bundle shall be carried between a clamp on the door and on one fixed portion of the board or cabinet. These shall be adjacent to the hinge and shall be between 300 mm to 600 mm (12 to 24 inches) apart, with the door fully open.

Clamps elsewhere shall be spaced uniformly at a distance approximately no greater than 24 inches apart.

Terminal boards shall be provided for all controls, instruments, annunciators, meters and relays requiring external cable connections.

Contractor's wiring shall be terminated on terminal boards or equipment with insulation-gripping insulated wire terminal lugs.

The tongue portion of the terminal lugs shall be flanged-spade indented-spade or ring type.

Ratchet-type tools shall be used in attaching lugs to wires, to avoid loose connections due to insufficient pressure while crimping.

Box-clamp or saddle-clamp terminals are not acceptable because of possible damage to wire ends. Relays and other devices sometimes provided with saddle clamps shall be procured without such clamps, or the clamps shall be removed during panel assembly; ring-type lugs shall be used for panel wiring to these devices.

No solder or "push-on" or "quick" type terminals shall be used except:

a. Solder-type for pushbuttons, on indicating lights, when specified

b. Solder-type for plat resistors when specified

c. Push-on for indicating lights when specified

External connections will be via cable with 3.5 mm^2 (No. 12) or 1.25 mm^2 (No.16 AWG) stranded copper conductors, and lugs similar to those described above.

Terminals for external connections shall be arranged for consecutive connection of conductors within one cable. One external wire will be connected to each outgoing terminal point.

If accidental short circuiting of certain wires can result in malfunction of equipment, such as closing or tripping of a circuit breaker, these wires shall not be terminated on adjacent terminal block points.

Provision shall be made for conveniently testing the continuity of all control circuits in the field.

Wire markers shall be provided on both ends of each wire that is longer than 12 inches. The markers shall use indelible designations in accordance with Contractor's wiring diagrams.

Adequate space shall be provided on both sides of the terminal blocks, for connecting wires, and for wire markers. To allow for stripping and bending of incoming cables, terminal strips shall be located a minimum of 8 inches away from cable entrances at the top and/or bottom cabinets.

EW-15.3.6 Instrumentation and Controls

The chargers shall be equipped with the following protective and control devices:

a. Chargers shall be self-protected against high transient overvoltages in dc and ac control and power circuits. This protection shall be built into the equipment and no special external connections, configuration of leads or connections of any external equipment shall be required.

b. AC input thermal magnetic air circuit breaker (number of poles and interrupting capacity in accordance with system requirements).

c. DC output thermal magnetic air circuit breaker (2 poles having capacity to interrupt the associated DC system short circuit current at its terminals; and one auxiliary switch normally closed when the breaker is open for alarm).

d. Adjustable current limiting networks, which, in the event of heavy current demands on the chargers, shall limit the maximum output current to the maximum 2.5 hours force charge rate. For loads of less than maximum 2.5 hours force charge rate, the current limiting network shall have no effect upon the operation.

e. Protection against discharge of the battery into the battery chargers upon failure of the AC supply, with automatic resumption of preset charging rate when power is restored.

f. Loss of AC power relays (all three phases if a three-phase unit is specified).

g. Low DC voltage relay.

h. DC overvoltage relay.

i. Earth-fault monitoring

j. Any failure of the charger detected by any of these alarm or protective devices shall be indicated locally, either by LED's, relay targets or local annunciator and by a contact closure to a single element ("window") of remote annunciator. Where substation is controlled through MBSC, any failure and/or alarms shall be completely known or incorporated in the MBSC structure for the substation.

k. All alarm and protective relays contacts shall be rated 125 volts DC, 5-ampere make and carry and 1.1 ampere non-inductive interrupting duty (NEMA ICS 2 - 125 designation 600 minimum).

l. Forced air cooling system failure alarm shall be provided if such a cooling system is used.

The following devices shall be furnished and mounted on the instrument panel of the chargers:

a. MANUAL-AUTOMATIC change over switch

b. Required output and input meters and accessories

c. Required instrument/equipment for "equalizing charge" current setting, "float charge" voltage setting and to set the charger from "float charge" to "equalizing charge" for the required number of cells for the battery system both in "Manual" and "Automatic" position

d. an equalizing timer with a range of 0 to 24 hours. Timers specified as automatically activated upon restoration of AC supply voltage following the loss of AC input power.

e. serial interface port for connection with the MBSC of the substation, if substation control is by MBSC. The interface port to be provided shall be compatible with the required type of connection with the MBSC.

EW-15.3.7 Accessories

Contractor shall provide accessories as required for proper operation and maintenance of the equipment.

EW-15.3.8 Other Technical Requirements for the Charger/Rectifier

Other technical features for the battery charger/rectifier, if required by the NPC are stated in the Technical Data Sheets.

EW-15.4 INSTALLATION

Installation will be by Contractor as specified in Section B.1.0 of the Technical Data Sheets.

When the installation is by Contractor, such as for turnkey contracts, complete details of proper handling, transport and storage, installation, testing, commissioning, performances guarantees, etc. shall be furnished for NPC's review and approval.

EW-15.5 TESTS

EW-15.5.1 Material Tests

All materials shall comply with test criteria, and NPC acceptance of the equipment shall not relieve Contractor of his responsibility for meeting all the requirements of this specification. The Contractor shall carry out at his own expense all tests necessary to ensure the satisfactory design and manufacture of battery charger/rectifier in accordance with ANSI/IEEE or IEC equivalent.

EW-15.5.2 Shop Test

The charger shall be completely wired and at the factory and given standard factory inspection, wiring check, operation and dielectric tests to insure completeness, adequacy, and proper functioning of equipment in accordance with the requirements of this specification, standards and codes. Even though Contractor performs the required tests and the equipment meets the acceptance criteria, Contractor shall not be relieved of the responsibility of providing equipment conforming to all the requirements of the specification.

The control wiring shall be factory tested as follows:

a. Each circuit shall be given a continuity test.

b. Each circuit shall be given an insulation resistance test with equipment connected, using a 100volt megger. The insulation resistance shall not be less than 25 megaohms. (This test is not applicable to circuits containing semiconductors).

Assembled battery charger shall be tested in accordance with applicable standards.

Surge withstand test will be conducted using the appropriate sections of ANSI C37.90 or IEC 60255-22 as a guide.

EW-15.6 DATA AND DOCUMENTATION REQUIREMENTS

EW-15.6.1 General

Contractor furnished data and information shall be the guaranteed performance data, predicted performance, interface requirements and construction features of all Contractor's furnished equipment. The accuracy of such information and its compatibility with overall performance requirements specified by NPC are the sole responsibility of the Contractor.

All information submitted as part of Proposal Data will become part of contract data for successful bidder. Any deviation from such data requires NPC's approval.

EW-15.6.2 Data and Information to be Submitted During Post Qualification

Contractor shall furnish during post qualification the filled-in Section B.15.0 of the Technical Data Sheets.

EW-15.6.3 Data and Information to be Submitted After Award of Contract

After award of the contract, the Contractor shall furnish drawings and data, in quality and quantity as specified herein and in purchase order, for NPC's review and acceptance as follows:

a. Brochures and catalogues to support the filled-in Technical Data Sheets and to allow NPC to evaluate the equipment /materials being offered;

b. Outline drawings of Battery Charger and accessories showing all critical dimensions and weights, including the following:

    1. Overall dimensions;
    2. Mounting dimensions including location and size of anchor bolt holes, including base drilling plan;
    3. Plans, elevation and sectional views;
    4. Detail layout of cabinet with racks and modules;
    5. Control and power cable entrance openings at the cabinet;
    6. Details of main terminals and grounding connections;

c. Type, catalogue designation and description of major components furnished by Contractor;

d. Installation details and foundation requirements, loads, fastening details;

e. Detailed material list contained in the cabinet;

f. Terminal box and terminal blocks details and schematic diagram;

g. Detailed functional diagram, schematic diagram, panel wiring diagram, terminal block diagram and cabling layout;

h. Protection and alarm monitoring scheme;

i. General assembly and erection/installation drawings and procedures;

j. Complete design calculations;

k. Routine Tests Reports;

l. Field Tests to be performed and Field Test Reports duly signed and witnessed by NPC's representative(s);

m. List of codes used;

n. List of drawings and schedule of submittal;

o. Detailed QA Program based on ISO 9001;

p. Certified Field Test data;

q. Final Technical Data Sheets conforming to the specification;

r. Detailed Contract Schedule Activity for the equipment;

s. ISO 9001 Certification of the proposed manufacturer;

t. Complete instruction manuals for installation, maintenance and operation; and

u. As-built drawings as finally approved.

The Contractor shall provide in the manner, number of copies, and within the time set forth in the purchase order, Instruction Manuals in accordance with Section GW-2.9 of the General Works.

EW-16.0 STATION SERVICE TRANSFORMER

EW-16.1 SCOPE

EW-16.1.1 General

This specification covers the technical and associated requirements for the station service transformer and accessories for use in electric generating station, substation and/or switchyard. The requirements of the project are indicated in the Technical Data Sheets for Station Service Transformer and the equipment details are in the same section and volume of the Specification.

It is not NPC's intent to specify all technical requirements nor to set forth those requirements adequately covered by applicable codes and standards. Contractor shall furnish high quality station service transformers meeting the requirements of these specification and industry standards.

The Contractor shall bear full responsibility that the equipment has been designed and fabricated in accordance with all codes, standards, and applicable governmental regulations and performs under the conditions and to the standards specified herein.

No departure shall be made from these specification and standards unless waived or modified in writing by NPC. Contractor shall obtain from its subcontractors a statement as to the compliance with this specification without exception and/or if there are any exceptions, these shall be described in detail and included in the Contractor's proposal. Contractor shall add a statement that no other exceptions are taken to this specification.

EW-16.1.2 Work to be Provided by the Contractor

Contractor shall provide the equipment, accessories and services delineated in Section B.1.0 of the Technical Data Sheets.

EW-16.1.3 Work to be Provided by NPC

NPC will provide the materials (if any) and services listed in Section B.1.0 of the Technical Data Sheets.

EW-16.2 CODES AND STANDARDS

EW-16.2.1 General

The equipment furnished shall be in accordance with, but not limited to, the latest issues of the following applicable standards, including all addenda, in effect at time of purchase order unless otherwise stated in this specification. These shall include:

ANSI/IEEE **American National Standards Institute and/or Institute of Electrical & Electronic Engineers**

B1.1	Unified Inch Screw Threads (UN and UNR Thread Form)
B1.1.a	Metric Translation, Optional Supplement to Unified Screw Threads
B.2.1	Pipe Threads (Except Dryseal)
B16.1	Cast Iron Pipe Flanges and Flanges Fittings, Class 25, 125, 250 and 800
B.16.10	Face-to-Face and End-to-End Dimensions of Ferrous Valves
B57.1	Compressed Gas Cylinder Valve Outlet and Inlet Connections
C37.2	Transformer for switchgear assemblies
C57.12.00	General Requirements for Liquid-Immersed Distribution, Power and Regulating Transformer
C57.12.22	Standard Requirements for Pad-Mounted Compartmental Type, Self-cooled, Three-phase Distribution Transformer with High Voltage Bushing (High Voltage 34.5 kV and below; and 2500 kVA and smaller)
C57.12.50	Ventilated dry-type distribution transformers to 500 kVA single or three-phase and voltages to 34.5 kV on primary and 600 V on secondary
C57.19.00	Standard General Requirements and Test Procedure for Outdoor Power Apparatus Bushings
C57.19.01	Standard Performance Characteristics and Dimensions for Outdoor Apparatus Bushings
C57.19.101	Trial-Use Guide for Loading Power Apparatus Bushings
C57.12.70	Terminal Markings and Connections for Distribution and power transformers
C57.12.80	Terminology (IEC76), including Supplement C57.12.80a
C57.12.90	Test Code for Distribution, Power and Regulating Transformers, including Supplement C57.12.90a
C57.12.91	Test Code for Dry-Type Distribution, Power Transformer
C57.13	Standard Requirements for Instrument Transformers
C57.91	Guide for Loading Mineral-Oil Immersed Overhead and Pad-Mounted Distribution Transformers rated 500 kV and less with 55°C or 65°C average winding rise
C57.92	Guide for Loading Oil-Immersed Distribution and Station Service Transformers
C57.98	Guide for Transformer Impulse Tests
C57.106	Guide for Acceptance and Maintenance of Insulating Oil in Equipment
C57.109	Guide for Transformer Through-Fault-Current Duration
C57.110	Recommended Practice for Establishing Transformer Capability when Supplying Non-Sinusoidal Load Currents
C80.1	Specification for Rigid Steel Conduit, Zinc Coated
ASTM	**American Society for Testing and Materials**
A344	Electrical and Mechanical Properties of Magnetic Materials
A153	Zinc coating (hot dip) on iron and steel hardware
B432	Copper and Copper Alloy Clad Steel Plate
D3487	Specification for Mineral Insulating Oil Used in Electrical Apparatus
IEC	**International Electro-Technical Commission**

60044-1 & 2	Instrument Transformers
60071	Insulation Coordination
60076	Power Transformers, Parts 1-5
60060	High Voltage Test Technique
60137	Bushings for Alternating Voltages above 1000V
60214	On-Load Tap Charger
60270	Partial Discharge Measurements
60296	Specification for unused mineral insulating oil for transformer and switchgear
60354	Loading guide for oil-immersed power transformer
60551	Determination of Transformer and Reactor Sound Levels
60599	Interpretation of the analysis of gases in transformers and other oil-filled electrical equipment in service
60606	Application guide for Power Transformers
60616	Terminals and tapping markings for power transformers
60722	Guide to the lightning and switching impulse testing of power transformer and reactors
60726	Dry-type transformer
ISO	**International Standards Organization**
9001	Quality System Model for Quality Assurance in Design/Development, Manufacture and Testing
9002	Quality System Model for Quality Assurance in Production, Installation and Servicing
NEMA	**National Electrical Manufacturers Association**
107	Methods of Measurement of radio Influence Voltage of High-Voltage Apparatus
ST20	Dry-type transformers for general applications
SSPC	**Steel Structures Painting Council**
SP1	Solvent Cleaning
SP3	Power Tools Cleaning
PA1	Shop, Field and Maintenance Painting
PA2	Measurement of Dry Paint Thickness with Magnetic Gages
UL	**Underwriters Laboratories, Inc. (all parts apply)**
44	Rubber Insulated Wire and Cables

These codes and standards set forth the minimum requirements which may be exceeded by Contractor if, in Contractor's judgment and with NPC's acceptance, superior or more economical designs or materials are available for successful and continuous operation of Contractor's equipment as required by this specification.

EW-16.3 TECHNICAL REQUIREMENTS

EW-16.3.1 Description of Services

The station service transformer(s) covered by this specification is (are) for use in a generating station and/or a substation. The application details are in the Technical Data Sheets.

All materials and parts which are not specifically mentioned herein but are necessary for proper erection, assembly and safe operation of the station service transformer shall be identified and furnished by the Contractor and included in the price for the station service transformer.

EW-16.3.2 Design Requirements

EW-16.3.2.1 Ratings

Transformer rating, specified in Technical Data Sheets shall be the basis of the Contractor's guarantee of performance and temperature rise. The ratings indicated are based on actual load requirements at the service and operating conditions specified herein.

EW-16.3.2.2 Frequency

Frequency for operation shall be 60 Hertz.

EW-16.3.2.3 Overload Requirement

The overload rating and operation shall be in accordance with ANSI C57.92 or IEC 60354. The overload capability of any auxiliary equipment such as bushing, CT's, oil expansion tanks, leads, etc. shall not be less than the transformer overloading rating. If other considerations will limit the overload capability of the transformer, the Contractor shall specify these limitations in his proposal.

EW-16.3.2.4 Short Circuiting Capability

The transformer, including its accessories such as, but not limited to, bushings, current transformers, tap changers, etc., shall be capable of withstanding the specified short circuit requirements without mechanical deformation or impairing the electrical capabilities.

The thermal and mechanical capability of the transformer and its accessories shall meet or exceed the requirements listed in ANSI C57.12.00, Section 7 or IEC 60076 for liquid or oil-immersed transformer and ANSI C57.12.50 or IEC 60726 for dry-type transformers. The transformer shall be capable of withstanding external short circuits for at least three seconds after overload.

The transformer shall be so designed that the final winding temperature T_f reached at the end of the specified short circuit duration shall not exceed 250°C for copper and 200°C for aluminum conductors or another temperature stipulated by the Contractor without annealing the conductor, without causing insulation damage and gas generation from oil or solid insulation. It shall be assumed that prior to and after the short circuit, the transformer is loaded at its maximum nameplate rating and the ambient temperature is the specified maximum.

EW-16.3.2.5 Impedances

Impedance between winding will generally vary with changes of transformer turns ratio. Limitations on this change of impedance shall apply to all fully-rated taps on all main power windings, but not to autotransformers. These limitations are, in part, defined in terms of the tested impedance on the fully-rated tap nearest the middle of the fully-rated tap range. This impedance is called the mid-tap impedance.

EW-16.3.2.6 Audible Sound Level

The average sound level of the transformer shall not exceed the values as specified in the Technical Data Sheets when measured in accordance with the conditions outlined in the latest ANSI/IEEE C57.12.90 or IEC 60551 for oil-immersed transformers or ANSI/IEEE C57.12.91 or IEC 60726 for dry-type transformers.

EW-16.3.2.7 Tolerances

Tolerances for all data as gathered from tests, shall be as stated in the Technical Data Sheets.

EW-16.3.2.8 Bushings

All porcelains used in bushing shall be wet process, homogenous and free from cavities or other flaws. The glazing shall be uniform in color and free from blisters, burrs and other defects. All porcelain parts shall be one piece. The bushings of the same rating shall be interchangeable.

Bushings up to 110 kV BIL shall be porcelain bulk type whereas bushings above 110 kV BIL shall be condenser-type. In the latter case, the bushing shall be provided with capacitance test tap.

Should compound filled condenser type bushing be adopted, provisions shall be made to avoid compound entering the main tank during vacuum treatment. Bushings shall have the continuous current-carrying capacity necessary to carry the full 65°C rise current. The bushings shall also be capable of carrying overload currents as required by Section EW-16.3.2.3.

For pad mounted transformer, the high voltage terminations and equipment shall be dead front and shall conform to ANSI C57.12.26 requirements or equivalent IEC Standards.

The low voltage bushings shall be molded epoxy and provided with blade type spade terminals with NEMA standard hole spacing arranged for vertical take-off.

EW-16.3.2.9 External Clearances

External clearances between energized parts and ground, and spacing between adjacent phases shall be coordinated with the transformer internal insulation class.

EW-16.3.2.10 Oil (For Oil-Immersed Station Services Transformer)

This technical specification applies for the condition of transformer oil at delivery. The oil shall be of such a quality that it is, suitable as an insulant and coolant for transformers.

The oil shall be new and napthenic based mineral oil. It shall be free from moisture, acid alkali and sulfur compounds and shall not form a deposit at normal operating temperature.

Except for inhibitors, no additives are permitted.

The oil furnished shall be compatible with other oils meeting the requirements of ASTM D3487 and this specification. The oil shall be suitable for mixing with other insulating oils in any combination and the mixture shall still meet the required functional properties of this specification. Any reservation to this requirement shall be clearly stated by the Contractor in his proposal.

The oil shall accept 2, 6-ditertiary-butyl-paracresol (DBPC) as an oxidation inhibitor, added as necessary to bring inhibitor content of the oil to the required ASTM D3487, Type I or II value. The Contractor shall state if any other type of oxidation inhibitor is acceptable and if so, its advantages over DBPC.

The supply of insulating oil per transformer shall include a sufficient quantity to fill the tank and radiators up to the operating level plus an excess of 5%.

The power factor of the oil shall not exceed 0.05 percent at 25°C or 0.3 percent at 100°C, as determined by ASTM Test Method D924 (oil samples shall be taken in accordance with ASTM D923).

The oil flow pattern shall exclude turbulence and impinging of oil on any part of the solid insulation system.

Containers for oil shall also be designed that, with the indicated level for initial filling at 25°C, the oil will not fall below a safe operating level, nor rise to such a height as to overflow or leak. Design shall be for a standard top oil temperature range or greater, if required by the upper and lower limits of ambient temperature specified in Section B.1.0 of the Technical Data Sheets.

If the transformer oil will be delivered in containers or drums, these shall be approved by the NPC. The containers and/or drums shall be well-cleaned internally and shall otherwise be in such a condition that there is no risk of endangering the oil quality.

Before delivery, a test certificate shall be submitted to the NPC for approval. The test certificate shall contain result for tests carried out in order to confirm the oil's quality as specified.

EW-16.3.3 Design and Construction Features

EW-16.3.3.1 General

Depending on the requirement, the station service transformer can either be a liquid filled or oil filled transformer or dry type transformer of epoxy cast resin insulation.

All transformers of the same design and rating, furnished on a given order, shall be electrical duplicates, shall have mechanically interchangeable parts and shall be operable in parallel.

Construction of transformer shall provide for successful transportation so that on arrival at destination, transformer shall be in condition for immediate permanent operation after field installed accessories and coolant have been added, if required.

Transformer and accessory design, manufacture and assembly shall minimize vibration and shall prevent damage by inherent vibration and stress during operation, transportation and short circuits. If a flood level is specified in Section B.1.0 of the Technical Data Sheets, no device, control cabinet, fan, etc. should be located below the level.

The assembled transformer including its accessories shall withstand the wind forces specified in Section B.1.0 of the Technical Data Sheets.

Current carrying joints and splices shall be welded, brazed or made by compression fittings so that the contact resistance remains unchanged during the life of the transformer. Soldered connections shall not be used.

All leads not brought directly to bushing terminals or tap changers shall be brought to terminal boards, constructed over insulating material and substantially and rigidly supported inside of case.

All terminal boards of liquid filled transformer shall have live parts submerged under the liquid and so located that any reconnections can conveniently be made from handhole or manhole with removal of a minimum quantity of liquid. Where compliance with this requirement is impractical due to large clearance and creepage distance necessary with high voltages, the Contractor shall so state in his proposal. There shall be a minimum of detachable fittings and other parts which might come loose and lodge in transformer windings.

The core shall be grounded to the tank through a detachable connector and ground lead.

Jacking facilities shall be in accordance with ANSI C57.12.10 with the locations stated in Section EW-16.3.3.8.

EW-16.3.3.2 Cores

Cores for the transformer shall be constructed of the highest quality, non-aging high permeability grain oriented silicon steel. The steel shall be in thin lamination, annealed after cutting and rolled to insure smooth surface at the edges.

The laminations must be free from impurities and must receive stress relief treatment after punching. The lamination shall be accurately flattened, especially at the edges and insulated by suitable procedures with long-life heat resistant insulating coat

Both sides of each sheet shall be insulated with a durable heat resistant insulation. The core shall be held firmly by core clamp and braced to ensure adequate mechanical strength to support the winding and to withstand without damage or deformation, the forces caused by short circuit stresses, transportation or handling and to prevent shifting of the core laminations.

For oil-filled transformer, the core shall be solidly grounded to the tank while for the cast resin type, the core shall be earthed at one point only with a removable connection readily accessible from the outside through an appropriate window on the enclosure of the transformer.

The core shall be provided with approved lifting devices or lifting lugs at suitable points of the core assembly for core lifting.

EW-16.3.3.3 Winding (For Oil-Filled Transformers)

Winding for the transformer shall be of the best modern design conductor having constant cross-section and uniform insulation or graded insulation as required.

The design, construction, and treatment of windings shall give proper consideration to all service factors, such as high dielectric and mechanical strength of insulation, coil characteristics, uniform electrostatic flux distribution, prevention of corona formation and minimum restriction to free oil circulation.

Winding conductors shall be free from scale, burrs and splinters and shall be uniformly insulated. Permanent current-carrying joints for splices shall be welded or brazed, properly formed and finished, and insulated to conform to the basic insulation.

The completed winding assembly shall be securely held in place so that there will be no derangement or deformation by stresses incident to shipment.

The completed assembly of core and coils shall be vacuum dried, immediately impregnated and immersed in dry oil. They shall be adequately braced to withstand ocean shipment, short circuit forces and earthquakes with seismic coefficient specified in the Technical Data Sheets.

The windings shall be designed to permit practically no change or very small change in transformer impedance regardless of tap position.

EW-16.3.3.4 Windings (For Dry-Type or Epoxy Cast Resin Type Transformer)

Depending on the requirements mentioned in the Technical Data Sheets, the windings shall be made of copper or aluminum of high conductivity. To keep the inter-turn stresses to a minimum preferably foil-windings shall be provided.

The insulation material shall be based on an epoxy-resin powdered quartz mixture which makes the windings maintenance free, humidity resistant and tropicalized as well as fire-resistant and self-extinguishing. No toxic fumes or gases must be produced in the event of secondary fire or arcing.

The thermal class in accordance with IEC 60085 shall be **"B"** for the HV windings exceed 75 K for windings designed for thermal **class "B"** and is to be limited to 95 K for application of **class F** under consideration of the prevailing annual average ambient temperature.

The coils must be capable of withstanding movement and distortion caused by all overload operating conditions as specified. Adequate barriers shall be provided between windings and cores as well as between high voltage and low voltage windings. All leads or bars from the windings to the termination points shall be rigidly supported. Stresses on coils and connection must be avoided.

The windings shall be capable of withstanding thermal short circuits for the windings after overload. The temperature values shall be assumed with 120 °C for class B and with 140 °C for class F to be the initial temperatures before the short circuit. The maximum permissible value of the average temperature of the windings after short circuit shall not exceed 350 °C for copper windings and is to be limited to 200 °C for aluminum windings.

The temperature/expansion coefficient of the epoxy resin shall be compatible with that of the copper conductor and of all insulating materials within the coil under all operating conditions prevailing for the transformers.

The completed winding must be thermal shock proof even at the highest and at the lowest temperatures. It must have a smooth surface to prevent accumulation of dust, moisture, dirt and other foreign materials.

EW-16.3.3.5 Enclosures (For Dry-Type and Compartmental Type Oil-Filled Transformer)

The transformer, if required in the Technical Data Sheets shall be supplied with necessary enclosure of protection class specified in the Technical Data Sheets. To ensure the free movement of cooling air, the enclosure must be fitted with perforated sheet floor and top cover.

The enclosure must be fitted with removable rear panels and doors for the front panels for easy reconnections of HV-tappings and assembling of connecting cables. Cut-outs must be provided in the enclosure floors to bring cables through.

To ensure a satisfactory supply of cooling air, the base of the enclosure of the transformer must be 200 mm above the ground.

The top of both front and rear walls shall be provided with air louvers. Where side panels do not require the entrance of bus duct or cables, they shall be louvered. The louvers are especially designed with doubled-sided offset slots, thus preventing the insertion of foreign bodies.

All steel works for the enclosure shall be thoroughly cleaned by sand-blasting and bonerized or given similar and equal treatment after a welding is completed. The treatment shall be followed immediately with a rust resisting priming coat. Interior surfaces of enclosure shall be given a light gray or white finish coat and exterior surfaces of all panels of enclosure shall be given a finish coat of RAL 7032 or equivalent.

EW-16.3.3.6 Bushings

Each bushing rated below 2000 amperes shall be provided with single-tang flat-pad terminal. Terminals rated 600 amperes and below shall have two or four hole pads. All other shall have four hole pads drilled in accordance with NEMA CC-1. The width of two hole pads shall be a minimum of 50 mm (2 in). The minimum pad thickness shall be 6.25 mm (¼ in). Terminal construction shall permit rotation around the bushing stud to facilitate connection to the bus.

The terminal pads shall be of high conductivity bronze, copper or aluminum alloy and shall be plated with hot-flowed electro-silver or electro-tin to a thickness of not less than 0.0127 mm (0.005 in).

Whenever, a larger terminal pad is required for higher current rating, the mounting holes shall conform to NEMA Standards and details of the mounting holes shall be submitted for approval.

EW-16.3.3.7 Gaskets

Gaskets shall be unaffected by hot insulating oil, retain their resiliency during the life of the associated equipment, and be unaffected by weather while maintaining oil and gas tightness. Nitrile and cork-neoprene gaskets are acceptable, but gaskets of cork only neoprene only are not acceptable. Gasket flanges shall have grooves or metal stops to prevent over compression of gaskets. All bolted transformer tank or accessory opening shall be gasketed.

Hatches in the tank cover and sides, intended to be opened a number of times (e.g. connection and inspection hatches), shall have gaskets which can be reused after opening (rubber type, not glued).

EW-16.3.3.8 Tanks (For Oil-Filled Transformers)

Only hermetically sealed type of tanks shall be provided. All seams required in the fabrication of the main tank, including those for the cover, shall be welded. All joints, which may be opened from time to time in the course of operation, shall be designed to be oil-tight in reassembly.

The tank shall be capable of withstanding, without leakage or permanent distortion, an internal gas pressure of 1 kilogram per square centimeter (measured at the top of the tank) and vacuum of 76 cm of mercury and shall be designed and constructed for vacuum filling in the field.

All valves, fittings and pipings shall be designed and constructed for such vacuum filling.

The upper side of the tank shall be designed in such a way as to avoid water deposits on top of the tank.

The tank shall be provided with the fabricated or structural steel base designed and built to allow skidding or moving on wheels or rollers. The wheels or rollers, if required in the Technical Data Sheets can be turned at right angle, thereby eliminating the need for a traverser for turning the transformer.

The jacking pads provided for the transformer tank shall be located at least 300 mm above the service level with the open space in front of the attaching plates or pads at least one meter above the service level.

EW-16.3.3.9 Radiators and Coolers (If required)

Self-cooled or forced-cooled transformers shall preferably be equipped with removable radiators or coolers for heat radiation. Clearances shall permit painting and maintenance of tank, tubes, and radiators. Radiators and coolers shall be designed to withstand the same pressure and vacuum as the main tank.

Removable radiators and coolers shall be fastened to transformer case with bolted flange connections. Butterfly valves, or other suitable devices shall be provided to permit the ready installation and removal of radiators, and drainage of oil from radiators without drawing oil from the transformer tank. Radiators and coolers shall be equipped with lifting eyes, and so designed that they may be handled without the addition of special bracing. Cooler units shall be of corrosion resistant metals and shall be designed to permit replacement of individual cooler tube groups. Welds shall be smooth to facilitate cleaning.

EW-16.3.3.10 No-Load Tap Changer

When specified in the Technical Data Sheets, tap changers shall be mechanically and electrically rugged, arranged to provide the convenient inspection and maintenance without necessity for untanking and provided with an external mechanism for manual operation.

The tap changer, as well as the arrangement of leads and connection thereto, shall be designed for transient voltage conditions.

The external mechanism shall be protected against unauthorized operation and provided with positive indication of the tap in use and so located that it may be observed without need for unlocking the mechanism. Its location shall be on the wall of the tank so that inspection is permitted without de-energizing any circuit. The tap changing mechanism shall be designed so that they can be operated conveniently by a man standing on the same level as the transformer base.

The supply shall include operating handle, indicating pointer and dial and means for locking the tap changer in any desired position.

EW-16.3.4 Protection and Instrumentation

EW-16.3.4.1 General

The Contractor shall provide all standard protective devices, and instrumentation in addition to the equipment specified hereunder. The Contractor shall provide alarm and trip contacts and shall wire them to the appropriate terminal boards.

EW-16.3.4.2 Protective Devices

General

Leads from auxiliary contacts of all protective devices shall be wired to proper terminal boards in terminal boxes suitable for outdoor installation. Auxiliary contacts shall generally be two sets and freely convertible to either normally open or normally closed contacts. Auxiliary contacts for temperature indicators shall be multi-staged.

Pressure Relief Device

An automatic pressure relief valve shall be provided as a standard protective measure for the transformer tank. It shall open and close automatically to prevent excessive pressure rise in the transformer tank.

Pressure relief vents for pressure relief valve shall have the vent outlet face towards the ground with the height about 50 cm above the ground level in order prevent splash-over of oil in case of pressure relief valve operation.

The device shall be provided with weatherproof hand reset contacts for tripping.

Winding Temperature Detectors

Winding hot spot temperature detector for each windings and oil temperature detector (if oil is used as insulation medium) in the form of heater coil, RTD's and/or thermocouple shall be provided for local indication. Contractors shall provide description and details of the winding temperature detectors.

EW-16.3.5 Accessories

The following accessories shall be provided for the transformer:

a. Surge arrester mounting provision (if required in the Technical Data Sheets);
b. Base designed for rolling and skidding parallel to either center line;
c. Combination pulling eyes and jacking bosses;

d. Lugs for lifting complete transformer;
e. Eyes for lifting cover;
f. Drain plug (for oil-filled transformer);
g. Filling plug (for oil-filled transformer);
h. Liquid or oil level indicator (for oil-filled transformer);
i. Pressure relief value (for oil-filled transformer);
j. Dial type thermometer;
k. Pressure-vacuum gauge; and
l. Alarm and trip contacts for accessory gauges.

EW-16.3.6 Other Technical Requirements for the Station Service Transformer

Other features of the station service transformer if required by the NPC are stated in the Technical Data Sheets.

EW-16.4 INSTALLATION

Installation will be by Contractor unless specified otherwise in Section B.1.0 of the Technical Data Sheets.

When the installation is by Contractor, such as for turnkey contracts, complete details of proper handling, transport and storage, installation, testing, performance guarantees, etc. shall be provided for NPC's review and approval.

EW-16.5 FACTORY ASSEMEBLY TESTS

EW-16.5.1 General

The transformer shall be completely assembled and adjusted at the factory and given the manufacturer's routine shop tests and also other test as specified herein. All parts shall be properly marked for ease of assembly in the field. All routine tests required herein shall be witnessed by the NPC or his authorized representative(s) unless waived in writing, and no equipment shall be shipped until released for shipment by the NPC or his authorized representative.

The test equipment, test methods, measurements and computations shall be in accordance with the latest applicable requirements of ANSI C57.12 and IEC 6076.1 for oil-filled transformer and ANSI C57.12.91 and/or IEC 60726 for dry-type transformer except in cases where otherwise set forth, and shall be subject to the approval of the NPC.

EW-16.5.2 Shop Tests

Routine, design, "other" tests and optional tests, shall be performed in accordance with ANSI C57.12.00 and ANSI C57.12.90 or IEC 60076 for oil filled transformer or ANSI C57.12.91 or IEC 60726 for dry-type transformer.

The Contractor shall make all preparation for test and provide the test apparatus and personnel and shall notify the NPC the date of the test forty-five (45) days in advance. Certified test reports shall be submitted.

EW-16.6 DATA AND DOCUMENTATION REQUIREMENTS

EW-16.6.1 General

Contractor-furnished data and information shall be guaranteed performance data, predicted performance, interface requirements and construction features of all Contractor's furnished equipment. The accuracy of such information and its compatibility with overall performance requirements specified by NPC are the sole responsibility of the Contractor.

All information submitted as part of Proposal Data will become part of contract data for successful bidder. Any deviation from such data requires NPC's approval.

EW-16.6.2 Data and Information to be Submitted During Post Qualification

Contractor shall furnish during post qualification the filled-in Section B.16.0 of the Technical Data Sheets.

EW-16.6.3 Data and Information to be Submitted After Award of Contract

The following drawings and information, but not limited to these, shall be provided by the Contractor for NPC's review, comment and approval:

a. Brochures and catalogues to support the filled-in Technical Data Sheets and to allow NPC to evaluate the equipment /materials being offered;

b. Outline drawings of transformer with parts lists and accessories showing all critical dimensions and weights, including the following:

   1. Base mounting and transport dimensions;
   2. Bushing and cable box locations;
   3. High and low voltage terminal arrangement;
   4. Control cabinet size and location;
   5. Connection points for all external connections;
   6. Conservator, if oil filled;
   7. Nameplate connection plate and all other designation plate drawings.

c. Certified test reports;

d. Mounting and foundation drawings;

e. Bushing drawings including terminal details, voltage rating, BIL, cantilever strength, minimum creepage distance, etc.;

f. A lifting diagram including the recommended sling length, spreader position and spacing of lifting eyes, if applicable;

g. Total weight of insulating material within the tank and total weight of oil;

h. Detailed radiator drawings showing number, dimensions, spacing and configuration of radiator coolers;

i. Description and instructions covering the installation, operation and maintenance of the reactor and all accessories; drawings or cuts showing assembly of the accessories including, but not limited to, inert gas or conservator systems, hot spot devices, temperature indicators, relays, and cooling control and draining of oil;

j. Complete instructions for untanking the core and coils;

k. ISO 9001 Certification of the proposed manufacturer;

l. Detailed QA Program based on ISO 9001; and

m. As-built drawings as finally approved.

The Contractor shall furnish in the manner, number of copies and within the time set forth in the contract, instruction manuals in accordance with Section GW-2.9 of the General Works.

EW-17.0 CONDUITS AND CABLE TRAY SYSTEM

EW-17.1 SCOPE

EW-17.1.1 General

This specification covers the technical and associated requirements for the design, supply, laying and installation of conduits and cable trays as required within the substation/switchyard, including associated fittings, accessories (elbows, tees, steps, crossings etc.), supporting racks and brackets, joint and pull boxes and all hardware. Included in the scope is supply and embedment of concrete inserts for supporting cable tray brackets on walls and ceilings and provision of openings and recesses in walls and floor concrete.

It is not NPC's intent to specify all technical requirements nor to set forth those requirements adequately covered by applicable codes and standards. Contractor shall furnish a high quality conduits and cable tray systems meeting the requirements of this specification and industry standards.

The Contractor shall bear the full responsibility that the materials have been designed and fabricated in accordance with all codes, standards, and applicable governmental regulations and performs under the conditions and to the standards specified herein.

No departure shall be made from this specification and standards unless waived or modified in writing by NPC. Contractor shall obtain from its subcontractors a statement as to compliance with this specification without exception and/or if there are any exceptions, these shall be described in detail and included in Contractor's proposal. Contractor shall add a statement that no other exceptions are taken to this specification.

EW-17.1.2 Works to be Provided by the Contractor

The work to be provided by Contractor shall include, but not necessary be limited to the services delineated in Section B.1.0 of the Technical Data Sheets.

EW-17.1.3 Works to be Provided by NPC

NPC shall provide the materials (if any) and services listed in Section B.1.0 of the Technical Data Sheets.

EW-17.2 CODES AND STANDARDS

EW-17.2.1 General

All materials furnished and installed under this specification shall be in accordance with, but not limited to, the latest issues of the following applicable standards, including all addenda, in effect at time of purchase order unless otherwise stated in this specification:

NEMA	National Electrical Manufacturers Association

NEMA VE 1	Metallic – Cable Tray Systems
ASTM	American Society for Testing and Materials
ASME	American Society of Mechanical Engineers
AWS	American Welding Society
NEC	National Electrical Code
PEC	Philippine Electrical Code
NESC	National Electrical Safety Code
IEC	International Electro-Technical Commission

These codes and standards set forth minimum requirements which may be exceeded by Contractor, if in Contractor's judgement and with NPC's acceptance, superior or more economic designs or materials are available for successful and continuous operation of Contractor's equipment as required in this Specification

EW-17.3 TECHNICAL REQUIREMENTS

EW-17.3.1 Description of Services

The Contractor shall furnish, lay, install and test in operating condition a complete and integrated conduits and cable tray systems for the substation/switchyard.

All materials and parts, which are not specifically mentioned herein but are necessary for proper erection, installation and safe operation of the system shall be furnished, installed, tested and placed by the Contractor in operating condition at no additional cost to the NPC.

EW-17.3.2 Design and Requirements

EW-17.3.2.1 General

The conduits and cable tray system shall conform to the material and fabrication requirements of the specification. All miscellaneous materials required for proper installation shall include but are not limited to, the following:

a. Plug and fillers, couplings and bends;

b. Spacers, inserts and ties for conduits;

c. Conduit splicing solvent and connector materials for uPVC conduit, if uPVC conduits are used;

d. Fire barriers, duct and conduit sealant;

e. Cable tray brackets, anchor bolts or expansion bolts, hangers, lock washers, shims, etc.;

Conduit and cable tray edges shall be reamed and smoothen to avoid damage to cable outer sheath during cable installation. The conduits and cable trays shall have the following characteristics:

a. High mechanical strength;

b. Corrosion resistant; and

c. Heat resistant

EW-17.3.2.2 Conduits

Metallic Conduits

Rigid metal conduits shall be hot dip galvanized conforming to ANSI Standard C80.1, Specification for Rigid Steel Conduit, Zinc-Coated. It shall be finished with a durable clear lacquer coat for additional protection. The inside of the conduit shall have stove enamelled coating to prevent erosion and assure smooth wire pulling.

Metal fittings and covers shall have the same property and finish as that of the metallic conduits. They shall comply with NEMA Publication No. FB-1, "NEMA Standards for Conduit Fittings, Cable Fittings and Accessories".

Rigid metal expansion joints, where required, shall be of standard manufactured product, of watertight construction, equipped with approved means to provide electrical continuity of the conduit runs, zinc-coated, and so designed as to prevent damaged to the cables. They shall permit a small amount of transverse movement as well as the longitudinal movement.

Installation of all conduits, fittings and accessories shall conform to the requirements of the National Electrical Code and the latest edition of the Philippine Electrical Code (PEC).

Non-metallic Conduits

Where non-metallic conduits are allowed to be used by the NPC, it shall be made of unplasticized polyvinyl chloride (uPVC) smooth walled inside and outside, colored red-orange, schedule 40.

uPVC conduits shall be non-corrosive and weatherproof, resistant to the attacks of acids and alkalis and must have a self-extinguishing property, hence shall not support combustion. It shall resist corrosion, rust and scale.

The outside diameter and wall thickness of uPVC shall conform to the testing requirements of PNS/ISO 3126.

Installation of all uPVC conduits and accessories shall conform to the requirements of the National Electrical Code and the latest edition of the Philippine Electrical Code (PEC).

EW-17.3.2.3 Cable Trays

The cable tray shall be designed and manufactured in accordance with the NEMA Standards Publication No. VE-1. Depending on the requirements mentioned in the Technical Data Sheets, the cable tray shall be made of either aluminum or hot-dip galvanized steel, ladder rung type. All accessories necessary for the complete cable tray system shall be supplied by the Contractor.

The cable tray system shall be supported at intervals not exceeding 1.5 meters unless specifically approved for supports at greater intervals.

The cable trays, particularly the straight sections and fittings, shall be neat, smooth, free from defects, sharp edges or projections, weld splatters and burrs which might cause defects on the insulation of the cable during laying operation.

Filling of the cable trays shall be in accordance with the Philippine Regulations, the IEEE Regulations and/or North-American National Codes (CSA Standard C22.1 or NEC ANSI/NFPA-70-1981).

Cable tray and fittings shall be capable of carrying a uniformly distributed working load for the specified span with a load safety factor of one and one-half (1.5). In addition to and concurrent with the working (cable) loads, the cable tray shall be capable of carrying an additional concentrated live load of 200 pounds (90 kgs) applied at the center of the midspan rung, or at the center of the span of the tray without rungs. This shall not result in permanent deformation of the tray. The live load requirement is in addition to NEMA VE-1 requirements. This live load may be converted to an equivalent load in pounds per linear feet (kgs per linear meter) and added to the static weight of cables in the tray. The working load capacity shall be as follows:

Cable Tray (Per Table 3-1, NEMA VE-1)

NEMA Class Designation	Support Span-Feet (meter)	Working Load Lb./linear foot (kg/linear meter)
12C	12 (3.66)	100 (149)

Ladder type cable tray shall be constructed with rungs transverse members. Rungs shall be either welded or cold-swaged into side members by mechanical means to provide strong connection, which does not adversely affect the temper and strength of the surrounding metal and to insure the integrity of an electrical fault ground path. Cold-swaged rungs shall not produce cracks in the side members.

Solid bottom cable tray shall consist of a prefabricated metal structure with no openings within integral or separate longitudinal side rails. Bottoms shall be welded to side members if three-piece construction is used.

Fittings and straight sections shall be identical as to load bearing capability and dimensions of side rails and bottom. At butting joints of solid tray sections, a bottom binder strip shall be supplied to bush the opening and insure a smooth joint with no possibility of bent or sharp lips to damage cable while pulling in or during vibration. Fittings shall have a tangent or straight section beyond the curvature to accept one type of universal splice plate to simplify field erection. The design and construction of fittings shall be in accordance with NEMA VE-1.

Cable trays other than solid bottom trays, shall be designed to accept cable clamping devices and cable barriers without drilling or welding.
Tray design shall provide for interchangeability of like parts and easy assemblage of the system without the use of special tools.

Connector plates shall be high pressure rigid plate types, connected by ribbed-neck; case hardened plated steel bolts with flanged serrated locknuts, locknut with serrated washer or locknut with captive washer. Design shall provide for undiminished structural strength of the connection. Hardware for use with expansion plates may be different to allow for movement of the tray.

The Contractor shall supply and install galvanized steel or aluminium cable tray covers, as directed by the NPC, where cables are liable to mechanical damage in sections of vertical cable tray runs or where debris may fall directly into the trays. Also, the cable tray carrying low voltage signals shall be provided with a cover to act as a shield against electromagnetic interference. Cable tray covers shall be solid. The preferred cover fastening device shall require no drilling of the cable tray for installation. An alternate cover fastening device requiring maximum of one-half inch pilot hole with self-drilling screws may be submitted for acceptance by NPC. Cable tray covers shall be attached to the tray with a heavy duty device to permit easy removal and replacement. The cover and cover clamp shall be equally suitable for vertical and horizontal runs.

Prefabricated galvanized steel barriers shall be supplied and installed if deemed necessary and only with prior written approval of the NPC.

Trays installed under floors shall have minimum clearance of 25 cm. from the top of tray to the bottom of floor or beam.

Cable trays shall be electrically continuous and shall be solidly grounded.

Special care shall be taken to adequately support cables on all vertical cable runs by using cable clamps of approved design.

Completed cable tray systems shall be rigid and have all components firmly bolted and in good electrical contact with the ground grid.

EW-17.3.2.4 Supports, Racks and Conduits

Where the cables leave cable trays to enter equipment or to pass through floor or wall openings or, where it is not feasible to support cables by means of tray, the cables shall be adequately supported by means of the approved racks and clamps. Use of electrical galvanized rigid steel conduit, fittings and compatible hardware is not precluded. The Contractor shall submit his own design, complete with component description for the above conditions, for prior written approval of the NPC.

Cable tray supports shall be of heavy duty reinforced type, hot-dip galvanized steel, suitably sized to accommodate the tray system, cables and live loads normally experienced during cable installation. The maximum deflection between two consecutive supports shall not exceed 7.5 mm for ladder type trays. The Contractor shall design methods for securing supports to walls and ceilings, and shall submit them for prior written approval of the NPC.

Cables supports and racks together with fixing bolts, nuts and screws shall all be made of stainless steel. All steelwork supports shall be designed with a safety factor of not less than four.

Multicore cables shall be clamped to the racks with smooth finish split packing pieces with bore diameters to suit the cable sizes. The packing pieces shall be of non-magnetic material. Single core power cables shall be erected in separate non-magnetic clamps to the approval of the NPC. Wooden cleats will not be accepted.

For any cable trays to be provided outdoors, if applicable, covers of approved design and materials shall be included and erected as necessary to protect the cables against the effect of sun, weather, rain, and mechanical damage etc.

The fixing of racks and associated hardware to the building structural steelwork, where approved by the NPC, shall be by means of bolted clamps. Weld gun stud fixing shall be allowed at the discretion of the NPC on site.

The methods of fixing racks, supports and conduits to walls or ceiling shall be submitted by the Contractor for prior written approval of the NPC.

EW-17.3.2.5 Cable Markers

Power, control/instrumentation, and telephone cables shall be provided with identification markers of permanent materials and of an approved type at the termination of cable runs. The cost of such identification markers shall be included in the rates for cable installation.

EW-17.3.2.6 Cable Ducts

Cable ducts, including spare ducts, for duct sleeves through floors and walls shall be provided as required by the NPC and sealed at each end by approved means to prevent the ingress of water and vermin.

The installation bending radius of the cable shall not be less than that recommended by the manufacturer.

EW-17.3.2.7 Joint & Termination

The Contractor shall be responsible for properly sealing the cables that will not be terminated immediately after installation to prevent ingress of moisture into the cable, and protect it against physical damage.

Cable sealing and jointing shall be in accordance with the best current practice and of first class workmanship. Where cable armour is used as ground continuity conductor, glands shall have the necessary contact surfaces or straps to provide a low resistance path to ground.

The cost of all jointing materials for the termination cables in sealing boxes attached to equipment supplied under other contracts shall be included in the prices for conduits and cable tray system.

EW-17.3.2.8 Welding

Arc welding procedures and welders shall be qualified in accordance with AWS B3.0, AWS D1.3, ASME IX or AWS D1.1 code. Production welds shall meet the following minimum visual examination acceptance criteria:

a. No cracks

b. No undercut greater than 10 percent of the thickness of the sheet

c. Fillet shall be flat or slightly convex

Resistance welding shall follow the recommendations of AWS C1.1. Resistance welding schedules shall be qualified by tests to demonstrate the minimum required spot nugget size and strength are attained. Test coupons for spot welds shall contain a minimum of two spot welds with a minimum spacing between them. Any change in the welding schedule and electrode trip type shall require requalification. Verification test shall be performed prior to start of each day's production and at least once during each shift. The test coupons shall contain a minimum of two spots with minimum spacing. If an in-production verification test shows a rejectable condition, all welds made from the previous acceptable condition, all welds made from the previous acceptable verification test shall be considered rejected unless it can be demonstrated otherwise by test.

EW-17.3.2.9 Cable Tray Marking

A corrosion-resistant nameplate with clearly legible lettering shall be permanently attached to each layer of the cable tray spaced at an interval of 3.0 m.

EW-17.4 INSTALLATION

Installation will be by the Contractor unless specified otherwise in Section B.1.0 of the Technical Data Sheets.

The Contractor shall provide complete details of proper handling, transport and storage, installation and testing, commissioning, performance guarantees, etc. shall be provided for NPC review and approval.

EW-17.5 FACTORY ASSEMBLY AND TESTS

EW-17.5.1 General

The Contractor shall carry out at his own expense all tests necessary to ensure the satisfactory design and manufacture of conduits and cable tray systems in accordance with the applicable Standards.

The Contractor shall make all preparations for test and provide the test apparatus and personnel and shall notify the NPC the date of the test in advance. The NPC or his representative reserves the right to witness all the field tests and qualify conformance tests unless waived in writing.

All materials and/or equipment shall comply with test criteria and NPC acceptance of the materials shall not relieve the Contractor of the responsibility for meeting all the requirements of this specification. Even though the Contractor performs the required tests and the materials meet the acceptance criteria, he shall not be relieved of the responsibility of providing conduits and cable tray systems conforming to all the requirements of this specification.

In general, the following acceptance criteria shall be performed as a minimum:

a. Mechanical and Visual Inspections

   This shall be physical inspection of all components of the conduits and cable tray systems as a whole to ensure that all components are mechanically sound and that there are no imperfections. Also attention should be given to establish that all special requirements of the specification have been met. Levelling and alignment of all installed materials, proper grounding connections, visual check for any damage to each component shall also be performed with the NPC representative(s).

EW-17.6 DATA AND DOCUMENTATION REQUIREMENTS

EW-17.6.1 General

Contractor-furnished data and information shall be the guaranteed performance data, predicted performance, interface requirements and construction features of all Contractor's furnished equipment. The accuracy of such information and its compatibility with overall performance requirements specified by the NPC are the sole responsibility of the Contractor.

All information submitted as part of Proposal Data will become part of contract data for successful bidder. Any deviation from such data required NPC approval.

EW-17.6.2 Data and Information to be Submitted During Post Qualification

Contractor shall furnish during post qualification the filled-in Section B.17.0 of the Technical Data Sheets.

EW-17.6.3 Data and Information to be Submitted After Award of Contract

The following data shall be submitted by the Contractor after award of contract:

a. Brochures and catalogues to support the filled-in Technical Data Sheets and to allow NPC to evaluate the equipment/materials being offered;

b. Complete assembly drawings showing the Contractor's identification, plans elevation and section views, mounting dimensions and details;

c. General assembly and erection/installation drawings and procedures;

d. Routine test reports;

e. Instruction manual; and

f. As-built drawings as finally approved.

The Contractor shall furnish in the manner, number of copies and within the time set forth in the contract, instruction manuals in accordance with Section GW-2.9 of the General Works.

EW-18.0 LIGHTING SYSTEM

EW-18.1 SCOPE

EW-18.1.1 General

This specification covers the technical and associated requirements for the supply, installation, testing and commissioning of indoor and outdoor lighting system and all associated equipment and devices for use in switchyards, substations building structures.

It is not NPC's intent to specify all technical requirements nor to set forth those requirements adequately covered by applicable codes and standards. Contractor shall furnish high quality lighting fixtures, outlets, panelboards and all other accessories meeting the requirements of this specification and industry standards.

Contractor shall bear full responsibility that the lighting system equipment and accessories have been designed and fabricated in accordance with all codes, standards, and applicable governmental regulations and performs under the condition and to the standards specified herein.

No departure shall be made from these specification and standards unless waived or modified in writing by NPC. The Contractor shall obtain from its subcontractors a statement at to the compliance with this specification without exception and/or if there are any exceptions, these shall be described in detail and included in the Contractor's proposal. The Contractor shall add a statement that no other exceptions are taken to this specification.

EW-18.1.2 Works to be Provided by the Contractor

The work to be provided by Contractor shall include, but not necessary be limited to the services delineated in Section B.1.0 of the Technical Date Sheets.

EW-18.1.3 Works to be Provided by NPC

NPC shall provide the materials (if any) and services listed in Section B.1.0 of the Technical Date Sheets.

EW-18.2 CODES AND STANDARDS

EW-18.2.1 General

The equipment and materials to be furnished and the works to be provided by the Contractor shall be in accordance with this specification and shall comply with, but not limited to, the following codes and standards, including all addenda, in effect at the date of the Contract unless otherwise states in this specification:

ANSI/IEEE	**American National Standards Institute and/or Institute of Electrical and Electronic Engineers**
C2.2	National Electrical Safety Code, Section 9 – Rules covering methods of protective grounding circuits, equipment and surge arresters for stations, lines and utilization equipment.
AWS	**American Welding Society**
D1.1	Structural Welding Code
UL	**Underwriters Laboratory**
PEC	**Philippine Electrical Code (Part I)**

These codes and standards set forth minimum requirement which may be exceeded by Contractor if, in Contractor's judgment and with NPC's acceptance, superior r more economic designs or materials are available for successful and continuous operation of Contractor's equipment required by this specification.

EW-18.3 TECHNICAL REQUIREMENTS

EW-18.3.1 Description of Services

The lighting system covered by this specification shall include all indoor and outdoor lighting system of a substation and/or switchyard. The application details are in the Technical Data Sheets. Lighting system includes outlets (convenience and power), switches, associated conduits and cables, lighting fixtures (indoor, outdoor and emergency), fittings, distribution panelboards, lighting transformers, contactors, timers, etc.

All materials and parts which are not specifically mentioned herein but are necessary for the proper installation, assembly and safe operation of the lighting system shall be identified by the Contractor and furnished by the Contractor at no cost to the NPC. Any cost involve are deemed to be included in the price for the Lighting System.

EW-18.3.2 Design Requirements

EW-18.3.2.1 General

Normal lighting/small power outlet and emergency lighting systems shall consist of:

a. 230/115 Volt A.C., 1-phase and 3-phase, 60Hz, normal station lighting system, including outlets (single and three-phase, indoor and outdoor) and emergency lighting system (inside control house only);

b. 460 Volts A.C., 60Hz, three-phase outlets, motor connections (indoor and outdoor);

c. Automatic Stand Alone Emergency Lamp (12 VDC), dual lamp, portable type emergency station lighting system for warehouse, door entrances, guardhouse. This emergency lighting system must switch on automatically in the event of a lighting failure.

d. 125 VDC emergency lighting for Bay Control Unit (BCU) Auxiliary Building. This emergency lighting system shall be connected to the DC power supply and must be switched-on automatically in the event of failure of normal lighting system.

The normal lighting/small power outlet and convenience outlet system, and the automatic stand-alone lamps power shall be supplied from lighting/small power outlet distribution boards fed from the 230/115 Volt A.C. sub-distribution board. The normal station lighting/small power shall be fed by several independent circuits.

The emergency lighting system, including illuminated emergency exit and warning signs power, etc. inside the Control House shall be supplied from distribution boards fed from the Uninterrupted Power Supply (UPS).

Three-phase outlets and three-phase motors power shall be supplied from station distribution boards fed from the 460 Volt A.C. main distribution board.

The emergency lighting system for the BCU Auxiliary Building shall be supplied from the outdoor sub-distribution board fed from the 125 VDC distribution board.

All lighting equipment shall have a degree of protection specified in the Technical Data Sheets. The connection shall be between phase and phase, and all electrical equipment shall be connected to protective earth by separate conductor colored yellow/green.

All lighting materials and supplies furnished by the Contractor under this specification shall have passed adequate factory test. Field tests shall be conducted upon completion of all or any of the electrical works, in the presence of the NPC or his Authorized representatives, to establish conformance with the specifications. All defects shall be eliminated or corrected and expenses for such corrections and test shall be borne by the Contractor.

EW-18.3.2.2 Short Circuit Strength

All electrical components and equipment have to be designed, to meet the expected thermal and dynamics short-circuit strengths.

EW-18.3.2.3 Voltage Drop

The maximum allowable voltage drop of the most remote consumers shall be as follows:

- Outlet feeders 2% of rated voltage
- Lighting branch circuit 3% of lamp rated voltage
- Motor feeders 3% of motor rated voltage at rated output

EW-18.3.2.4 Ageing Factor

The normal and emergency lighting design shall consider a sufficient and dirty ageing factor. The ageing factor shall be as stated in the Technical Data Sheets.

EW-18.3.2.5 Lighting Requirements

The permanent AC Lighting illumination level for each area of the substation shall be as stated in the Technical Data Sheets.

Circuits shall be separated between normal lighting, emergency lighting, single-phase outlets and three-phase outlets.

Substation lighting switching shall be design as follows:

- Station lighting not normally required during daylight hours shall be controlled by photocells and by separate switches (MCB's) from the station lighting/small power outlet distribution boards.

- Stations lighting branch circuits shall be switched locally at each room door or close to the lighting areas.

Replacement of fixtures bulbs or tubes shall be possible without disconnecting any part of the power supply and without any risk of touching live parts of the installation.

The design of the 230 VAC emergency lamps shall consider a sufficient illumination for survey in all rooms, on the staircases, loading areas and gangways (15 Lux). In addition, the emergency lamps in the control room, relay room, battery room and in the AC/DC room shall be designed for an illumination sufficient to enable reading of instruments, relay and terminal numbers on the supervision panels as well as inside and outside of all installed protection panels and of all interfacing panels and local control panels in the switchyard (minimum 100 Lux).

Likewise, for the 125 VDC emergency lighting for the BCU Auxiliary Building, it shall be designed for an illumination level sufficient to enable reading of instruments, relay and terminal numbers on the BCU panels and all other panels housed inside the BCU Auxiliary Building.

12 Volt DC dual lamp, portable type emergency lamps shall be installed at the warehouse building doors and guardhouse.

EW-18.3.3 Lighting Fixtures, Luminaires and Accessories

EW-18.3.3.1 Lighting Fixtures

The Contractor shall submit for approval complete photometry data and type of lighting fixture to be installed together with the shop drawings.

Fixtures shall conform to Underwriter's Laboratories Inc. Standard (UL). Design, materials and finishing of the fixtures and their accessories shall be such as to grant a long life to all components and to reduce maintenance and cleaning. Maintenance shall be safe and easy. All fixtures shall be protected against entry of insects.

All floodlights and fixtures to be installed outdoor shall be sealed and watertight/weatherproof, and shall comply to the latest NEMA Classification Standards.

The fixtures shall be self-cooled design, considering also the ambient conditions, so that the installation is not limited by heating problems.

Fixtures shall be such as to provide for an even distribution of the intensity of the light without glaring. The design of fixtures shall be agreeable and suitable for architectural effect. They shall be approved by the NPC.

All lighting fixtures when installed shall be true and free of leaks, warps, dents and other irregularities. The finished of exposed metal parts of lighting fixtures and finish trims of all recessed lighting fixtures shall be as directed by the NPC.

The hangers, cable, supports, channels, frames and brackets of all kinds for safety and proper installation of lighting fixtures shall be finished and installed by the Contractor at his own expense.

The housing of lighting fixtures shall be fabricated of steel sheet or other material with following qualifications:

- corrosion resistant
- good ventilation
- easy installation

The outdoor lighting fixtures be rain and dust proof and shall have a high quality sealing gasket.

All lighting fixtures, samples and catalogues shall be submitted for NPC's review and approval prior to the order. If requested by the NPC, a sample of some or all proposed lighting fixtures shall be submitted for approval. No lighting fixtures shall be installed without having approved by the NPC.

Lighting fixtures shall be wired with approved fixture wire, 90°C insulation. Each fixture shall be wired to a single point with an adequate slack for proper connection. All lighting fixtures shall be protected from damage during installation. Any broken lighting fixtures, globes, receptacles, stems and the like, shall be replaced with new parts, at no cost to the NPC and to the satisfaction of the NPC.

EW-18.3.3.2 Lighting Luminaires

Gas Discharge Luminaires

Gas discharge luminaires shall have separate chokes, power factor correction capacitors and radio interference suppression capacitors. Ballasts shall be rated 220 VAC, 60 Hz operation.

Power factor correction capacitors shall correct each luminaire to a resultant power factor not less than 0.95 lagging.

The following are the different types of gas discharge luminaires that will be used:

a. High-bay Luminaires

High-bay luminaires shall be of rugged cast aluminum ballast housing, spun aluminum reflector and with impact resistance lens suitable for the type of lamp shown in the Bid Drawing or in the Technical Data Sheets complete with the required control gears and other accessories.

High-bay luminaires shall be used for the lighting of high bay areas within the building, particularly warehouse building.

b. Floodlights

Floodlights shall be used for illuminating outdoor equipment areas. The type of lamp shall be as specified in the Technical Data Sheets.

c. Street/Perimeter Lighting Luminaires

Street/perimeter lighting luminaires shall be used for illuminating roads, parking spaces, perimeter fence area and outdoor equipment areas. They shall be pole mounted unless otherwise indicated.

Support for street/perimeter lighting luminaires shall consist of a pole and a bracket arm, giving a mounting height of approximately 5m and the arm shall overhang by 1.8m. Pole and brackets shall be fabricated from galvanized steel or aluminum. Suitably enclosed terminals mounted 600mm above finished ground level shall be provided in each pole, for connection of the luminaire and looping of the power supply cable.

Poles shall have concrete foundations with provisions for cable entry into the pole base. Poles shall be grounded by the grounding conductor of the branch circuit.

d. Structure Mounted Luminaires

The type of lamps shall be as stated in the Technical Data Sheets.

Structure mounted luminaires shall be used for illuminating outdoor equipment in the substation yard. They shall be mounted on gantry structures or as directed by the NPC.

Flourescent Luminaires

Flourescent luminaires shall be quick start and have separate ballast, p.f. correction capacitors, radio interference suppression capacitors and fuses, easily accessible when the luminaires is mounted in position.

Starters shall be of the glow type, with a preheat time of 0.3 to 0.5 seconds and shall start the lamp within two operations. It shall be possible to remove starters without the removal of diffusers or lamps.

Flourescent tube color shall be cool white, unless otherwise specified. The lamps shall have silent operation; sound pressure level shall be less than 35 dB at all frequencies form any point 1500mm below the luminaire.

The following types of flourescent luminaires are to be used:

a. Opal Diffuser/Louver Type Diffuser. This shall be used in control room, relay room, offices, conference room, station auxialiary room, hallways and areas as indicated in the Bid Drawings.

b. Reflector Luminaires. This shall be used in general utility areas, workshops, areas in the warehouse where high bay luminaires will not be used.

c. Vapor Tight Luminaires. The battery room shall be provided with a vapor tight, corrosion resistant flourescent luminaires capable of containing gas emissions from the battery system. It shall have a molded fiberglass body and a clear shatterproof plastic cover/diffuser sealed with a gasket. The design of the fixture shall be at the same as that intended for louver/opal type diffuser.

d. Special Purpose Luminaires. This shall be used in wet and damp locations and provided with corrosion and explosion proof body, with one (1) 40-watt flourescent luminaire.

Incandescent Luminaires

Incandescent lamps shall be rated for 220V AC, 60Hz operation. General purpose incandescent lamps shall have frosted glass when visible and clear glass when used in luminaires with diffusers. Lampholders shall have a medium screw base and be of porcelain or brass.

Incandescent spotlight shall have reflector type incandescent lamps. The lampholders shall be fully adjustable both vertically and horizontally.

When used in damp and wet locations, it shall have an explosion and corrosion proof body and sealed.

Light Emitting Diode (LED) Tube Luminaires

Light Emitting Diode (LED) tube lamps shall be rated for 220V AC, 60Hz operation. It shall be quick start, electronic type ballast with high power factor, easily accessible when the luminaire is mounted in position

The following types of Light Emitting Diode (LED) tube luminaires are to be used:

a. Opal Diffuser/Louver Type Diffuser. This shall be used in control room, relay room, offices, conference room, station auxialiary room, hallways and areas as indicated in the Bid Drawings.

b. Reflector Luminaires. This shall be used in general utility areas, workshops, areas in the warehouse where high bay luminaires will not be used.

c. Vapor Tight Luminaires. The battery room shall be provided with a vapor tight, corrosion resistant LED luminaires capable of containing gas emissions from the battery system. It shall have a molded fiberglass body and a clear shatterproof plastic cover/diffuser sealed with a gasket. The design of the fixture shall be at the same as that intended for louver/opal type diffuser.

d. Special Purpose Luminaires. This shall be used in wet and damp locations and provided with corrosion and explosion proof body, with one (1) LED tube luminaire.

Compact Light Emitting Diode (LED) Luminaires

Compact LED luminaire shall be rated for 220V AC, 60Hz operation. Lamp holders shall have a medium screw base and be of porcelain or brass. The lamp holders shall be fully adjustable both vertically and horizontally. When used in damp and wet locations, it shall have an explosion and corrosion proof body and sealed.

Automatic Stand Alone Emergency Lamps

The Contractor shall supply and install the automatic stand-alone emergency lamps of the self-contained battery unit as specified herein for safety lighting.

When the A.C. main supply is interrupted, the lamps shall be automatically switched ON with a time delay of 1 second to the battery-powered operation. Lamps shall be switched OFF when the batteries are discharged at the low-level voltage (below 7.5V). The limited charging system of both maximum-constant voltage and constant current shall be able to recharge the completely discharged batteries to their full capacity within 20 hours. The charging system shall cut-off the batteries automatically and instantaneously upon fully charged.

Under normal supply, the charging system shall provide a circuit to maintain the batteries in a fully charged state, ready to supply power to loads and shall be equipped with a reliable protective device to protect the batteries against overload and short circuit.

Batteries shall be of long life, maintenance free, sealed lead acid type. The batteries shall have sufficient capacity to operate the lamps at full luminous efficiency for up to 2.5hours after failure of the main supply.

The unit shall have two 12-volt DC, 55W halogen lamps, on top of the unit. The lamps shall be assembled in such a way that vertical and horizontal adjustments are possible.

Rated input voltage of the automatic stand-alone emergency lamps shall be 230 VAC, 1-phase, 60Hz. Rated output of the batteries shall be 12 Volt D.C.

The metallic enclosure shall be protected against corrosion by one anti-rust primer and one-stoved-enameled finish coat on both sides of the enclosure.

EW-18.3.4 Switches and Single and Three-Phase Outlets

EW-18.3.4.1 General

Switches and single and three-phase outlets shall comply with NEMA Standard. The ratings of switches and single and three-phase outlets with one conductor earthed shall be as specified herein. All switches and single and three-phase outlets shall be of the flush mounted, impact resistance and splash proof type.

The appearance of the switches and single and three-phase outlets will require NPC's approval.

EW-18.3.4.2 Switches

Switches of lighting fixtures shall be of the toggle quiet and flush mounted and fixed to the wall 1.20m above the finished floor level. The rating of the switches shall be 15A, 230 VAC, single-phase.

Switches shall be installed directly adjacent to each entrance door at the strike side of the door.

EW-18.3.4.3 Single and Three-Phase Outlets

All outlets shall be provided with separate earthing pins connected to the yellow/green part in the feeder cable. Outdoor outlets shall be weatherproof with cover plates made of stainless steel.

Outlets for 15A and with rated voltage not exceeding 250V shall be in accordance with PHILIPPINE ELECTRICAL CODE STD.1 for 2-pole two-wire (indoor and outdoor), and shall be installed as follows:

Buildings: The number of outlets shall be in accordance with the Philippine Electrical Code, but not less than two sockets in each room (excluding lavatory or battery room) close to the control panels and distribution boards.

Switchgears: Adjacent to high-voltage breakers, transformers, distribution boards and beside a limited number of disconnect switches.

Sockets for 15A and with a rated voltage not exceeding 750V, shall be in accordance with NEMA Standard, and shall be installed as follows:

Buildings: One Outlet in the control room, relay room and ac/dc distribution boards.

Switchgears: Close to the marshalling kiosk, pumping pits, transformer/ reactor area

EW-18.3.5 Outlet Boxes and Pulling Boxes

EW-18.3.5.1 Outlet Boxes

All outlet boxes for concealed work shall be of hot dip galvanized steel. All wall boxes on exposed work shall be of aluminum plasted cast iron.

Outlet boxes shall be firmly anchored in place and where required provided with fixture supports. The Contractor shall provide special supports for recessed lighting fixtures, etc. Suitable expansion screws shall be used for securing boxes to solid masonry and approved type toggles for securing to hollow masonry units.

EW-18.3.5.2 Pulling Boxes

Pulling boxes shall be installed at all necessary points, to prevent damage to the insulation or other damage that might result from pulling resistance or for other reasons related to improper installation. Pulling box locations shall be approved by the NPC prior to installation. All pulling boxes shall be constructed of galvanized sheet steel of a thickness of not less than 2mm. Where pulling boxes are used in connection with exposed conduits, plain covers attached to the pulling box with a suitable number of countersunk flathead machine screws may be used.

Where so indicated, certain pulling boxes shall be provided with barriers and shall have a single cover plate, and the barriers shall be of the same gauge as the pull boxes. Each circuit in the pulling boxes shall be marked with a cable tag guide denoting panels to which they connect. Exposed pulling boxes are not permitted in areas normally occupied or regularly used by staff or operators.

EW-18.3.6 Lighting Distribution Boards

Lighting distribution boards for the lighting system shall be manufactured to NEMA standards.

Substation lighting distribution boards shall be surface mounted or recess mounted.

Busbar shall be of the phase sequence type suitable for plug-on or bolt-on circuit breakers and other protection devices.
Main circuit breaker shall be mounted case type with instantaneous magnetic trip and thermal over-current trip shall be coordinated with up-stream feeder circuit breaker.

Branch circuit breaker shall be quick-made, quick-break, thermal magnetic and trip indicating type with rating as required by connected load.

Name plate shall be black plastic with engraved white letter. Contractors shall be responsible for the proper identification and labeling of all branch circuits.

EW-18.3.7 Cables

EW-18.3.7.1 General

All cables associated with lighting system shall comply with ICEA and ASTM Standards. They shall suitable for installation in conduits, on cable trays or cable ladder as appropriate.

All types of cables shall be provided with means of rodent protection and/or other acceptable means of protection. It shall be odorless, uniform throughout the entire length and cat up to the expected operational life of the cables. It shall have no damaging effects on the insulation characteristics of the cables. All cables shall be stranded annealed copper conductors.

Insulation shall be suitable for wet and dry locations, fungi resistant and ultraviolet stable. Cables shall be generally moisture and heat resistant thermoplastic or cross-linked synthetic polymer unless otherwise approved by the NPC.

In general, cables shall be suitable for continuous conductor temperature of 75°C. The minimum size of conductor to be used shall be $3.5mm^2$.

EW-18.3.7.2 Cables/Conductors Sizing

The cable/conductors sizes shall be calculated on the following basis:

a. between substation 460 Volt A.C. main distribution board and normal lighting/small power and three-phase outlets and motor distribution boards, allowable voltage drop shall be 1%.

b. between 230/115V A.C. normal lighting/small power, 460V A.C. three-phase outlets and motor distribution boards and motor distribution and 125V D.C. emergency lighting distribution boards and any termination point the allowable voltage drop shall be

   - 1% for normal and emergency lighting
   - 3% for 230/115V and 460V outlets
   - between lighting/small power distribution boards and miscellaneous equipment, the allowable voltage drop shall be 3%.

The design for the conductor cross sections shall consider the following criteria:

a. power transmitted
b. voltage level
c. type of current
d. power factor
e. method of laying
f. proximity of other cable
g. ambient temperature
h. permissible voltage drop
i. electrical characteristics of the cables etc.

The cable installation shall be arranged to obtain a maximum phase balance.

The conductor minimum cross-section for the indoor lighting/small power outlet and emergency lighting system shall be 3.5mm^2.

EW-18.4 INSTALLATION

Installation will be by Contractor unless specified otherwise in Section B.1.0 of the Technical Data Sheets.

When the installation is by Contractor, such as for turn-key contracts complete details of proper handling, transport and storage, installation, testing, commissioning, performance guarantee, etc. shall be provided for NPC's review and approval.

EW-18.5 FACTORY ASSEMBLY AND TESTS

EW-18.5.1 General

The Contractor shall carry out at his own expense all tests necessary to ensure the satisfactory design and maintenance of all components of the Lighting system in accordance with the applicable ANSI or equivalent Standards.

All materials and/or equipment shall comply with test criteria and NPC acceptance of the equipment shall not relieve the Contractor of the responsibility for meeting all requirements of this specification. Even though the Contractor performs the required test and the equipment meet the acceptance criteria, he shall not be relieved of the responsibility of providing equipment conforming to all the requirements of this specification.

After complete installation of the Lighting System, the following shall be perform as a minimum:

a. Complete Ringout of All Wiring

   A complete point to point ringout of all wiring against the latest wiring diagram shall be made to ensure that the assembly has been wired in accordance with its wiring diagram and further to ensure that the wiring diagram for any assembly is an accurate representation of that assembly.

b. Complete Function Test

   This test is intended to check the functional operation of all components of the lighting system.

c. Mechanical and Visual Inspections

   This shall be a physical inspection of all components of the lighting system as a whole to ensure that all components are mechanically sound and that there are no imperfections. Also attention should be given to establishing that all special requirements of the Specification have been met. Levelling and alignment of all installed equipment, proper grounding connections, visual check for any damage to each component shall also performed with the NPC representative(s).

EW-18.6 DATA AND DOCUMENTATION REQUIREMENTS

EW-18.6.1 General

Contractor-furnished data and information shall be the guaranteed performance data, predicted performance, interface requirements and construction fritters of all Contractor's furnished equipment. The accuracy of such information and its compatibility with overall performance requirements specified by the NPC are the sole responsibility of the Contractor.

All information submitted as part of the Proposal Data will become part of contract data for successful bidder. Any deviation from such data required NPC's approval.

EW-18.6.2 Data and Information to be Submitted During Post Qualification

Contractor shall furnish during post qualification the filled-in Section B.18.0 of the Technical Data Sheets.

EW-18.6.3 Data and Information to be Submitted After Award of Contract

The following drawings and information, but not limited to these, shall be submitted by the Contractor for NPC's review, comment and/or approval:

a. Brochures and catalogues to support the filled-in Technical Data Sheets and to allow NPC to evaluate the equipment/materials being offered;

b. Complete shipping and assembly drawings showing the Contractor's identification, plans, elevation and section views, mounting dimensions and details, weight and cable entrance openings;

c. Detailed computation for each of the lighting circuits giving the proper size of cables and conduits and circuit breakers;

d. Complete lighting system overview both indoor and outdoor;

e. Detailed bill of materials and parts list for the lighting system;

f. General assembly and erection/installation drawings and procedures;

g. Detailed schematic diagram and cabling layout; and

h. Detailed test procedures to be followed after installation of the equipment and Field Test Reports duly signed and witnesses by NPC's representative(s);

The Contractor shall furnish in the manner, number of copies and within the time set forth in the contract, instruction manuals in accordance with Section GW-2.9 of the General Works.

EW-19.0 LINE PROTECTION SYSTEM

EW-19.1 SCOPE

EW-19.1.1 General

This specification covers the technical and associated requirements for protective relay systems and relay panels, including all the various equipment and devices necessary for protection and disturbance analysis requirements of a power plant/ substation(s). All materials and parts which are not specifically mentioned herein but are necessary for the proper erection, assembly and operation of the equipment shall be furnished at no increase in cost to the NPC.

It is not NPC's intent to specify all technical requirements nor to set forth those requirements adequately covered by applicable codes and standards. The Contractor shall furnish equipment meeting the requirements of these specification and industry standards.

The Contractor shall bear full responsibility that the equipment has been designed and fabricated in accordance with all codes, standards and applicable governmental regulations and performs under the conditions and to the standards specified herein.

No departure shall be made from this specification and standard unless waived or modified in writing by NPC. The Contractor shall obtain from its subcontractors a statement as to compliance with this specification without exception and/or if there are any exceptions these shall be described in detail and included in Contractor's proposal. The Contractor shall add a statement that no other exceptions are taken to this specification.

EW-19.1.2 Works to be Provided by the Contractor

The Contractor shall provide the equipment; accessories and services delineated in Section B.1.0 of the Technical Data Sheets.

EW-19.1.3 Works to be Provided by NPC

NPC shall provide the materials (if any) and services listed in in Section B.1.0 of the Technical Data Sheets.

EW-19.2 CODES AND STANDARDS

EW-19.2.1 General

The equipment furnished shall be in accordance with, but not limited to, the latest issues of the following applicable standards, including all addenda, in effect at time of purchase order unless otherwise stated in this specification. These shall include:

ANSI/IEEE	**American National Standards Institute/or Institute of Electrical & Electronic Engineers**
C33.10	Safety Standard for Fuseholders
C33.65	Safety Standard for Cabinets and Fuseholders
C37.1	Standard Definition, Specification and Analysis of Systems used for Supervisory Control, Data Acquisition, and Automatic Control
C37.2	Standard Electrical Power System Device Function Number
C37.21	Standard for Control Switch Boards
C37.90	Standard for Relays and Relay Systems Associated with Power Apparatus
C37.90.1	Standard for Surge Withstand Capability (SWC) tests for Protective Relays and Relay Systems.
C37.90.2	Standard for withstand capability of relay systems to radiated electromagnetic interference from transceivers.
C37.100	Definitions for Power Switchgear
C37.103	Guide for differential and polarizing relay circuit testing
C37.111	Standard common format for transient data exchange (COMTRADE) for power systems
C57.13	Standard Requirements for Instrument Transformers
C57.13.1	Guide for Field Testing of Relay Current Transformers
C57.13.3	Guide for the Grounding of Instrument Transformers
Z55.1	Gray finishes for Industrial Apparatus and Equipment
8802-2, to -6	Information Technology, Local and Metropolitan Area Networks, Parts 2,3,4,5 and 6
EIA	**Electronic Industries Association**
310-C	Racks, Panels and Associated Equipment
ICBO	**International Conference of Building Officials**
UBC	**Uniform Building Code, Section 2312 – Earthquake Regulations**
ICEA	**Insulated Cable Engineers Association**
S-66-524	Crossed-linked-thermosetting-polyethylene-insulated Wire and Cable for the Power and Distribution of Electrical Energy
IEC	**International Electrotechnical Commission (all parts of listed Standards apply)**
60051	Direct acting indicating analogue electrical measuring instruments and their accessories
60255	Electrical Relays
60258	Direct acting recording electrical measuring instruments and their accessories
60337	Control Switches
60359	Expression of the Performance of Electrical and Electronic Measuring Equipment

60414	Safety requirements for indicating and recording electrical measuring instruments and their accessories
60473	Dimensions for panel-mounted indicating and recording measuring instruments
60625	An interface system for programmable measuring instruments
60688	Electrical Measuring transducers for converting ac electrical quantities
60870-5-103	Interfacing
ISO	**International Standards Organization**
9001	Quality System Model for Quality Assurance in Design/Development, Manufacture and Testing
9002	Quality System Model for Quality Assurance in Production, Installation and Servicing
SSPC	**Steel Structure Painting Council**
PA1	Shop, Field and Maintenance Painting
PA2	Measurement of Dry Paint Thickness with Magnetic Gages
UL	**Underwriters Laboratories, Inc. (all parts apply)**
44	Rubber-Insulated Wires and Cables

These codes and standards set forth minimum requirements which may be exceeded by Contractor if, in Contractor's judgment and with NPC's acceptance, superior or more economic designs or materials are available for successful and continuous operation of Contractor's equipment as required in this specification.

EW-19.3 TECHNICAL REQUIREMENTS

EW-19.3.1 Description of Services

The equipment covered by this specification shall include all electrical features for complete protection and disturbance analysis of a Power line. The application details are in the Technical Data Sheets.

All materials and parts which are not specifically mentioned herein but are necessary for the proper erection, assembly and safe operation of the line protection relays shall be identified and furnished by the Contractor. Any cost involved are deemed to be included in the price for line protection relays.

EW-19.3.2 Design Requirements

EW-19.3.2.1 General

The relays shall be the rack mounted type, mounted on EIA standard 19" rack and shall be provided with panel enclosure. All of the relay targets shall be visible without opening any doors.

Where rack mounted switchboard is to be provided for the relays, it shall be mounted side by side with raceways provided for wiring to adjacent racks. The rack shall be designed for easy separation and addition of future on either side.

The relay panels shall be supplied complete with all relays, instruments, meters, indicators, control switches, push buttons, indicating lamps, terminal blocks, wiring and miscellaneous devices as called for by this Specification or indicated in the Bid drawings. The relay panel shall include all required auxiliary relays, resistors, etc., whether or not expressly called for or indicated on the bid drawings. All relay coils, contacts and other features shall be suitable for the apparatus controlled or for the purpose intended. A large number of cables will be brought in through the bottom of the relay panel and adequate provisions shall be made to accommodate, support and terminate these cables on the terminal blocks.

The relay panels shall be designed and wired with relays and devices adequate to protect not only the equipment supplied under this contract but also the future equipment shown in the single line diagram or in the substation layout.

The Contractor shall ensure that all equipment will allow sufficient room for operation, maintenance, future additions and possible future replacement of the defective components.

The Contractor shall ensure that all equipment he supplies, functions correctly and safely.

The characteristics and ratings of the equipment and devices given in the applicable sections are not necessarily the standards of any particular manufacturer but they are the minimum requirements that must be satisfied by the Contractor.

The construction of the different parts of the Supply must be as standard as possible in order to reduce to a minimum the spare parts and to make the maintenance and replacement operation easy. All similar parts must be interchangeable.

The relay panels shall be complete with grounding connection and with all accessories and shall be such as to guarantee correct and trouble free operations.

EW-19.3.3 Design and Construction Features

EW-19.3.3.1 Relay Construction and Mounting

The relay shall comply with the relevant requirements of IEC Publication 60255 or equivalent ANSI/IEEE Standard.

Modular constructed equipment (example, rack mounted solid state relaying equipment) shall be tested as a complete assembly and details of such tests shall be agreed with the NPC when details of the construction are known.

Individual relays and protection equipment intended for the panel or rack mounting shall be designed so that the internal function module(s) are capable of being removed from the case or rack without disconnecting any external wired connections. Means shall be provided to positively locate each withdrawable unit in the "service" position.

Each protection relay, or protection scheme shall be provided with an adequate number of output contacts of suitable rating to carry out the prescribed tripping functions, alarms indication and fault recorder functions and such supplementary signaling functions as may be necessary for the initiation of automatic reclosing or automatic switching control, etc. In all cases, contacts intended for tripping duty shall be designed so that they cannot inadvertently interrupt trip coil current.

For contacts intended to be used to directly energize circuit breaker tripping coils, the Contractor shall indicate the peak value of the permissible making current, and the current carrying capability for 0.5 seconds. Where appropriate, details shall also be given of the operating characteristics of any reinforcing contactor. The Contractor shall also quote the maximum breaking capability of the trip output circuit (in Amp) when associated with an inductive burden having a time constant of not less than 40 ms at a rated voltage 125 volts d.c. and at such other voltage as may be specified for a particular installation.

All electronic protective relays shall be designed to withstand the impulse voltage and high frequency interference test requirements as specified in Clause 8, IEC Publication 60255-5 or ANSI C37.90.1 and Appendix E, IEC Publication 60255-4 or ANSI C37.90.2, respectively. The relay should also comply with IEC EMC Standards listed in Section EW-1.16.8 of the General Technical Requirements. Test frequency requirements shall be as specified in the Technical Data Sheets.

Protective relay which require an independent low voltage DC supply shall preferably use D.C./A.C/D.C. converter power pack for this purpose. Separate power packs are preferred for each individual discriminative relay unit. This may be an integral part of the relay.

If the power pack is separately housed from the relay unit(s) which it is supplying, care must be taken that the cabling between the power pack and the relay unit and between relays units is adequately screened and physically separate from all "power type" circuits associated with the CT, VT and DC tripping circuits. All interconnecting screened cables shall preferably be terminated by plug and sockets.

It shall not be possible to gain direct access by means of external connection to any low voltage DC power supply without first removing an appropriate protective cover suitably engrave with a warning that high voltage test shall not be applied. That is, there shall be a degree of mechanical segregation on the CT, VT and DC tripping connection and the low voltage circuits.

All input and output terminals of the power packs which are connected to "power type" circuits shall be subjected to the same over voltage, impulse and interference tests as specified for the protection. The low voltage supply to each discriminative relay unit shall be continuously monitored and an alarm shall be given whenever the voltage exceeds the limits for reliable protection operation.

Each relay, or relay scheme, shall be provided with an adequate number of indications to facilitate post fault analysis including identification of the faulted phase and faulted zone, etc. Requirements for operation indicators are as follows:

a. Long term storage of the indication is not dependent upon an auxiliary supply.
b. Means are provided to ensure that the indication is complete.
c. Each indicator, whether of the electrical or mechanical operated type, shall be capable of being reset without opening the relay case.
d. Unless otherwise approved, indication shall only be given by the protection(s) which causes the fault to be cleared.
e. All indications shall be clearly visible without opening of relay cases or relay panel doors.

Rectifiers used in association with protective relays shall preferably be of the silicon type and appropriately rated for the application.

Where relays are required to operate with accurate time settings, the delaying attachment shall not be of the dash-pot type.

Wherever practicable the design of the relay schemes shall be based on the "fail-safe" principle. For example, care shall be taken to ensure that the loss of DC supply or an open circuit does not cause incorrect opening or closing of a circuit breaker. Circuit breaker or isolator repeat relays should be of the latching type and a discrepancy alarm shall be provided to check correct operation of the relays following a circuit breaker or isolator operation.

Lockout tripping relays shall be of the latching type and shall be hand or electrically reset as specified.

Numerical relay must be provided by at least two serial interfaces according to IEC 870-5-103.

EW-19.3.4 Power Line Protection requirements

EW-19.3.4.1 General

The protection system for the Power line shall be as stated in the Technical Data Sheets. Depending on the requirements and importance of the line, the protection system may consist of one, two or more completely independent sets.

When two or more protection sets have been specified in the Technical Data Sheets, they shall be fully independent of each other and shall be located in separate cubicles unless otherwise indicated in the Bid Drawings and shall be made preferably by different manufacturers, unless otherwise indicated in the Technical Data Sheets. If, however, different operating principles are required for each of the protection sets, (such as distance relay, digital current differential relay or digital directional comparison relay) they can come from the same manufacturer.

In addition to the basic function of the line relays, supplementary and back-up protective functions shall also be provided as described in this specification and in the Technical Data Sheets.

The line protection system shall also include auto-reclosing relays and sychro-check/voltage -check relays if required in the Technical Data Sheets.

If required in the Technical Data Sheets, the line protection relays shall be equipped with fault locators. The fault locator shall provide the location of both transient and permanent faults on Power lines. The fault locator can either be in the Main 1 or Main 2 protection set or both if required in the Technical Data Sheets.

All protective relays shall be of numerical or microprocessor-based design.

The relay design shall include extensive automatic self-checking facilities to supervise and monitor the condition of the individual processors, measuring elements, DC supply, etc. Any abnormal condition detected shall initiate an alarm and indicate the defective element. Defects that may cause mis-operation of the relay shall inhibit operation of that particular relay or element of a relay system. Less critical defects may initiate an alarm only.

When voltage inputs are required, these shall be monitored continuously. Any open phase shall be detected high speed and shall prevent mis-operation of the affected protective relays. Unbalanced conditions in the current circuits due to defective connections should also be monitored.

Test facilities shall also be provided for each protective relay.

EW-19.3.4.2 Relay Performance Requirements under CT Saturation/CVT Transients

The protective relay system shall operate correctly in the presence of simultaneous CVT transients and CT saturation.

Current Transformers. The protection shall operate correctly and within the required operating speed even when the CTs supplying current to it saturate completely one cycle after fault inception. When two circuit breakers control a line, Contractor shall ensure that when one of the CTs saturates for any external fault at the bus or other circuits, mis-operation of the relay shall not occur.

Capacitor Voltage Transformers. The relay system shall operate correctly and with high speed and shall have correct directional sensing in the presence of severe CVT transients produced in accordance with ANSI Standard C93.2 or IEC equivalent. The CVT transient requirement shall include the conditions of relaying accuracy with the rated burden of the CVT connected. The relay response to CVT transients shall be demonstrated during model power system testing.

The relay contractor shall ensure that the relay system being furnished will operate satisfactorily with the instrument transformers to which they will be connected. The relay contractor shall coordinate with the instrument transformer manufacturer in making sure that the CT and CVT characteristics satisfy the protection requirements for all conditions, including CT remanence, high-speed autoreclosing and allowing for some future system expansions. The relay contractor shall provide the NPC with copies of any coordination correspondences with the instrument transformer manufacturer or calculation to prove that the relay requirements will be met. CT's or CVT's that are found to be unsuitable, as a result of failure of the relay manufacturer to coordinate his requirements, must be replaced by the relay contractor at no cost to the NPC.

EW-19.3.4.3 Relay System Security, Dependability and Speed

The relay system shall meet basic security, dependability and speed requirements described below.

Security. The relay system shall be very secure. The consideration for selection of the relay system will place much emphasis on the security of the relay system. Any false trip output cannot be tolerated due to the difficulties that would arise with more than one Power line out of service. The security of the protection relays themselves shall be demonstrated through conjunctive model power system tests as discussed in Section EW-19.5.1.2. The relay shall not commit maloperation with any of the following conditions:

a. Any kind of external faults beyond the protected sections
b. Transient system disturbances
c. Current surges due to sudden change of line charging capacity in the case of one phase to ground fault, line switching on external faults, etc.
d. DC components of short circuit currents
e. Magnetic fields from other relays
f. Normal discharges of arresters installed in the protected sections.

Speed. The operating time of the relay system shall conform to the operating time listed in the Technical Data Sheets.

Dependability. The relay system shall be highly dependable. The relay system shall produce a trip output for all Power line faults within the zone of protection. The dependability of the protection relays themselves shall be demonstrated through conjunctive model power system tests as discussed in Section EW-19.5.1.2.

EW-19.3.4.4 Relay System Disabling

A master disabling switch or equivalent features shall be supplied for the purposes of completely disabling the relay system. The features shall include the following:

a. Open all relay system trip outputs
b. Open all potential supplies to the relay system
c. Short circuit current transformer secondaries before opening all current circuits to the relay system

d. Energize a substation annunciator lamp
e. Input to the station sequence of events recorder
f. Disable all relay system outputs such as breaker fail initiate, reclose initiate, reclose block, out of step trip, transfer trip, etc.

EW-19.3.4.5 Transient Protection

The Contractor shall provide adequate surge protection on all current, voltage and DC control leads entering a panel or rack in order to mitigate induced voltages and currents and prevent equipment malfunction or damage. The relay system shall be capable of passing the ANSI/IEEE C37.90 or equivalent IEC Standard surge withstand capability test.

Appropriate wire and cable shielding, twisted wire pairs, separate power and signal grounds and wire routing shall be applied to mitigate induced voltages and currents.

The equipment shall not be damaged or produce a false output with radio frequencies, from 25 to 500 MHz and a field strength of 7 volts/meter measured at the front of the relay case, applied with the relays energized and connected for normal operation.

EW-19.3.5 Distance Relay Protection System

EW-19.3.5.1 General

The distance relay shall be a directional comparison type of system. The distance relay shall utilize either fiber optic cable communication system, a power line carrier communication system or a microwave communication system as a medium of teleprotection system.

The distance relay shall be of microprocessor based design or numerical type of relay.

EW-19.3.5.2 Distance Relay Measuring Zones and Zone of Protection

The basic protection function of the relay is a full scheme distance protection with various impedance zones having an individual measuring element for the different types of faults under each impedance zones. The relay system shall detect and give a trip output for any type of faults (multiple phase faults and ground faults) on the Power line being protected.

The relay system shall be capable of detecting both forward looking and reverse looking faults at each terminal depending on the setting.

The relay system operating characteristics shall be field adjustable to take into account system parameters, system conditions, load flow, etc. It shall be possible to provide sufficient margin (as determined by NPC) between the relay operating characteristics and the system load characteristics.

The protection shall include three independent impedance measuring zones designated Z1, Z2, and Z3 all having programmable forward sensing directionality. These three basic zones shall have the following characteristics:

a. Zone 1. This will be non-switched and shall measure simultaneously the individual phase loops A-B, B-C, C-A, A-N, B-N and C-N.

b. Overreaching Zone 2 or pilot protection zone. This shall have independent measuring elements. This will be non-switched and shall measure simultaneously the individual phase loops A-B, B-C, C-A, A-N, B-N and C-N. Zone 2 shall include a timer.

c. Forward sensing Zone 3 with an offset reach or can be set in the reverse direction. This will provide the required measurement for weak-infeed and open breaker echo logic and current (transient) reversal blocking logic. This will be non-switched and shall measure simultaneously the individual phase loops A-B, B-C, C-A, A-N, B-N and C-N. zone 3 shall be provided with blinders or shall have lens shaped characteristics to prevent undesired operations during load condition.

Depending however on the requirements or as stated in the Technical Data Sheets, the relay system can have an additional one or two impedance measuring zones without changing the basic hardware configuration of the distance relay. Their directionality must be programmable either in the forward or reverse direction and must be independent of each other. These impedance zones shall have the following characteristics:

a. Forward sensing Zone 4 measuring element, if required in the Technical Data Sheets, shall be provided for time-stepped backup function for the protected line. Zone 4 shall include either non-switched or switched measuring elements.

b. Forward sensing Zone 5 measuring element, if required in the Technical Data Sheets, shall also be included for time-stepped backup protection of adjacent lines. Either non-switched or switched measuring elements may be used. Zone 5 shall include a timer.

The relay impedance characteristics shall be as stated in the Technical Data Sheets.

EW-19.3.5.3 Phase Selector Logic

The distance relay shall have a phase selector logic which shall be able to discriminate reliably the faulted phase during single phase to ground faults. Phase to ground faults shall always be detected as phase to ground faults and multi-phase faults whether or not involving ground shall not be detected as single-phase faults but always as multi-phase faults and shall provide three-phase trip output.

The phase selection logic may use separate measuring elements in combination with level detectors measuring the symmetrical components of the relay currents to determine the type of fault and which phase is faulted.

Phase selection which depend on undervoltage is not acceptable.

EW-19.3.5.4 Setting Parameters and Setting Changes

The distance relay shall have the setting parameters and setting ranges as indicated in the Technical Data Sheets. The relay setting shall be done with ease from the front panel. Provision shall be made also, such that relay setting can be done remotely and/or through the use of a lap-top PC or other external setting devices.

EW-19.3.5.5 Relay System Operation Mode

The distance relay shall be used with permissive under reaching (PUTT) and/or overreaching transfer trip (POTT) pilot or teleprotection schemes.

Carrier send:

PUTT Scheme	Zone 1
POTT Scheme	Zone 2 (Pilot)
Blocking Scheme	Zone 3 (Reverse)

At the Receiving End:

Permissive Trip	Zone 2 or Pilot

For the blocking scheme, provide an adjustable timer (10-50 ms or longer) started by the-forward-looking Pilot Zone to wait for the blocking signal from the opposite end before tripping is allowed.

Provide also an auxiliary/lockout relay which shall receive direct trip commands from breaker fail protection at the opposite line end. This shall trip the line breaker, provide annunciation and initiate an alarm.

The teleprotection schemes shall provide instantaneous tripping for both close-in and far end faults even when the breaker at the far end is open.

EW-19.3.5.6 Switch into Fault Protection

The relay shall be provided with a switch into-fault protection function which shall cause instantaneous tripping for both close-in and far end faults when a faulted line is energized. The logic shall use the voltage from VTs connected on the line side. It shall also be possible to start this function by a contact of the control switch and/or from SCADA remote closing.

EW-19.3.5.7 Evolving Faults

Logic to detect evolving faults after the relay has reset during the single-phase open time of reclosing cycle shall be provided in the distance relay. The relay system shall operate correctly for all types of evolving faults. Evolving faults shall result in three-phase tripping.

EW-19.3.5.8 Current Reversal

A logic to block undesired tripping of the unfaulted line on current reversal caused by sequential opening of the breakers on the faulted parallel line for use with overreaching schemes shall be provided. This logic shall use a reversed-looking zone to start blocking and this should be coordinated with the forward-looking element of the opposite station. After tripping of the breaker on the parallel line and when the reversed-looking element resets, this blocking shall be cancelled in the shortest time possible. However, this shall be coordinated with the reset time of the teleprotection signal to avoid mal-operation of the relay. The time to blocking cancellation shall preferably be adjustable. The relay manufacturer shall coordinate with the protection signaling equipment manufacturer to ensure security of the protection system.

Schemes with current reversal blocking logic started by the reception of the transfer trip signal may be accepted only when consideration of the fastest breaker trip time and slowest signaling time can guarantee correct operation.

EW-19.3.5.9 Simultaneous Fault

The distance relay system shall correctly respond to simultaneous faults at any section or sections of the power system. Simultaneous external faults shall not cause any mal-operation or protection failure. An external fault occurring simultaneously with an internal fault shall not prevent proper clearing of the internal fault. When the relay system blocks a trip output for any type of external fault which evolve into an internal fault after the external fault is detected, blocking shall be canceled without further delay to allow high-speed clearing of the internal fault.

EW-19.3.5.10 Power Swing

The relay shall be provided with an out-of-step (power swing) blocking function to prevent undesired operation or tripping of the relay during stable power swing conditions. Power swing blocking shall be inhibited during the dead time of a single phase auto-reclose cycle or when an earth fault is detected. It shall also be possible to select blocking of any one or more selected zones, e.g., block tripping of all zones, except Zone1. This will allow the relay to trip on out-of-step conditions where the swing locus enters Zone 1.

EW-19.3.5.11 Voltage Transformer Supervision

The relay shall be provided with a voltage transformer supervision function to monitor the ac input voltages and block operation of the relay when the ac input is lost on one or all of the phases. This shall be fast enough to enable blocking of zone1 even when the input current is equal to the rated current. The auxiliary contact of the VT circuit miniature circuit breaker may also be used to supplement blocking.

EW-19.3.5.12 Self Supervision

The distance relay shall have built-in continuous and periodic self-checking and monitoring facilities to detect any failures of all measuring and logic elements of the relay. If any abnormal condition that can lead to mal-operation of relay is detected, the relay shall be blocked and an alarm given; otherwise less serious condition that do not hamper the proper functioning of the relay shall give an alarm only.

EW-19.3.5.13 Trip Circuit Supervision

The provision in Section EW-1.16.6 of the General Technical Requirements shall apply.

EW-19.3.5.14 Relay Indication and Output Contacts

The relay shall provide an indication of trips and starts or operations of its various measuring elements by means of LEDs or an LCD located at the face of the relay. The relay system shall be furnished with contacts output for the substation annunciator.

Relay trips, measurement starts such as zone 2 (phase A-B), power swing block, general start, phase A trip, shall have at least 12 configurable voltage-free contact outputs for use in fault and events recorders. Alternatively, relays with oscillography/event reporting features (with 2 ms resolution or better) having all these measuring elements monitored shall be acceptable provided that the necessary software (for communications and analysis) and hardware (modems and/or modem splitters) are supplied.

The relay shall also be provided with the necessary output contacts for tripping, autoreclose initiation, autoreclose blocking, breaker fail initiation, alarm and annunciation. The number of contacts shall be sufficient for use in substation scheme shown in the Bid Drawings and with single phase tripping.

EW-19.3.5.15 Other Requirements

Distance relay resistive reach for blinders, when included, shall have a setting range stated in the Technical Data Sheets. Each zone shall preferably be provided with its own resistive reach setting and be independent of the other zones and shall preferably have separate settings for phase faults and ground faults.

For mho-type measurements, the line impedance angle setting shall be adjustable and shall have the values required in the Technical Data Sheets.

For directional discrimination, the relay shall use a voltage memory for three-phase faults. For unbalanced faults, partial cross-polarization or other equivalent forms of non-faulted phase polarizing shall be employed.

The distance relay shall measure accurately within 5% of the set reach for all zones and under worst operating conditions (such as CVT transients and CT saturation) for setting values of 0.5 to 10 ohms (for 5A CTs) and SIR (source impedance ratio) less than 30. Dynamic overreach shall not exceed 5% under the same conditions.

Reset ratio shall be less than 105% of settings for all zones.

The operating time characteristics of the relay (with filter delay and relay trip units included) for both typical and under worst condition with fault located at 80% of the set reach and with a source impedance ratio (Zs/Z1) equal to ten and less and with the presence of severe CVT transients shall be as stated in the Technical Data Sheets. Contractor shall provide with his bid, type test results and isochronic operating time (or equivalent time curves) together with the test set-up and assumptions (especially with regard to performance with CVT transients).

The reset time of measuring elements shall be as stated in the Technical Data Sheets.

The distance relay shall be suitable for both three-phase and single-phase tripping and reclosing. The means to prevent autoreclosing in the event of a three-phase fault being detected by the distance protection shall be provided.

The relay impedance characteristics shall be as stated in the Technical Data Sheets. However, each zone measurements shall be completely independent and shall have no common side.

Phase-to-ground faults shall generally be measured with relays having variable mho characteristics with increased fault resistance coverage. Where polygonal element is used, the load flow current compensation shall tilt the reactance characteristics in such a way to minimize overreaching as well as under reaching, depending on the direction of power flow. The resistive reach for polygonal elements shall be limited by some form of blinders and shall consider the overreaching effects of fault resistance and load flow current.

EW-19.3.5.16 Relays Associated with the Distance Relay

<u>Directional Earth Fault (DEF) Overcurrent Relay System</u>

The relay shall be a microprocessor based or numerical type capable of single phase tripping and three phase tripping in conjunction with the distance relay system described in this specification.

The DEF may be a built-in function of the distance relay.

DEF protection shall detect high resistance faults not seen by distance relays.

DEF shall include following functions:

a. The DEF protection shall have both forward sensing and reverse sensing elements.

b. It shall operate in a POTT teleprotection scheme with current reversal blocking logic. This logic shall use the reversed-looking element to start blocking and this should be coordinated with the forward-looking element of the opposite station.

c. DEF directional elements shall compare the relative angles of zero sequence or negative sequence components for making their directional decisions. The optimum directional characteristics angle for maximum sensitivity and speed of operation shall be as stated in the Technical Data Sheets. External auxiliary VT's shall be provided, if required by the relay, for derivation of a zero sequence polarizing voltage. For the protection of double circuit lines where the two circuits are routed to different remote substations, negative sequence DEF directional elements must be used.

Depending on the requirements stated in the Technical Data Sheets, the POTT scheme for the DEF shall use a teleprotection signal that is either common or separate from the tripping signal used for the distance teleprotection scheme. The DEF shall be provided with a short delay, adjustable between 50 ms to 150 ms, in tripping of high-resistance faults and to improve security of the scheme from over tripping; however, if the teleprotection signaling command used can have a high security or probability of unwanted commands of less than 10^{-6} or better, then a fixed delay to coordinate with the distance relay will be acceptable. Tripping by the DEF POTT scheme shall be single-phase whenever the distance relay phase selector can distinguish the faulted phase; otherwise it shall be blocked by distance relay teleprotection trip. During the single-phase autoreclosing cycle, the DEF shall be blocked by the auto-recloser.

The current and voltage sensitivity setting for both forward and reverse sensing elements of the relay for the rated voltage of 64.4V shall be as stated in the Technical Data Sheets.

The DEF protection shall be stabilized and shall not mal-operate with magnetizing inrush currents during energization of external transformers or during line energization with shunt reactors.

The DEF relay shall also employ self-checking and continuous monitoring functions, including monitoring of the voltage input circuits.
The overcurrent time delayed characteristics shall be programmable so that it shall be possible to field select definite time, IEC normal inverse, very inverse or extremely inverse characteristics or equivalent US moderately inverse, inverse, very inverse or extremely inverse characteristics.

The overcurrent relay operating parameters shall be as stated in the Technical Data Sheets.

Similar logical circuits as those for the distance protection, i.e. switch-into-fault, current reversal, weak end infeed echo and tripping shall be provided if required in the Technical Data Sheets.

EW-19.3.6 Digital Current Differential Protection System

EW-19.3.6.1 General

The current differential protection system, if required in the Technical Data Sheets, shall consist of identical relay units located at each end of the protected line. The protection system shall be able to interface with a range of dedicated or multiplexed communication links or directly via optical fiber pairs. The relay shall be all digital, microprocessor-based design or numerical type and shall have continuous self-monitoring and diagnostic checks of its components and the communication channel just like the distance relay. Sensitivity of the relay shall be as stated in the Technical Data Sheets.

EW-19.3.6.2 Performance

The current differential protection system shall have a typical operating time of not more than what is specified in the Technical Data Sheets. This will include communication channel and trip unit delays, for all faults within the protected line for differential fault currents above 150% of the operating current pick-up setting, which shall have a setting range of 0.2 to 1.5 times the nominal rated current.

The relay shall have uniform tripping time for all faults within the protected line. For close-in faults both, for multi-phase fault and ground faults and up to 50% of the line length from the relay location, the differential relay operating time shall be as stated in the Technical Data Sheets.

EW-19.3.6.3 Stability and Security Requirements

The line differential protection system shall be designed to ensure a high level of stability and security during faults and during normal power system conditions. As such the following measures should be performed by the relay:

The protection system shall operate on a differential operating principle. For biased relays with low fault currents just above the pick-up setting, a lower bias setting shall be used to increase sensitivity. As the fault current increases, extra errors may be introduced due to current transformer saturation and the bias slope setting shall, therefore, increase to compensate for this error and ensure stability. Alternative methods for increasing sensitivity for low fault currents and ensuring stability for high through fault currents may be offered but subject to NPC's evaluation and acceptance.

The relays shall ensure that the current samples being compared from both ends of the line are effectively in synchronism.

Filtering techniques shall be employed to ensure that data used are suitable for measurement and calculation of the differential and bias current magnitudes.

Each relay terminal, when used with multiplexed systems where inadvertent signals may be injected into the protection channel during tests on the communication system, shall be provided with addressing features so that it will accept only data addressed to it.

The bit error rate (BER) and status of the communication channel shall continuously be measured and monitored. If the BER is high that it can jeopardize the security of the protection system, the relay shall be blocked from tripping an alarm shall be raised if the condition persists. The relay shall be able to detect recovery of the communication channel and shall cancel blocking after a short time to ensure security.

EW-19.3.6.4 Communication Requirements

The protection scheme shall be designed to interface with and be compatible with the following communication equipment and media:

Direct optical fiber link for distances up to 10 km or more.

PCM Multiplexed using CCITTG.703 co-directional interfacing recommendation with the digital equipment with Power rate of 56 or 64 kbits/s. Where relays not installed near the multiplexing equipment and/or where the connection passes through a noisy environment, then optical cables should be used to interconnect the relay and the multiplexer. The optical/electrical conversion interface units shall be provided which shall support the G.703 co-directional interfacing recommendation.

The Contractor shall coordinate the communication interfacing requirements with both the relay and communication equipment manufacturers to ensure that the highest security and dependability of the protection system will be satisfied. The Contractor will be responsible for resolving any interfacing problems between different equipment manufacturers.

EW-19.3.6.5 Single-phase Tripping Requirements

When single-phase tripping is required, the relay shall be capable of providing single phase tripping for single-phase to ground fault.

EW-19.3.6.6 Setting, Metering and Test facilities

The relays shall be provided with facilities for setting and testing the protective relays from the front panel. The test facilities for isolation and current injection and monitoring of contacts shall be provided. These facilities shall include an LCD display where settings, service values like currents of each phase, communication status, fault records, etc. can be viewed. The display and settings shall be controlled by a keypad located below the display. As an aid in commissioning and trouble-shooting, phase currents as well as differential and bias currents at the remote terminal shall be displayed also on the local relay display.

EW-19.3.6.7 Direct Transfer Trip Facilities

Provide an integral direct transfer trip facility which may also be used to block remote auto-reclosing. A permissive transfer trip function shall also be provided to facilitate remote breaker tripping for a local fault located between the line protection CT's and the circuit breaker.

EW-19.3.6.8 Indications

The relay shall provide an indication of the operations of its various elements by means of LEDs or an LCD located at the face of the relay. In addition, these indications shall have at least 12 programmable voltage free contact outputs for use in fault and events recorders. The relay shall be able to store information from the last two trippings. Older information should be written over.

EW-19.3.6.9 Input / Output Circuits

The relay shall be provided with necessary input and output contacts for preparation of three-phase trip, tripping, auto-reclose initiation, breaker fail initiation, transfer trip signaling, alarm and annunciation. The number of contacts shall be sufficient for use in substation scheme shown in the Bid Drawings and with single-phase tripping.

EW-19.3.6.10 Other Relays Associated with the Digital Current Differential relay

The digital current differential relay shall include as back-up protection those relays mentioned in the Technical Data Sheets. These may be an integral part of the digital current differential relay or an independent relays providing back-up functions to the differential relay.

EW-19.3.7 Other Relays Associated with Line Protection

EW-19.3.7.1 Single and Three-Pole Autoreclosing Relay

The Line Protection relay panel, if required in the Technical Data Sheets, shall include autoreclosing relays for reclosing one or two breakers, as shown in Bid Drawings, and shall be included either in the Main 1 or Main 2-line protection panel. The autoreclose functions shall be provided by independent relaying equipment so that the autoreclose functionality will be available with either of the main protection system out of service.

The reclosing relay shall be microprocessor-based or numerical type with programmable autoreclosing modes.

The reclosing relays shall be provided with a priority circuit which shall permit programming of the breaker reclosing sequence when two breakers are being controlled. The following reclosing modes shall be possible.

- close breaker A only (1+3-phase and 3-phase);
- close breaker B only (1 + 3-phase and 3-phase);
- close breaker A first followed by breaker B only after successfully reclosing breaker A or vice-versa (1 + 3-phase and 3-phase for A and B)
- close breaker A and B simultaneously (for single phase trips only) (1 + 3-phase and 3-phase for A and B)

The reclosing relay shall be provided with its own switch to allow functional testing even while other related equipment is in normal operation, without risking any undesired breaker operation or relay mis-operation. Testing shall be performed by inserting a test plug into test switch whereupon the reclosing relay shall be automatically disconnected and all circuits necessary for performing the test shall be accessible. Information shall be sent to both line protective relays or trip circuits shall be bridged to ensure correct tripping if a line fault occurs while the auto reclose equipment is out of service.

The reclosing shall be single-shot. After a reclosing shot is given it will block reclosing for the duration of the reclaim time which will be adjustable from 5s to 300s. The relay shall send information to prepare the line protective relays or trip circuits for three-phase tripping during the reclaim time. If a fault occurs within the reclaim time the recloser will lockout.

The reclosing relay shall be provided with a memory circuit which prevents reclosing of a circuit breaker that is initially open before a fault occurs. Only breakers which were in the closed position for a preset breaker closed time (about 5 s preferably adjustable with 2 s to 20 s) before the fault shall be allowed to reclose. It shall be possible to reclose. It shall be possible to use either 52A or 52B auxiliary contacts to indicate position of the circuit breaker.

The reclosing relay shall be provided with a selector switch or other equivalent means with four operating modes: a) OFF, no reclosing; b) three-phase tripping and reclosing (the line protective relays shall be prepared to trip three-phase; c) reclosing for single-phase tripping only; and d) reclosing for single-phase or three-phase tripping depending on the type of fault.

The reclosing relay system shall be provided with a facility to field select single-phase tripping of one breaker and three-phase tripping of the other breaker.

When the reclosing relay is in the OFF position, the line protection relays or CB trip circuits shall be prepared to trip three-phase.

The reclosing relay shall be provided with two timers for individual setting of the dead time for single-phase reclosing and three-phase reclosing. The timers will be adjustable from 0.2 to 2.0 s for single-phase reclosing and 0.2 to 20 s for three-phase reclosing. The dead time shall start only after the circuit breakers have opened.

If following initiation of autoreclosure the protective relay has not yet reset or one of the breaker has not opened within a preset trip fail time, adjustable within 0.1 s to 0.3 s, the reclosing relay shall lock out.

When sequential reclosing of circuit breakers A and B is selected, the follower circuit breaker time delay (breaker B) shall start after the dead time of the leading circuit breaker A. One autorecloser may be used for two breakers (A and B) if required in the Technical Data Sheets. When sequential tripping is used with single-phase autoreclosing the follower circuit breaker shall always trip three-phase and reclose after the follower circuit breaker time delay if the leader circuit breaker has reclosed successfully.

The detection of an evolving fault during single phase trip interval shall cause the line protective relays to trip three-phase and start three-phase autoreclosing.

The reclosing relay shall use voltage-check and synchro/check relay permissive conditions to control three-phase reclosing of the circuit breaker. If after the end of the three-phase dead time, reclosing does not take place within a preset closing check time, the recloser will lock out. This timer shall have a range of 2 s to 20 s. When sequential breaker closing is selected the follower circuit breaker shall have its own closing check time.

The recloser of each circuit breaker shall automatically reset from lockout if the circuit breaker has been closed and remains closed for the breaker closed time and that no blocking input exists. It shall also be possible to select "manual only" instead of "automatic" resetting of the recloser from lockout by energizing reset input to the recloser.

The reclosing relay shall be provided with separate three-digit counters for recording the number of single-phase and three-phase reclosing shots.

The reclosing relay shall be provided with inputs to accept reclosing initiation from two or more-line protection relays. Whenever the inputs from the relays are inconsistent in the phase to be tripped, the reclosing relay shall change the tripping mode to three-phase.

The reclosing relay shall be provided with blocking inputs for such purpose as delayed distance relay tripping, manual closing of breakers, pole discordance, breaker failure trip, insufficient circuit breaker stored energy for close-trip sequence, communication channel failure, etc. A blocking signal shall override and interrupt an initiated reclosing cycle and reset the reclosing relay. Depending on the blocking signal, blocking shall either remain as long as the blocking input is present, or shall result in lockout.

When used in 1-1/2 breaker arrangements wherein the middle breaker is controlling two Power lines within a bay, the recloser shall be coordinated so that the middle breaker will reclose last and only when reclosing of the two other breakers are successful, otherwise it shall lock out.

Sufficient number of output contacts shall be provided for closing one or two breakers in sequence or simultaneously depending on the selected program. The contacts shall have sufficient capacity to make and carry the closing coil currents and break the same whether reclosing is successful or fails.

Sufficient output contacts shall be provided for inhibiting the DEF relay, power swing blocking, alarms and recording equipment inputs for reclosing attempts, recloser on/off, recloser out of service, etc., indications.

Means shall be provided to allow autoreclosing to be remotely switched in or out of service via SCADA.

EW-19.3.7.2 Synchronism-Check and Voltage Check Relays

Where Line Protection system is required to have autoreclosing of the circuit breakers, it shall also include synchro-check and voltage check relays. The relays shall provide permissive functions when performing three-phase autoreclosing. These relays shall be housed where the autoreclosing relay is housed.

It shall be possible to switch between the synchro-check and voltage check functions for each breaker.

The relay shall have adjustable settings as detailed in the Technical Data Sheets.

Relay input voltage shall be selectable between about 115 V and 66.4 V.

The synch-check/voltage-check relays shall be provided with their own test switches or may have test switch common to that of the reclosing relays.

EW-19.3.7.3 Overcurrent Relay

The overcurrent relay shall be used for back-up protection of Power lines or feeders. The relay shall employ modern microprocessor technology and numerical methods. Extensive self-checking and monitoring to ensure security shall be provided.

The overcurent relay if used with the distance relay or current differential relay protection as a back-up protection for the Power line shall be an integral part of the protection panel.

Minimum features and technical data shall be as follows:

The overcurrent relay shall include three phase and ground overcurrent time delayed elements.

The overcurrent time delayed characteristics shall be programmable so that it shall be possible to field select definite time, IEC normal inverse, very inverse or extremely inverse characteristics, or equivalent US moderately inverse, inverse, very inverse, or extremely inverse characteristics. It shall be possible to field select the characteristics for phase units independently and different from the ground relay.

Each overcurrent unit shall be capable of being controlled independently by a directional relay through an input on the overcurrent unit. Overcurrent relays with built-in directional elements are also acceptable. The directional relays shall have the features as described in Section EW-19.3.7.4.

Overcurrent relays shall include output contacts for initiating tripping of two breakers and for use in substation alarms and event recorders.

Overcurrent relays shall include a test switch.

Overcurrent relay current setting ranges and parameters shall be as stated in the Technical Data Sheets.

If required in the Technical Data Sheets, the overcurrent relay shall be provided with built-in fault and events recorder. If provided with these features, it shall record all the analog voltage and current inputs as well as the operation of the output relays and the control inputs. The relay shall be able to store that last three fault records. The required software and other hardware needed to connect to a standard portable computer to access and analyze the recorded information shall be supplied.

EW-19.3.7.4 Directional Relays

The directional relay, when specified in Bid Drawings and Technical Data Sheets, shall be used to control the directionality of the overcurrent relays described above. The directional relay may be a separate unit or may be an integral part of the overcurrent relay.

The directional relay shall include the three phase and one ground directional elements, if specified in the Bid Drawings and Technical Data Sheets. Each individual directional unit shall have an output contact for controlling the operation of the overcurrent relay.

Provide a test switch for the directional relay. This switch may be common with that of the overcurrent relay.

For the phase directional units, the operational quantity shall be the phase current and the polarizing voltage shall be the non-faulted phase-to-phase voltage which is in quadrature with the current under unity power conditions, the current leading the polarizing voltage by 90 degrees. Maximum sensitivity shall occur when the current leads the polarizing voltage by about 45 or 30 degrees (field selectable). This is equivalent to the current lagging the system phase to neutral voltage by 45 or 60 degrees.

For the ground directional unit, the operating quantity shall be the residual line current and the polarizing quantity shall be derived from the residual voltage of the line. The maximum sensitivity shall occur when the residual current lags the residual voltage by about 60 degrees.

The directional relays shall have an operating parameter listed in the Technical Data Sheets.

The directional relays shall operate when the inputs are in the correct direction, for current values of 0.1 to 30 times rated current and for voltage inputs down to 2% of rated voltage. The boundary of operation shall be ± 90 degrees from the maximum sensitivity angle with an accuracy of + 5 degrees.

The directional relay shall remain stable for voltage inputs of 0 to 2 x rated and currents between 0 to 30 times rated in the restrain direction.

EW-19.3.7.5 Stub Protection

Stub Protection (for lines controlled by two breakers and a line disconnect switch), if required in the Technical Data Sheets shall be included in the scope of line protection system and shall be housed either in Main 1 or Main 2 protection panel as indicated in the Technical Data Sheets. This should be a microprocessor-based or numerical type of relay system for 3-phase tripping and must have the following basic functions:

phase overcurrent	-	to detect phase faults
ground overcurrent	-	to detect ground faults

The stub protection shall protect the section of the bus between the two power circuit breakers and the associated line disconnect switch, when the line disconnect switch is open. The stub protection shall normally be out of service when the line is in service and when the disconnect switch is in the closed position.

This protection shall consist of overcurrent relays (which will be enabled by the line disconnect switch open contact) and a trip relay to trip the breakers three phase, block autoreclosing, and to issue an alarm.

The overcurrent relay shall have elements for at least two phases and one ground. The relay characteristics shall be instantaneous with a setting range of 10 % to 150 % of rated CT secondary current. The relay shall have the operating parameters indicated in the Technical Data Sheets.

The protection should remain stable in the event that transient saturation of bay CT's takes place for a bay through fault.

EW-19.3.7.6 Line Terminal Overvoltage Protection

Line terminal overvoltage protection, if required for the line protection system shall include overvoltage protection relays both for Main 1 and Main 2 protection panel. This should be a microprocessor-based or numerical type of relay system for 3-phase tripping.

Energizing a long Power line or a cable from one end only can result in excessive voltage at the open end and cause equipment damage. The Power line shall not be allowed to be energized from one end only for more than one minute with 1.2 per unit voltage at the open end.

Contractor shall provide an overvoltage relay with two stages of overvoltage sensing, each stage with its own timers. The overvoltage relays shall be connected phase-to-phase and shall have voltage setting ranges of 110 V to 150 V and time setting ranges of 1 s to 99 s. Each stage shall have two output contacts. The relays shall have an accuracy of $\pm$ 2% of voltage setting and a drop-off ratio $\geq$ 97%. Operation of the overvoltage relay shall initiate an alarm for overvoltage stage 1 function and send a direct transfer trip signal to the energizing end to trip the line breakers for the overvoltage stage 2 function. The same direct transfer trip equipment as used for the breaker fail protection shall be used for this purpose.

EW-19.3.8 Breaker Failure Protection (If required as built-in feature of the Line Protection Relay System)

The provisions in Section EW-20.3.10 shall apply.

EW-19.3.9 Fault Locator

The line protection relay panel shall include a fault locator for locating faults on the lines. The fault locator shall be microprocessor-based system.

The fault locator shall provide visual information to the operator by means of a LCD and/or printout of the following:

a. Location of the fault in km or percent length of line length;

b. Pre-fault and fault voltage and currents, including their magnitudes and phase angles;

c. Date and Time of fault occurrence and magnitude of fault resistance.

The fault locator range shall be at least 0.5 to 15 ohms for a 5 A rated current input.

The basic accuracy of fault location shall be within a maximum error of ± 2% of the actual fault location for all types of fault anywhere on the monitored line, as measured from the location of the relay unless otherwise indicated in the Technical Data Sheets. Reference conditions for this basic accuracy are 1.0 to 2.0 times rated current, 60 Hz frequency and for any setting above 1 ohm.

The fault locator shall employ an algorithm that is not affected by the simultaneous presence of fault resistance and load flow with fault current coming from both line ends.

For monitoring parallel lines, zero sequence mutual compensation shall be provided to maintain above specified accuracy. This compensation shall be effective only for the fault locator and shall not affect the distance protection reach measurements when it is a part of the relay.
Accuracy tests shall be conducted for the following conditions:

a. Fault resistance greater than twice the line reactance;

b. Fault current coming from both line ends;

c. Load transfer through the line equal to 50% of the rated capacity at a power factor not less than 90% lagging;

d. Source angle impedances of both ends in either or both the positive- and zero-sequence networks differing by as much as 10 degrees;

e. Strong source and weak source behind relay; also for the source at the other end of the line; and combinations of the above;

f. Faults on the monitored line with a parallel line in service having a zero sequence mutual impedance of 65% of the line zero-sequence impedance.

For cases where three or more of the above conditions occur simultaneously, a 3% maximum error shall be satisfied for faults up to 60% from the relay location; for fault locations of 60% to 75% from the relay location error shall not exceed 5%; and for faults near the end of the line the error shall not exceed 10% under the worst conditions.

Provide type test reports to prove compliance with these requirements. These shall also be verified by simulator testing.

The fault locator shall include provisions for transmitting fault records to the Control Center via an RS232C serial communication port. Any required software and hardware (such as modem or modem splitter) shall be supplied. The required PC-based communication software shall be supplied as part of the fault locator system.

EW-19.3.10 Protection Signaling Equipment

EW-19.3.10.1 General

The protection signaling equipment shall be used for Power line teleprotection schemes and other protection purposes. The types of signaling equipment that shall be employed shall be as stated in the Technical Data Sheets.

The details and characteristics of the protection signaling equipment shall be as described in the Technical Data Sheets.

EW-19.3.11 Other Technical Requirements

Other features for the Line Protective Relays, if required by the NPC are stated in in the Technical Data Sheets.

EW-19.4 INSTALLATION

Installation will be by Contractor unless specified otherwise in Section B.1.0 of the Technical Data Sheets.

When the installation is by Contractor, such as for turn-key contracts complete details of proper handling, storage and transport, installation, testing and commissioning, performance, guarantees, etc. shall be furnished for NPC's review and approval.

EW-19.5 FACTORY ASSEMBLY AND TESTS

EW-19.5.1 Type Tests

EW-19.5.1.1 General

The Contractor shall perform a comprehensive type test on the prototype of the relays to confirm the adequacy of its design and the protection techniques. This test shall include all the necessary tests stipulated in IEC Publication 60255 (all applicable sections). ANSI Std. C37.90 and C37.90a and other standard tests done by the manufacturer, such as the following: power frequency, impulse, high frequency interference, surge withstand capability, spark test, thermal capability, temperature dependency, temperature rise, static accuracy, power consumption, phase selection, dynamic accuracy, distance measurement, directional measurement, operating characteristics and others.

An advanced computer-controlled digital power system simulator, if required in the Technical Data Sheets, shall be used to check the operating characteristics and functional performance of the relays as described in Section EW-19.5.1.2.

EW-19.5.1.2 Model Power System Simulator Testing

EW-19.5.1.2.1 General

Where required, in lieu of minimum service experience as detailed in the Technical Data Sheets, the Contractor shall demonstrate the adequacy of the protection, teleprotection signaling, reclosing, and fault locator systems by connecting them to a power system simulator test system where the protected line and other adjacent sections and plant components are modeled. Digital simulating equipment shall be used for network components modeling.

The adequacy of the protection system is defined to mean that the tests pass all the functional and specific requirements of the specification and that the NPC is completely satisfied with the result of the tests. NPC will not allow shipment of the goods or make any payment to Contractor if not satisfied with the model power system testing.

All of the model power system shall be witnessed by the NPC or his representatives. Any tests performed without the presence of NPC shall be repeated in their presence.

The Contractor shall propose tests to be performed, based on the procedures laid down in the following sections, but the tests to be done shall be mutually agreed upon with the NPC.

The model power system simulation testing shall be done with a frequency of 60 Hz.

EW-19.5.1.2.2 Test Procedures

Faults shall be introduced at locations directly in front of the relay, 25%, 50%, 75% and 100% from the relay terminal. Relay performance for external faults shall also be verified.

The types of faults and any special conditions are indicated in the next section.

A digital fault recorder with 12-bit resolution and frequency response of 1 kHz or better shall be used to record and plot the results of each test shot. All analog input signals and digital input and outputs shall be monitored. Plotting of waveforms and relay contact operations shall be in different colors for each phase quantities. Fault records shall also be stored in 3-1/2" diskettes in a format which can be used with commercial software like DaDisp or RIS TR analysis software so that it can be analyzed further. The diskettes shall be part of the test report.

Each fault type shall be initiated at 15^0 increments in the voltage waveform from 0^0 to 180^0. The shot which gives the worst performance shall be plotted but all shots shall be recorded on diskette.

The line modeling shall include series impedances, shunt admittances, and mutual impedances between the circuits. Several Tee or Pi sections shall be used to increase the modeling accuracy of the lines.

Other system components to be modeled are the sources, line reactors and transformers.

The tests shall be performed with and without load and for both minimum and maximum source conditions. Source impedances may have different phase angle values.

Breaker pole dissymmetry shall be introduced on all tripping. It is recognized that the actual current interruption occurs at a current zero.

Data on the CVT and CT instrument transformers and the connected burden that will be used in the actual system will be used. The modeling will use CVTs and CTs with equivalent or worse characteristics than those which will be used on the actual system.

The protection signaling equipment shall be connected back-to-back if it is not possible to have the communication equipment tested together with the relays; if necessary, the delay time of the Power path may be simulated using a high-speed auxiliary relay. Maximum and minimum Power and reset times of the protection signaling and communication equipment shall be considered.

EW-19.5.1.2.3 Fault Types and Locations

The testing that shall be performed to a minimum is described below:

a. Three-phase faults
b. Phase-to-phase faults
c. Double phase-to-ground faults
d. Single-phase-to-ground faults
e. Successful and unsuccessful single-pole tripping and autoreclosing
f. Simultaneous faults; both external, internal and external for various type and combination faults
g. Internal evolving faults including single-phase faults evolving to double-phase-to ground faults, and phase-to-ground fault tripped single pole and a second phase is faulted later during the single-pole reclose cycle.
h. External single phase-to-ground fault evolving into an internal phase-to-ground fault on the same phase and also on different phase. Different combinations of fault types should also be simulated.
i. Broken conductor with a single-phase-to-ground fault occurring on one side of the break.
j. Relay operation with saturated CTs
k. Relay operation with CVT transients
l. Fault impedances. Single-phase-to-ground fault with fault impedance. Decrease the impedance until the relays operate. This shall be performed both with and without load flowing on the line.
m. Current reversal on parallel circuits with ground faults. The signaling reset time shall be increased until the protection maloperates to determine the limit of the delay margin.

n. System swing conditions, stable and unstable and with four different swing rates.
o. Other tests necessary to prove that the protection system will satisfy the technical specifications.

EW-19.5.1.2.4 Description of the Model Power System to be used

Contractor shall provide together with his proposal a complete and detailed description of the model power system simulator that will be used. This description shall include the number of lines, transformers, and sources that can be modelled, type and rating of components used, CT and CVT type and ratios, modelling limitations, drawings of the system, switching device used for the power circuit breaker, and all relevant data that may be required to model the NPC's power system.

EW-19.5.1.2.5 Additional Testing

NPC reserves the right to specify further tests, i.e. Relay performance near HVDC link, to be performed in order to be satisfied with the performance of the protective relaying system. Changes or additions in the testing procedures shall be mutually agreed upon by the Contractor and NPC.

Contractor's proposal shall indicate all costs and number of days for the performance of actual model power system testing. The Contractor shall provide cost per day for NPC's reference in case additional tests required by the NPC extend the testing time beyond what actually required

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EW-19.5.1.3 Routine Tests

This test shall include material tests during manufacture as per manufacturer's established practice and/or other approved standards. However, on electronic equipment, individual component tests and burn-in tests of important modules (temperature and voltage stress) shall be performed.

Routine testing shall be performed following the requirements of ANSI C37.90 and C37.20 or IEC equivalent and shall include but are not limited to the following:

a. Dielectric (power frequency) test
b. Mechanical operation test
c. Grounding of instrument transformer cases
d. Control wiring continuity test
e. Polarity test
f. Functional test
g. Compliance tests (demonstrating compliance with all parts of this specification)

The Contractor shall furnish a detailed description of the tests, test procedures and results.

EW-19.6 DATA AND DOCUMENTATION REQUIREMENTS

EW-19.6.1 General

Contractor-furnished data and information shall be the guaranteed performance data, predicted performance, interface requirements and construction features of all Contractor's furnished equipment. The accuracy of such information and its compatibility with overall performance requirements specified by NPC are the sole responsibility of the Contractor.

All information submitted as part of Proposal Data will become part of contract data for successful bidder.

EW-19.6.2 Data and Information to be Submitted with the Proposal

Contractor shall furnish with his proposal the filled-in Section A.4.0 of the Technical Data Sheets.

EW-19.6.3 Data and Information to be Submitted During Post Qualification

Contractor shall furnish during post qualification the following:

a. Filled-in Section B.19.0 of the Technical Data Sheets.

b. Contractor shall furnish the brochures and catalogues during post qualification to support the filled-in Technical Data Sheets and to allow NPC to evaluate the equipment/materials being offered

EW-19.6.4 Data and Information to be Submitted After Award of Contract

The following items shall be submitted by the Contractor after award of contract:

a. Outline drawings of the protective relay and accessories showing all critical dimensions and weights, including the following:

    1. Mounting dimensions and details and transport dimensions;
    2. Plans, elevation and sectional views;
    3. Details of relay cubicle and its contents;
    4. Control and power cable entrance openings at the relay cubicle;
    5. Details of terminals and grounding connections;
    6. Channel and support column outline drawing

b. Schematic diagrams for control and protection including interlocking scheme;

c. Arrangement of terminal blocks inside the panel;

d. Protective relay instruction manual covering installation, operation and maintenance;

e. Certified test data, if specified in the Technical Data Sheets;

f. Detailed QA Program based on ISO 9001;

g. Routine Tests Reports;

h. ISO 9001 Certification of the proposed manufacturer;

i. Field Test to be performed and Field Test Reports duly signed by NPC's representative(s); and

j. As- built drawings as finally approved.

The Contractor shall furnish in the manner, number of copies and within the time set forth in the contract, instruction manuals in accordance with Section GW-2.9 of the General Works.

EW-20.0 SUBSTATION PROTECTION SYSTEM

EW-20.1 SCOPE

EW-20.1.1 General

This specification covers the technical and associated requirements for protective relay systems, relay panels, including all the various equipment and devices necessary for protection and disturbance analysis requirements of a substation(s). All materials and parts, which are not specifically mentioned herein but are necessary for the proper erection, assembly and operation of the equipment, shall be furnished at no increase in cost to the NPC.

It is neither NPC's intent to specify all technical requirements nor to set forth those requirements adequately covered by applicable codes and standards. The Contractor shall furnish equipment meeting the requirements of this Specification and the industry standard.

The Contractor shall bear full responsibility that the equipment has been designed and fabricated in accordance with all codes, standards and applicable governmental regulations and performs under the conditions and to the standards specified herein.

No departure shall be made from this specification and standard unless waived or modified in writing by NPC. The Contractor shall obtain from its subcontractors a statement as to compliance with this specification without exception and/or if there are any exceptions these shall be described in detail and included in Contractor's proposal. The Contractor shall add a statement that no other exceptions are taken to this specification.

EW-20.1.2 Works to be Provided by the Contractor

The Contractor shall provide the equipment; accessories and services delineated in Section B.1.0 of the Technical Data Sheets.

EW-20.1.3 Works to be Provided by NPC

NPC shall provide the materials (if any) and services listed in Section B.1.0 of the Technical Data Sheets.

EW-20.2 CODES AND STANDARDS

EW-20.2.1 General

The equipment furnished shall be in accordance with, but not limited to, the latest issues of the following applicable standards, including all addenda, in effect at time of purchase order unless otherwise stated in this specification. These shall include:

ANSI/IEEE	**American National Standards Institute/or Institute of Electrical & Electronic Engineers**
C33.10	Safety Standard for Fuseholders
C33.65	Safety Standard for Cabinets and Fuseholders
C37.1	Standard Definition, Specification and Analysis of Systems used for Supervisory Control, Data Acquisition, and Automatic Control
C37.2	Standard Electrical Power System Device Function Number
C37.90	Standard for Relays and Relay Systems Associated with Power Apparatus
C37.90.1	Standard for Surge Withstand Capability (SWC) tests for Protective Relays and Relay Systems.
C37.90.2	Standard for withstand capability of relay systems to radiated electromagnetic interference from transceivers.
C37.91 (1990)	Guide for Protective Relay Application to Power Transformer
C37.97 (1990)	Guide for Protective Relay Application to Power System Buses
C37.98 (1987)	Standard for Seismic Testing Relays
C37.99 (1990)	Guide for Protection of Shunt Capacitor Banks
C37.109 (1988)	Guide for Protection of Shunt Reactors
C37.103	Guide for differential and polarizing relay circuit testing
C37.111	Standard common format for transient data exchange (COMTRADE) for power systems
C57.13	Standard Requirements for Instrument Transformers
C57.13.1	Guide for Field Testing of Relay Current Transformers
C57.13.3	Guide for the Grounding of Instrument Transformers
Z55.1	Gray finishes for Industrial Apparatus and Equipment
8802-2, to -6	Information Technology, Local and Metropolitan Area Networks, Parts 2,3,4,5 and 6
EIA	**Electronic Industries Association**
310-C	Racks, Panels and Associated Equipment
529	Enclosure Protection
ICBO	**International Conference of Building Officials**
UBC	**Uniform Building Code, Section 2312 – Earthquake Regulations**
ICEA	**Insulated Cable Engineers Association**
S-66-524	Crossed-linked-thermosetting-polyethylene-insulated Wire and Cable for the Power and Distribution of Electrical Energy
IEC	**International Electrotechnical Commission (all parts of listed Standards apply)**
60051	Direct acting indicating analogue electrical measuring instruments and their accessories
60255	Electrical Relays

60258	Direct acting recording electrical measuring instruments and their accessories
60337	Control Switches
60359	Expression of the Performance of Electrical and Electronic Measuring Equipment
60414	Safety requirements for indicating and recording electrical measuring instruments and their accessories
60473	Dimensions for panel-mounted indicating and recording measuring instruments
60625	an interface system for programmable measuring instruments
60688	Electrical Measuring transducers for converting ac electrical quantities
60870-5-103	Interfacing
ISO	**International Standards Organization**
9001	Quality System Model for Quality Assurance in Design/ Development, Manufacture and Testing
9002	Quality System Model for Quality Assurance in Production, Installation and Servicing
SSPC	**Steel Structure Painting Council**
PA1	Shop, Field and Maintenance Painting
PA2	Measurement of Dry Paint Thickness with Magnetic Gages
UL	**Underwriters Laboratories, Inc. (all parts apply)**
44	Rubber-Insulated Wires and Cables

These codes and standards set forth minimum requirements which may be exceeded by Contractor if, in Contractor's judgment and with NPC's acceptance, superior or more economic designs or materials are available for successful and continuous operation of Contractor's equipment as required in this specification.

EW-20.3 TECHNICAL REQUIREMENTS

EW-20.3.1 Description of services

The equipment covered by this specification shall include all electrical features for complete protection and disturbance analysis of a substation and/or switchyard. The application details are in the Technical Data Sheets.

All materials and parts which are not specifically mentioned herein but are necessary for the proper erection, assembly and safe operation of the substation protection relays shall be identified and furnished by the Contractor. Any cost involved are deemed to be included in the price for substation protection relays.

EW-20.3.2 Design Requirements

EW-20.3.2.1 General

The relays shall be the rack mounted type, mounted on EIA standard 19" rack and shall be provided with panel enclosure. All of the relay targets shall be visible without opening any doors.

Where rack mounted switchboard is to be provided for the relays, it shall be mounted side by side with raceways provided for wiring to adjacent racks. The rack shall be designed for easy separation and addition of future on either side.

The relay panels shall be supplied complete with all relays, instruments, meters, indicators, control switches, push buttons, indicating lamps, terminal blocks, wiring and miscellaneous devices as called for by this Specification or indicated in the Bid drawings. The relay panel shall include all required auxiliary relays, resistors, etc., whether or not expressly called for or indicated on the bid drawings. All relay coils, contacts and other features shall be suitable for the apparatus controlled or for the purpose intended. A large number of cables will be brought in through the bottom of the relay panel and adequate provisions shall be made to accommodate, support and terminate these cables on the terminal blocks.

The relay panels shall be designed and wired with relays and devices adequate to protect not only the equipment supplied under this contract but also the future equipment shown in the single line diagram or in the substation layout.

The Contractor shall ensure that all equipment will allow sufficient room for operation, maintenance, future additions and possible future replacement of the defective components.

The Contractor shall ensure that all equipment he supplies, functions correctly and safely.

The characteristics and ratings of the equipment and devices given in the applicable sections are not necessarily the standards of any particular manufacturer but they are the minimum requirements that must be satisfied by the Contractor.

The construction of the different parts of the Supply must be as standard as possible in order to reduce to a minimum the spare parts and to make the maintenance and replacement operation easy. All similar parts must be interchangeable.

The relay panels shall be complete with grounding connection and with all accessories and shall be such as to guarantee correct and trouble free operations.

EW-20.3.3 Design and Construction Features

EW-20.3.3.1 Relay Construction and Mounting

The relay shall comply with the relevant requirements of IEC Publication 60225 or equivalent ANSI/IEEE Standard.

Modular constructed equipment (example, rack mounted solid state relaying equipment) shall be tested as a complete assembly and details of such tests shall be agreed with the NPC when details of the construction are known.

Individual relays and protection equipment intended for the panel or rack mounting shall be designed so that the internal function module(s) are capable of being removed from the case or rack without disconnecting any external wired connections. Means shall be provided to positively locate each withdrawable unit in the "service" position.

Each protection relay, or protection scheme shall be provided with an adequate number of output contacts of suitable rating to carry out the prescribed tripping functions, alarms indication and fault recorder functions and such supplementary signaling functions as may be necessary for the initiation of automatic reclosing or automatic switching control, etc. In all cases, contacts intended for tripping duty shall be designed so that they cannot inadvertently interrupt trip coil current.

For contacts intended to be used to directly energize circuit breaker tripping coils, the Contractor shall indicate the peak value of the permissible making current, and the current carrying capability for 0.5 seconds. Where appropriate, details shall also be given of the operating characteristics of any reinforcing contactor. The Contractor shall also quote the maximum breaking capability of the trip output circuit (in Amp) when associated with an inductive burden having a time constant of not less than 40ms at a rated voltage 125 volts DC and at such other voltage as may be specified for a particular installation.

All electronic protective relays shall be designed to withstand the impulse voltage and high frequency interference test requirements as specified in Clause 8, IEC Publication 60255-5 or ANSI C37.90.1 and Appendix E, IEC Publication 60255-4 or ANSI C37.90.2, respectively. The relay should also comply with IEC EMC Standards listed in Section EW-1.16.8 of the General Technical Requirements. Test frequency requirement shall be as specified in the Technical Data Sheets.

Protective relay which require an independent low voltage DC supply shall preferably use DC/AC/DC converter power pack for this purpose. Separate power packs are preferred for each individual discriminative relay unit. This may be an integral part of the relay.

If the power pack is separately housed from the relay unit(s) which it is supplying, care must be taken that the cabling between the power pack and the relay unit and between relays units is adequately screened and physically separate from all "power type" circuits associated with the CT, VT and DC tripping circuits. All interconnecting screened cables shall preferably be terminated by plug and sockets.

It shall not be possible to gain direct access by means of external connection to any low voltage DC power supply without first removing an appropriate protective cover suitably engrave with a warning that high voltage test shall not be applied. That is, there shall be a degree of mechanical segregation on the CT, VT and DC tripping connection and the low voltage circuits.

All input and output terminals of the power packs which are connected to "power type" circuits shall be subjected to the same over voltage, impulse and interference tests as specified for the protection. The low voltage supply to each discriminative relay unit shall be continuously monitored and an alarm shall be given whenever the voltage exceeds the limits for reliable protection operation.

Each relay, or relay scheme, shall be provided with an adequate number of indications to facilitate post fault analysis including identification of the faulted phase and faulted zone, etc. Requirements for operation indicators are as follows:

a. Long term storage of the indication is not dependent upon an auxiliary supply.

b. Means are provided to ensure that the indication is complete.

c. Each indicator, whether of the electrical or mechanical operated type, shall be capable of being reset without opening the relay case.

d. Unless otherwise approved, indication shall only be given by the protection(s), which causes the fault to be cleared.

e. All indications shall be clearly visible without opening of relay cases or relay panel doors.

Rectifiers used in association with protective relays shall preferably be of the silicon type and appropriately rated for the application.

Where relays are required to operate with accurate time settings, the delaying attachment shall not be of the dashpot type.

Wherever practicable the design of the relay schemes shall be based on the "fail-safe" principle. For example, care shall be taken to ensure that the loss of DC supply or an open circuit does not cause incorrect opening or closing of a circuit breaker. Circuit breaker or isolator repeat relays should be of the latching type and a discrepancy alarm shall be provided to check correct operation of the relays following a circuit breaker or isolator operation.

Lockout tripping relays shall be of the latching type and shall be hand or electrically reset as specified.

Numerical relays must be provided by at least two serial interfaces according to IEC 60870-5-103.

EW-20.3.4 Substation Protection Requirements

EW-20.3.4.1 General

The protection system for the substation protection shall be as stated in the Technical Data Sheets. Depending on the requirements and importance of the equipment protected, the protection system may consist of one, two or more completely independent sets.

Where two of more protection sets have been specified in the Technical Data Sheets, they shall be fully independent of each other and shall be located in separate cubicles and shall be made preferably by different manufacturers, unless otherwise indicated in the Technical Data Sheets.

In addition to the basic function of the relays, supplementary and back-up protective functions shall also be provided in this specification and in the Technical Data Sheets.

All protective relays shall be of numerical design.

The relay design shall include extensive automatic self-checking facilities to supervise and monitor the condition of the individual processors, measuring elements, DC supply, etc. Any abnormal condition detected shall initiate an alarm and indicate the defective element. Defects that may cause mis-operation of the relay shall inhibit operation of that particular relay or element of a relay system. Less critical defects may initiate an alarm only.

Where voltage inputs are required, these shall be monitored continuously. Any open phase shall be detected high speed and shall prevent mis-operation of the affected protective relays. Unbalanced conditions in the current circuits due to defective connections should also be monitored.

Test facilities shall also be provided for each equipment.

EW-20.3.4.2 Relay Performance Requirements under CT Saturation/CVT Transients

The protective relay system shall operate correctly in the presence of simultaneous CVT transients and CT saturation.

Current Transformers. The protection shall operate correctly and within the required operating speed even when the CTs supplying current to it saturate completely one cycle after fault inception. When two circuit breakers control a line, Contractor shall ensure that when one of the CTs saturates for any external fault at the bus or other circuits, mis-operation of the relay shall not occur.

Capacitor Voltage Transformers. The relay system shall operate correctly and with high speed and shall have correct directional sensing in the presence of severe CVT transients produced in accordance with ANSI Standard C93.2 or IEC equivalent. The CVT transient requirement shall include the conditions of relaying accuracy with the rated burden of the CVT connected. The relay response to CVT transients shall be demonstrated during model power system testing.

The relay contractor shall ensure that the relay system being furnished shall operate satisfactorily with the instrument transformers to which they will be connected. The relay contractor shall coordinate with the instrument transformer manufacturer in making sure that the CT and CVT characteristics satisfy the protection requirements for all conditions, including CT remanence, high-speed autoreclosing and allowing for some future system expansions. The relay contractor shall provide the NPC with copies of any coordination correspondences with the instrument transformer manufacturer or calculation to prove that the relay requirements will be met. CT's or CVT's that are found to be unsuitable, as a result of failure of the relay manufacturer to coordinate his requirements, must be replaced by the relay contractor at no cost to the NPC.

EW-20.3.4.3 Relay System Security, Dependability and Speed

The relay system shall meet basic security, dependability and speed requirements described below.

Security. The relay system shall be very secure. The consideration for selection of the relay system will place much emphasis on the security of the relay system. Any false trip output cannot be tolerated due to the difficulties that would arise with more than one Power line out of service. The security of the relay system shall be demonstrated on model system tests as discussed in Section EW-20.5.1.2. The relay shall not commit maloperation with any of the following conditions:

a. Any kind of external faults beyond the protected sections

b. Transient system disturbances

c. Current surges due to sudden change of line charging capacity in the case of one phase to ground fault, line switching on external faults, etc.

d. DC components of short circuit currents

e. Magnetic fields from other relays

f. Normal discharges of arresters installed in the protected sections.

The operating time of the relay system shall conform to the operating time listed in the Technical Data Sheets.

Dependability. The relay system shall be highly dependable. The relay system shall produce a trip output for all types of faults within the zone of protection. The dependability of the relay system shall be demonstrated through conjunctive model system tests as discussed in Section EW-20.5.1.2.

EW-20.3.4.4 Relay System Disabling

A master disabling switch or equivalent features shall be supplied for the purposes of completely disabling the relay system. The features shall include the following:

a. Open all relay system trip outputs

b. Open all potential supplies to the relay system

c. Short circuit current transformer secondaries before opening all current circuits to the relay system

d. Energize a substation annunciator lamp

e. Input to the station sequence of events recorder

f. Disable all relay system outputs such as breaker fail initiate, reclose initiate, reclose block, out of step trip, transfer trip, etc.

EW-20.3.4.5 Transient Protection

The Contractor shall provide adequate surge protection on all current, voltage and DC control leads entering a panel or rack in order to mitigate induced voltages and currents and prevent equipment malfunction or damage. The relay system shall be capable of passing the ANSI/IEEE C37.90 or equivalent IEC Standard surge withstand capability test.

Appropriate wire and cable shielding, twisted wire pairs, separate power and signal grounds and wire routing shall be applied to mitigate induced voltages and currents.

The equipment shall not be damaged or produce a false output with radio frequencies, from 25 to 500 MHz and a field strength of 7 volts/meter measured at the front of the relay case, applied with the relays energized and connected for normal operation.

EW-20.3.5 Power Transformer Protection Requirements

EW-20.3.5.1 General

Depending on the requirements as indicated in the Technical Data Sheets, the protection system for the power transformer may consist of either one or two completely separate protection sets, Main 1 and Main 2. These two protection sets shall be fully independent of each other and shall be located in separate cubicles, unless otherwise indicated in the Technical Data Sheets. The composition of the two protection sets, if two separate protection cubicles are required, is indicated in the Technical Data Sheets.

If the transformer protection is required to be a part of the microprocessor-based substation control and protection system, the relay shall be a full numerical protection relay which shall have an integrated overcurrent, overvoltage (if required), restricted earth fault protection and thermal overload protection function.

EW-20.3.5.2 Transformer Differential Relay

The relays shall be of numerical type capable of three phase tripping.

Depending on the requirement stated on the Technical Data Sheets, the differential relay can be of the type using:

a. Percentage differential with harmonic restraint; or

b. Voltage operated bus type high impedance differential relay.

Differential protection using percentage differential with harmonic restraint shall have the following basic functions as a minimum:

a. Relays shall include harmonic restrained circuits to prevent undesired tripping on exciting inrush.

b. Relays shall include separate restraint circuits to be associated with each breaker current input source.

c. Relays shall include percentage differential characteristic to allow for individual CT errors.

d. Relays shall include instantaneous differential overcurrent element for high-speed trip on high fault currents.

e. The zone of protection shall include transformers, transformer leads, and transformer circuit breakers.

f. The relays shall include provision for CT ratio matching with values specified in the Technical Data Sheets to permit use of different CT ratios. These shall be by means of taps on relays, auxiliary CT's, or numerical methods.

g. The relays shall include targets and output contacts for tripping the lockout relay.

h. Relay operating time shall be as specified in the Technical Data Sheets.

Differential protection using voltage operated bus type high impedance relay shall have the following basic functions as a minimum:

a. Relays shall include high impedance voltage element differentially connected to CT's, to detect all types of phase faults and ground faults.

b. Relays shall include instantaneous overcurrent elements for high speed trip for high fault current.

c. The relays shall include targets and output contacts for tripping the lockout relay.

d. Relay operating speed shall be as specified in the Technical Data Sheets.

EW-20.3.5.3 Individual Transformer Single Phase Unit Differential Relays

Where transformer shall consist of single phase banks to form a three phase unit, an individual transformer single phase unit differential relay shall be provided having functions similar to those described in Section EW-20.3.5.2, except that the zone of protection shall be limited up to the transformer bushings.

EW-20.3.5.4 Transformer High Voltage Side Leads Differential Relays (If Required)

This type of relay is required only for single phase unit transformer bank and shall be of type specified in the Technical Data Sheets with the zone of protection up to the high voltage leads and high voltage breakers.

EW-20.3.5.5 Transformer Low Voltage Side Leads Differential Relays (If Required)

This type of relay is also required for single phase unit transformer bank with functions similar to those described in Section EW-20.3.5.4, except that the zone of protection shall include low voltage leads and low voltage breakers.

EW-20.3.5.6 Over excitation/Over fluxing (Excessive Volts/Hz) Relay (If Required)

This shall be of numerical type capable of three phase tripping and shall have the following basic functions as a minimum:

a. Relay shall include volts/Hz sensing unit to detect over excitation. Preference will be given to schemes in which the operating time decreases with increase in voltage or v/Hz so as to match the overheating characteristics of the protected equipment.

b. Relay shall include timing unit to provide selectable inverse time and definite minimum time characteristic for backup tripping on excessive volts/Hz. The setting shall be adjustable within the range which best guarantees safe protection of the primary equipment.

c. Relay shall include stage 1 contact for alarm and stage 2 contacts for tripping the lockout relay. Targets shall be provided.

d. The voltage circuit shall be designed with an adequate factor of safety to withstand the anticipated overvoltage without damage to the relay and without saturation of the relay circuit.

EW-20.3.5.7 Transformer Overcurrent Relays

Transformer overcurrent relays shall include as a minimum:

a. Phase instantaneous overcurrent (50) and phase time overcurrent (51) applied on the high voltage side of the transformer;

b. Instantaneous neutral overcurrent (50N) and time neutral overcurrent (51N) relay applied on the high voltage side of the transformer connected on neutral for back-up protection;

c. Phase time (51) and ground overcurrent (51G) functions applied on the tertiary side of the transformer for back-up protection;

d. Phase instantaneous overcurrent, phase time overcurrent and ground overcurrent time delayed relay applied on the low voltage side of the transformer, if required.

The overcurrent relay shall be numerical type capable of three phase tripping and shall include the following features as a minimum:

a. The overcurrent relay shall have a self-supervision system that continuously monitors/ supervises the function of the microprocessors and the program execution;

b. The overcurrent time characteristics shall be programmable so that it shall be possible to field select definite time, IEC normal inverse, very inverse or extremely inverse characteristics, or equivalent US moderately inverse, inverse, very inverse, or extremely inverse characteristics. It shall be possible to field select the characteristics for phase units independently and different from the ground relay.

c. Overcurrent relays shall include output contacts for tripping the associated breakers directly and for use in substation alarms and event recorders.

d. The overcurrent relays shall be made insensitive to harmonics by use of proper filtering techniques.

e. Overcurrent relays shall include a test switch.

f. Overcurrent relay current setting ranges and parameters shall be as stated in the Technical Data Sheets.

Where directional overcurrent and directional earth fault protection is specified, the following additional requirements are required:

a. The operating time of the directional element shall have negligible influence on the total operating time of the protection;

b. The directional overcurrent and earth fault protection shall operate as a non-directional protection if the directional elements fail to function for any reason (i.e. loss of VT voltage, directional element removed, etc.).

Where voltage controlled overcurrent protection is specified, the minimum operating current at any setting at zero voltage shall not be less than 25 percent of the operating current at 100 percent voltage at the same setting.

EW-20.3.5.8 Neutral Current Protection

Earth fault protection in two steps shall be installed in the transformer neutral. Operating speed and setting range shall be as specified in the Technical Data Sheets. The time delayed elements shall be field selectable to the applications required characteristics: definite time, normal inverse, very inverse, or extremely inverse.

EW-20.3.5.9 Restricted Earth Fault Differential Relay

A high impedance current operated function shall be provided for the high and low voltage side of the transformer with grounded neutral point as required in the Technical Data Sheets. The relay shall remain stable for external faults. The current function shall not be sensitive to harmonics. Operating speed and setting range shall be as specified in the Technical Data Sheets.

EW-20.3.5.10 Lockout Relay

The protection panel shall include a multi-contact lockout relay, selectable manual or electrical reset button on the front of the relay, with sufficient contacts for tripping, close blocking, reclose blocking, breaker failure initiation of the transformer breakers. Contacts for alarm, recorder, remote alarms, etc. shall be included.

If two protection sets are required for the transformer protection, each protection set or cubicle shall have an independent lockout relay equipment.

Operating parameters of the lockout relay shall be as stated in the Technical Data Sheets.

EW-20.3.5.11 Repeat Relays for Mechanical and Electrical Relays Associated with the Transformer

The gas accumulator (Buchholz) relay, sudden pressure (gas and oil) relay, temperature (winding and oil) relay, oil level and faulty cooling equipment relay are the mechanical and electrical relays associated with the protection of the transformer, each having a trip contact operating a trip relay directly. For local and remote alarms of these relays, repeat relays shall be provided and connected to each of the transformer protection trip device and the trip relay. These repeat relay shall have sufficient contacts for all remote alarm and indication functions.

The number of repeat relays required will depend upon the number of transformer protection devices, details of which shall be coordinated by the Contractor of the protection devices with the transformer manufacturer.

EW-20.3.5.12 Overvoltage Protection

Overvoltage protection, if required for the transformer protection, shall be of microprocessor based design or numerical type capable of three phase tripping and shall include the following basic functions as a minimum:

a. The protection shall monitor one or more of the phase voltages and tripping shall occur when the phase voltages exceed the setting in time to prevent damage to the transformer due to extreme high voltage conditions.

b. The setting shall be adjustable within the range with best guarantees safe protection of the reactor.

c. The relay shall have two steps, one for alarm and one for trip.

d. The voltage circuit shall be designed with an adequate factor of safety to withstand the anticipated overvoltage without damage to the relay and without saturation of the relay circuit.

EW-20.3.5.13 Transformer Tertiary Winding Protection

Protection against phase faults where the overall transformer differential protection may lack sensitivity, shall be provided by an overcurrent relay driven from tertiary BCT's. The relay shall be in accordance with Section EW-20.3.5.7 but without 50N/51N. The CT's for this protection shall be connected in Delta.

Protection against earth faults shall be provided by a neutral voltage displacement relay driven from a broken Delta secondary winding of a medium voltage VT connected to the tertiary bus connection. An anti-ferroresonance loading resistor shall also be applied. The relay shall be in accordance with Section EW-20.3.5.12 but with appropriate setting range and insensitivity to 3rd harmonic voltage.

EW-20.3.6 Shunt Reactor Protection Requirements

EW-20.3.6.1 General

Depending on the requirements as indicated in the Technical Data Sheets, the protection system for the shunt reactors may consist of either one or two completely separate protection sets, Main 1 and Main 2. These two protection sets shall be fully independent of each other and shall be located in separate cubicles, unless otherwise indicated. The composition of the two protection sets, if two separate protection cubicles are required, is indicated in the Technical Data Sheets.

If the shunt reactor is required to be a part of the microprocessor-based substation control and protection system, preference will be given to a numerical protection relay which shall have an integrated overcurrent, overvoltage, overfluxing, restricted earth fault (if required) and all other necessary relays including thermal overload protection function to act as a back-up function for the differential protection.

EW-20.3.6.2 Differential Relay

The relays shall be of numerical type capable of three phase tripping.

Depending on the requirement as stated on the Technical Data Sheets, the differential relay can be of the type using:

a. Percentage differential; or

b. Voltage operated bus type high impedance differential relay.

Differential protection using percentage differential shall have the following basic functions as a minimum:

a. Relays shall include separate restraint circuits to be associated with each breaker current input source.

b. Relays shall include percentage differential characteristic to allow the individual CT errors.

c. Relays shall include instantaneous differential overcurrent element for high speed trip on high fault currents.

d. The zone of protection shall include reactors, reactor leads and reactor circuit breakers.

e. The relays shall include targets and output contacts for tripping the lockout relay.

f. Relay operating time shall be as specified in the Technical Data Sheets.

Differential protection using voltage operated bus type high impedance relay shall have the following basic functions as a minimum:

a. Relays shall include high impedance voltage element differentially connected to CT's, to detect all types of phase faults and ground faults.

b. Relays shall include instantaneous overcurrent elements for high speed trip for high fault current.

c. The relays shall include targets and output contacts for tripping the lockout relay.

d. Relay operating speed shall be as specified in the Technical Data Sheets.

EW-20.3.6.3 Restricted Earth Fault Differential Relay

A high impedance current operated function shall be provided for the reactor as required in the Technical Data Sheets. The relay shall remain stable for external faults. The current function shall not be sensitive to harmonics. Operating speed and setting range shall be as specified in the Technical Data Sheets.

EW-20.3.6.4 Reactor Overcurrent Relays

Reactor overcurrent relays shall include as a minimum, phase instantaneous overcurrent (50), phase time overcurrent (51) and ground time overcurrent (51N) functions.

The overcurrent relay shall be of microprocessor based design or numerical type capable of three phase tripping and shall include the following features as a minimum:

a. The overcurrent relay shall have a self-supervisions system that continuously monitors/ supervises the function of the microprocessors and the program execution;

b. The overcurrent time delayed characteristics shall be programmable so that it shall be possible to field select definite time, IEC normal inverse, very inverse or extremely inverse characteristics, or equivalent US moderately inverse, inverse, very inverse, or extremely inverse characteristics. It shall be possible to field select the characteristics for phase units independently and different from the ground relay.

c. Overcurrent relays shall include output contacts for tripping two breakers directly and for use in substation alarms and event recorders.

d. The overcurrent relays shall be made insensitive to harmonics by use of proper filtering techniques.

e. Overcurrent relays shall include a test switch.

f. Overcurrent relay current setting ranges and parameters shall be as stated in the Technical Data Sheets.

EW-20.3.6.5 Overvoltage Relay

Overvoltage protection, if required for the shunt reactor protection, shall be of microprocessor based design or numerical type capable of three phase tripping and shall include the following basic functions as a minimum:

a. The protection shall monitor one or more of the phase voltages and tripping shall occur when the phase voltages exceed the setting in time to prevent damage to the reactor due to extreme high voltage conditions. (Note: Disconnection of the reactor from service shall coincide with the de-energization of the associated Power line for line connected reactor).

b. The setting shall be adjustable within the range with best guarantees safe protection of the reactor.

c. The relay shall have two steps, one for alarm and one for trip.

d. The voltage circuit shall be designed with an adequate factor of safety to withstand the anticipated overvoltage without damage to the relay and without saturation of the relay circuit.

EW-20.3.6.6 Neutral Current Protection

Earth fault protection in two steps shall be installed in the reactor neutral. Operating speed and setting range shall be as specified in the Technical Data Sheets. The time delayed elements shall be field selectable to the applications required characteristics: definite time, normal inverse, very inverse, or extremely inverse.

EW-20.3.6.7 Lockout Relay

The protection panel shall include a multi-contact lockout relay, selectable manual or electrical reset button on the front of the relay panel, with sufficient contacts for tripping, close blocking, and reclose blocking, breaker failure initiation of the transformer breakers. Contacts for alarm, recorder, remote alarms, etc. shall also be included.

If two protection sets are required for the reactor protection, each protection set or cubicle shall have independent lockout relay equipment.

Operating parameters of the lockout relay shall be as stated in the Technical Data Sheets.

EW-20.3.6.8 Repeat Relays for Mechanical and Electrical Relays Associated with the Reactor

The gas accumulator (Buchholz) relay, sudden pressure (gas and oil) relay, temperature (winding and oil) relay, oil level and faulty cooling equipment relay are the mechanical and electrical relays associated with the protection of the reactor, each having a trip contact operating a trip relay directly. For local and remote alarms of these relays, repeat relays shall be provided and connected to each of the reactor protection trip device and the trip relay. These repeat relay shall have sufficient contacts for all remote alarm and indication functions.

The number of repeat relays required will depend upon the number of reactor protection devices, details of which shall be coordinated by the Contractor of the protection devices with the reactor manufacturer.

EW-20.3.7 Shunt Capacitor Protection Requirements

EW-20.3.7.1 General

Depending on the requirements as indicated in the Technical Data Sheets, the protection system for the shunt capacitors may consist of either one or two completely separate protection sets, Main 1 and Main 2. These two protection sets shall be fully independent of each other and shall be located in separate cubicles, unless otherwise indicated. The composition of the two protection sets, if two separate protection cubicles are required, is indicated in the Technical Data Sheets.

EW-20.3.7.2 Shunt Capacitor Overcurrent Relays

Shunt capacitor overcurrent relays shall include as a minimum, phase instantaneous overcurrent (50), phase time overcurrent (51) and ground time overcurrent (51N) functions.

The overcurrent relay shall be of microprocessor based design or numerical type capable of three phase tripping and shall include the following features as a minimum:

a. The overcurrent relay shall have a self-supervisions system that continuously monitors/ supervises the function of the microprocessors and the program execution;

b. The overcurrent time delayed characteristics shall be programmable so that it shall be possible to field select definite time, IEC normal inverse, very inverse or extremely inverse characteristics, or equivalent US moderately inverse, inverse, very inverse, or extremely inverse characteristics. It shall be possible to field select the characteristics for phase units independently and different from the ground relay.

c. Overcurrent relays shall include output contacts for tripping two breakers directly and for use in substation alarms and event recorders.

d. The overcurrent relays shall be made insensitive to harmonics by use of proper filtering techniques.

e. Overcurrent relays shall include a test switch.

f. Overcurrent relay current setting ranges and parameters shall be as stated in the Technical Data Sheets.

EW-20.3.7.3 Overvoltage Relay (Unbalance Protection)

The relay shall be of microprocessor based design or numerical type capable of three phase tripping and shall include the following basic features as a minimum (from ANSI/IEEE C37.99 – 1990 Paragraph 7.3):

a. Relay shall include phase overvoltage functions with adjustable time delays of definite minimum time characteristics. Overvoltage settings shall be as specified in the Technical Data Sheets.

b. The relay should be coordinated with individual capacitor unit fuses such that the fuses will operate to isolate a defective capacitor unit before the bank is switched out of service, and thus provide a convenient visual means of locating the defective capacitor unit.

c. Where possible, the relay should be sensitive enough to alarm for the loss of one unit within a group and trip and lockout on loss of sufficient or additional capacitor units that will cause a group overvoltage condition in excess of 110% of rated voltage.

d. The relay should have a time delay short enough to minimize damage due to an arcing fault within the bank structure, and prevent exposure of the remaining capacitor units to overvoltage conditions beyond their permissible limits. The time delay should also be short enough to avoid damage to the current transformer or voltage transformer and relay system, for a single phase or an open-phase condition.

e. The relay should have a time delay sufficient to avoid false operations due to inrush, ground faults on the line, lightning, switching of nearby equipment, and non-simultaneous pole operation of the energizing switch.

f. The relay should be protected against transient voltages appearing on the control wiring (see ANSI/IEEE C37.90-1989 [6]).

g. The relay should be provided with filter to minimize the effect of harmonic voltages.

h. The relay scheme should have a lockout feature to prevent automatic reclosing of the capacitor bank switching device in the event that an overvoltage trip has occurred. The relay trip circuit components should be coordinated.

i. Other features specified in ANSI/IEEE C37.99 – 1990 Paragraph 7.3 should be considered in the application of this relay.

EW-20.3.7.4 Capacitor Bank Breaker Failure Protection

If the capacitor bank is connected to the bus by a circuit breaker, a breaker failure scheme shall be provided to remove the capacitor bank from the system in the event that the bank's switching device fails to operated correctly for a fault within the capacitor bank. Technical features and characteristics shall be as stated in Section EW-20.3.9.

EW-20.3.7.5 Undervoltage Relay (Loss of Bus Voltage: ANSI/IEEE C37.99 - 1990 [8.5])

The relay, if required shall be connected to the bus VT and shall detect the loss of supply bus voltage tripping the capacitor switching device. Tripping of the relay shall be timed delayed to prevent de-energization of the bank for transient undervoltage conditions which might occur when a source-side switching device operates to clear a fault and then automatically recloses.

The relay should be set such that the relay will not operate for voltages that require the capacitor bank to be placed in service.

EW-20.3.8 Bus Protection Requirements

EW-20.3.8.1 General

Depending on the requirements as indicated in the Technical Data Sheets, the protection system for the bus may consist of either one or two completely separate protection sets, Main 1 and Main 2. These two protection sets shall be fully independent of each other and shall be located in separate cubicles, unless otherwise indicated. The composition of the two protection sets, if two separate protection cubicles are required, is indicated in the Technical Data Sheets.

EW-20.3.8.2 Bus Differential Relay

The bus differential relay shall be of type specified in the Technical Data Sheets and shall be of microprocessor based design or numerical type capable of three phase tripping.

The bus protective relay shall ensure highly reliable protection for both short circuit and ground faults in the bus, and shall not necessarily operate even under extreme CT saturation and even if CTs are of different manufacturer.

Moderately high-impedance percentage differential type, if required, shall have percentage restraint characteristics that are insensitive to the effects of CT saturation on effective external faults. The relay shall respond to internal faults regardless of any possible current transformer saturation.

If a high impedance voltage differential type is selected, the characteristics of the current transformer intended for bus protective relays shall be suitable to the particular type of the relay.

Technical features and operating parameters shall be as specified in the Technical Data Sheets.

EW-20.3.8.3 Lockout Relay

The bus protection system shall include a lockout relay, with sufficient contacts for tripping, close blocking, reclose blocking, breaker failure initiation of all breakers connected to bus, including provisions for future breakers. Contacts for alarm, recorder, remote alarms, etc. shall also be included. The type of lockout relay shall be as specified in the Technical Data Sheets.

If two protection sets are required for the bus protection, each protection set or cubicle shall have an independent lockout relay equipment.

Operating parameters of the lockout relay shall be as stated in the Technical Data Sheets.

EW-20.3.9 Breaker Failure Protection Requirements

EW-20.3.9.1 General

To provide fast back-up protection in case a circuit breaker fails to open when ordered to trip by a protective relay, breaker failure relays shall be provided for each of the breakers as shown in the One Line Diagram. These relays shall be enclosed in a free-standing control cubicle similar to that of other relays. The name of the breaker shall be marked on the relay.

The BF relay functional and technical specification is described below:

The BF relay shall be applicable for use with both three-pole and single-pole tripping schemes. It shall be provided with three current detectors connected to the three-phase currents.

The circuit breaker failure relay shall be activated when the primary relays associated with the protected circuit breaker close their contacts and initiate the trip command to the corresponding circuit breakers. Successful tripping of the circuit breakers by the primary relay will automatically reset the BFR before the time relay of the BFR elapses. If the tripping fails, with the fault current still flowing after a predetermined time, a trip command shall be issued to the circuit breakers that must be opened to isolate the fault including provisions for transfer trip command to adjacent stations.

The BF relay shall be provided with a contact (per phase) to re-trip the primary circuit breaker, via separate wires to the second trip coil.

The design of the relay shall ensure that accurate and consistent timing shall always be achieved under all conditions. Current detectors shall not cause contact disturbances during adverse CT saturation independent of current magnitude and possible dc components. Breaker-fail current detector relays should not be driven from CT's which are also used to drive any high-impedance differential protection, since such CT's may become heavily saturated for in-zone fault conditions. This may impair correct operation of breaker fail current detector in the event of breaker failure to clear a fault within the zone of differential protection.

Also for reliable timing in case of contact bounce of the primary protection relay, seal-in of the breaker failure initiation signal shall be provided.

The BF relay shall be provided with initiation inputs as follows:

a. Per phase initiation for use with single pole tripping schemes.

b. Three phase initiation for use with three pole tripping schemes.

c. Initiation from non-current-operated detection relays (such as Buchholz relay) which shall use the circuit breaker 52a contacts in addition to the current detector as a decision criterion.

BF relay shall be designed to make it secure from unnecessary operation:

a. In case of accidental earth faults in the auxiliary voltage supply circuits.

b. The BF trip relay shall be actuated through an AND circuit from to different channels – the BF logic and BF initiating signal.

c. The output of the BF logic shall be continuously monitored and an alarm given in case a defect is found. If the defect could lead to potential mal-operation, tripping shall be blocked.

The BF relay unit setting ranges and parameters shall be as stated in the Technical Data Sheets. The BF relay unit shall be provided with an accurate timer with a setting range specified in the Technical Data Sheets.

The current detectors shall have a sufficiently wide setting range of at least 0.5A – 10A at 60 Hz in steps of 0.5A.

For the traditional BF scheme which relies on the reset of the current detectors, the reset time shall not be more than what is specified in the Technical Data Sheets. For the BF scheme which relies on the operation of the current detector to start the timer, the pick-up time shall not be more than what is specified in the Technical Data Sheets.

Each BF relay unit shall be provided with its own test switch to allow complete secondary injection and timing tests on the relay. During testing, the CT circuit shall be shorted and the tripping and output signals to the breaker and other BF units shall be opened automatically when the test position is selected or the test plug is mounted. The test facilities shall provide means for injecting currents, input signals, and monitoring all output points.

Initiate and Output/Tripping Logic

a. The BF Protection System shall be provided with the necessary auxiliaries to trip the failed breaker and the adjacent or back-up circuit breakers. For tripping of the bus breakers at least six (6) extra unused contacts shall be provided. It shall be possible to route the trip signal from the bus differential relay for tripping the bus breakers.

b. A hand-reset lock out relay shall be provided to prevent manual closing of the failed circuit breaker and the adjacent circuit breakers. Extra contacts shall also be provided for future use to block closing of the additional breakers in the future.

c. Breaker failure protection and tripping of back-up breakers shall give an alarm and local indications of the failed circuit breaker and adjacent breakers.

d. Breaker fail operation shall also be provided with contacts for use with direct transfer trip of the remote line end breakers, for event recording equipment and to block auto-reclosing.

The BFR shall be provided with a miniature circuit breaker control for the DC supply for each panel.

EW-20.3.9.2 CT Column Short-Zone Fault Protection (for live-tank breakers with CTs on one side only)

Protective relays shall be provided for detection and high-speed clearing of any fault between a circuit breaker and its associated CT column.

When a circuit breaker is open or is tripped, any fault between the circuit breaker and its associated current transformer shall be cleared high-speed.

The short-zone fault (SZF) protection shall be activated, after a short time delay, when the circuit breaker starts to open. Provide a timer (setting range of 20 ms to 200 ms in 10 ms steps) for each phase (when used with single pole-reclosing), which shall be started by the circuit breaker contact opening. When the circuit breaker is in the closed position the protection shall be de-activated.

Tripping may only occur when the following conditions are satisfied simultaneously:

a. The protection is activated

b. Current continues to flow after the breaker is open

c. The line, transformer, or bus protective relays have remained in their operated state.

This protective system may be part of the breaker fail protection but shall clear the fault high-speed and not through the breaker fail timer. The timer for activation of the short-zone protection shall be different from that of the breaker fail protection.

The tripping outputs of the short-zone protection may be the common to that of breaker fail protection; however, indication shall be given for short-zone fault and not breaker failure.

EW-20.3.10 Feeder Protection

EW-20.3.10.1 General

The principle of the feeder protection system is shown in the single line diagram. It shall be a complete and integrated protection for the feeder, the bus and overhead feeders in solidly-grounded networks.

The protection system shall employ modern microprocessor-based design preferably using numerical methods. Extensive self-checking and continuous monitoring function shall be provided to ensure security.

The relays shall be made insensitive to harmonics by use of proper filtering techniques.

Depending on the requirement specified in the Technical Data Sheet, the protection shall consist of phase and ground time and instantaneous overcurrent relays, directional phase and ground relays (if required) and reclosing relays (if required). Other relays such as bus protection relays, differential relays and features such as breaker failure functions, fault recording functions and metering may be included, if required in the Technical Data Sheets.

Alarm and signaling facilities and a test switch at least for each group of relays for every feeder or for each individual relay shall be provided.

EW-20.3.10.2 Overcurrent Relay

The overcurrent relay shall consist of three phase units and a ground unit. Each unit shall have an instantaneous element and a time delayed element.

The overcurrent time delayed characteristics shall be programmable so that it shall be possible to field select definite time, IEC normal inverse, very inverse or extremely inverse characteristics or equivalent US moderately inverse, inverse, very inverse or extremely inverse characteristics for phase units independently and different from the ground relay.

Each overcurrent unit shall be capable of being controlled independently by a directional relay through an input on the overcurrent unit. Overcurrent relays with built-in directional elements are also acceptable. The directional relays shall have the features described in Section EW-20.3.10.3.

Overcurrent relays shall include output contacts for tripping the associated breakers and for use in the substation alarms and event recorders.

Overcurrent relay setting ranges and parameters shall be as stated in the Technical Data Sheets.

The overcurrent relay, if required in the Technical Data Sheets, shall be provided with built-in fault and event recorder. It shall record all the analog voltage and current inputs as well as the operation of the output relays and the control inputs. The relay shall be able to store the last three fault records. The required software and other hardware needed to connect to a standard portable computer to access and analyze the recorded information shall be supplied.

EW-20.3.10.3 Directional Relay

The directional relay, when specified in Bid Drawings and the Technical Data Sheets, shall be used to control the directionality of the overcurrent relays described above. The directional relay may be a separate unit or may be an integral part of the overcurrent relay.

The directional relay shall include three phase and one ground directional elements, if specified in the Bid Drawings and Technical Data Sheets. Each individual directional unit shall have an output contact for controlling the operation of the overcurrent relay.

Each overcurrent units shall have an instantaneous element and a time delayed element. The overcurrent relay should also include an overload element to monitor the line load and provide an alarm when the load exceeds a preset level for some time.

The relay shall be programmable so that is shall be possible to field select definite time, IEC normal inverse, very inverse or extremely inverse characteristics or equivalent US moderately inverse, inverse, very inverse or extremely inverse characteristics. It shall be possible to field select the characteristics for phase units independently and different from the ground relay.

The directional characteristic angle setting for the ground element shall be separate from that of the phase elements.

The relay setting ranges and parameters shall be as listed in the Technical Data Sheets.

For the phase directional units, the operational quantity shall be three phase current and the polarizing voltage shall be the non-faulted phase-to-phase voltage which is in quadrature with the current under unity power conditions, the current leading the polarizing voltage by 90°. Maximum sensitivity shall occur when the current leads the polarizing voltage by about 45° or 30° (field selectable). This is equivalent to the current lagging the system phase-to-neutral voltage by 45°C or 60°C.

For the ground directional unit, the operating quantity shall be the residual line current and the polarizing quantity shall be derived from the residual voltage of the line. The maximum sensitivity shall occur when the residual current lags the residual voltage by about 60°.

The relay shall also include metering facilities with numerical read-out for amperes, voltage, watts, vars, and power factor. The relay shall be provided with a built-in fault and events recorder. It shall record all the analog voltage and current waveform inputs as well as the operation of the output relays and the control inputs. The relay shall be able to the last three fault records.

Interfacing with the relay for settings, reading alarms and event data shall be performed locally with a built-in keypad and by a local PC. It shall also possible to communicate with the relay remotely, via a personal computer with a software, to read data, view or change settings and configuration, and retrieve fault information. The required software and other hardware that are needed to connect to a communication modem and a standard computer to access and analyze graphically the recorded information shall be supplied.

The directional relay shall include output contacts for tripping the associated breakers and for use in the substation alarms and event recorders.

Provide a test switch for the directional relay. This switch may be common with that of the overcurrent relay.

EW-20.3.10.4 Reclosing Relay

When specified in the Bid Drawings and Technical Data Sheet, each feeder shall be provided with a reclosing relay which shall have a programmable auto-reclose sequence to be able to coordinate the instantaneous and time delayed characteristics of the feeder overcurrent relay with the downstream fuses and reclose on the protected circuit.

The autoreclosure unit shall receive its start commands from the instantaneous and time delayed units of the feeder overcurrent phase and ground relay. The starting signal determines whether a high speed or delayed reclosures and time delays required for each reclosure, until a final tripping is made. Consummation of the pre-defined autoreclosure program or sequence shall cause the relay to lockout until the reclaim time has elapsed.

It shall have at least three programmable reclosing shots (one high speed auto-reclose and one to two delayed auto-reclosures) with adjustable dead times specified in the Technical Data Sheets. A trip fail timer shall be provided which starts when the recloser is started and causes the relay to go into lockout if the start input stays on for the duration of the preset trip fail time. The relay shall also have a reset timer which allows the relay to reset from lockout after a successful manual close of the circuit breaker. The reset time shall also be started after the final dead time following successful autoreclosing.

The reclosing relay shall be provided with at least the following inputs:

a. Enable or disable autorecloser from a switch
b. Breaker status via 52a or 52b contact

c. Start by overcurrent protection
d. Start by instantaneous protection
e. Cancel or block autoreclosing and the lockout relay
f. Reset the relay from lockout

The reclosing relay shall be provided with at least the following outputs:

a. Close circuit breaker
b. Autoreclosing in progress
c. Block Instantaneous Overcurrent trip
d. Circuit breaker failed to close
e. Recloser out of service

The recloser shall be provided with counters to count the number of successful first shots, second shots and third shots and the total number of unsuccessful shots.

Each feeder protection, if required in the Technical Data Sheets shall include a breaker failure protection function to provide a faster tripping of the main feeder. This function may be a separate unit or could be a built-in function of the overcurrent relay. The breaker fail function shall be initiated by any overcurrent trip to start a timer. When the breaker fails to open and isolate the fault, the breaker fail protection will trip the adjacent breakers after a preset time delay if the protective relay remains operated and also after checking that the current flowing through the breaker is still above a preset current level. If any of these conditions is not satisfied the breaker fail function resets and does not trip the backup breakers.

The protection system shall also provide protection for faults on the 69 kV bus that is fast enough to operate with 100ms. Schemes using the feeder relays or a separate differential relay to provide this protection will be acceptable. The tenderer shall provide details of the scheme offered.

EW-20.3.11 Other Technical Requirements

Other features for the Substation Protection Relays, if required by the NPC are stated in the Technical Data Sheets.

EW-20.4 INSTALLATION

Installation will be by Contractor unless specified otherwise in Section B.1.0 of the Technical Data Sheets.

When the installation is by Contractor, such as for turn-key contracts complete details of proper handling, storage and transport, installation, testing and commissioning, performance, guarantees, etc. shall be submitted for NPC's review and approval.

EW-20.5 FACTORY ASSEMBLY AND TESTS

EW-20.5.1 Type Tests

EW-20.5.1.1 General

The Contractor shall perform a comprehensive type test on the prototype of the relays to confirm the adequacy of its design and the protection techniques. This test shall include all the necessary tests stipulated in IEC Publication 60255 (all applicable sections), ANSI Std. C37.90 and C37.90a and other standard tests done by the manufacturer, such as the following: power frequency, impulse, high frequency interference, surge withstand capability, spark test, thermal capability, temperature dependency, temperature rise, static accuracy, power consumption, phase selection, dynamic accuracy, distance measurement, directional measurement, operating characteristics and others.

EW-20.5.1.2 Type Tests Report

The Contractor shall submit six (6) certified copies of the results of type tests on each type of equipment to be supplied to show the adequacy of its design.

EW-20.5.2 Routine Tests

These tests shall include material tests during manufacture as per manufacturer's established practice and/or other approved standards. However, on electronic equipment, individual component tests and burn-in tests of important modules (temperature and voltage stress) shall be performed.

Routine testing shall be performed following the requirements of ANSI C37.90 and C37.20 or IEC equivalent and shall include but are not limited to the following:

a. Dielectric (power frequency) test
b. Mechanical operation test
c. Grounding of instrument transformer cases
d. control wiring continuity test
e. polarity test
f. Functional test
g. Compliance tests (demonstrating compliance with all parts of this specification)

The Contractor shall furnish a detailed description of the tests, test procedures and results.

EW-20.5.3 Additional Testing

NPC reserves the right to specify further tests to be performed in order to be satisfied with the performance of the protective relaying system. Changes or additions in the testing procedures shall be mutually agreed upon by the Contractor and NPC.

Contractor's proposal shall indicate all costs and number of days for the performance of actual model power system testing. The Contractor shall provide cost per day for NPC's reference in case additional tests required by the NPC extend the testing time beyond what is actually required.

EW-20.6 DATA AND DOCUMENTATION REQUIREMENTS

EW-20.6.1 General

Contractor-furnished data and information shall be the guaranteed performance data, predicted performance, interface requirements and construction features of all Contractor's furnished equipment. The accuracy of such information and its compatibility with overall performance requirements specified by NPC are the sole responsibility of the Contractor.

All information submitted as part of Proposal Data will become part of contract data for successful bidder.

EW-20.6.2 Data and Information to be Submitted with the Proposal

Contractor shall furnish with his proposal the filled-in Section A.5.0 of the Technical Data Sheets.

EW-20.6.3 Data and Information to be Submitted During Post Qualification

Contractor shall furnish during post qualification the following:

a. Filled-in Section B.20.0 of the Technical Data Sheets.

b. Contractor shall furnish the brochures and catalogues during post qualification to support the filled-in Technical Data Sheets and to allow NPC to evaluate the equipment/materials being offered

EW-20.6.4 Data and Information to be Submitted After Award of Contract

The following items shall be submitted by the Contractor after award of contract:

a. Outline drawings of the protective relay and accessories showing all critical dimensions and weights, including the following:

   1. Mounting dimensions and details and transport dimensions;
   2. Plans, elevation and sectional views;
   3. Details of relay cubicle and its contents;
   4. Control and power cable entrance openings at the relay cubicle;
   5. Details of terminals and grounding connections;
   6. Channel and support column outline drawing

b. Schematic diagrams for control and protection including interlocking scheme;

c. Arrangement of terminal blocks inside the panel;

d. Bill of material and parts list of relay cubicle components;

e. Protective relay instruction manual covering installation, operation and maintenance;

f. Certified test data, if specified in the Technical Data Sheets;

g. Detailed QA Program based on ISO 9001;

h. Type test reports summary sheets for the equipment types (or similar type) included in the Tender;

i. Routine Tests Reports;

j. ISO 9001 Certification of the proposed manufacturer;

k. Field Test to be performed and Field Test Reports duly signed by NPC representative(s); and

l. As- built drawings as finally approved.

The Contractor shall provide in the manner, number of copies and within the time set forth in the NPC order, instruction manuals in accordance with Section GW-2.9 of the General Works.

SECTION VI

PART I

TECHNICAL SPECIFICATIONS

MECHANICAL WORKS

PART I - TECHNICAL SPECIFICATIONS

MW - MECHANICAL WORKS

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MW - MECHANICAL WORKS

MW-1.0 GENERAL

The Work to be done under this section shall include the furnishing of all labor, materials, equipment, tools and other incidentals for all mechanical works enumerated hereunder or as shown on the accompanying drawings and installation manuals or as otherwise directed by NPC.

The work shall be performed and completed with high quality workmanship in accordance with generally accepted modern practice in installation/erection works of Mechanical Equipment for the **10 MVA MASBATE (MALINTA) SUBSTATION PROJECT**.

All equipment and materials which the Contractor shall supply and install shall be new and unused. They shall be suitable for their intended purpose and shall comply with all applicable regulations, quality and dimension standards.

The Contractor shall closely coordinate with other disciplines to avoid interference with other works specified in the relevant sections of this specification.

MW-2.0 SCOPE OF WORK

It is not the intent of this specification to specify all technical requirements or to set forth those requirements covered by applicable codes and standards. The Contractor shall furnish high quality work, materials and equipment meeting the requirements of this specification and industry standards.

The Contractor shall also be responsible to assess and determine all and every work and service although not specifically detailed but are deemed required to fully complete the work and smooth execution of the project. Relative costs of any additional works or materials which the Contractor deemed required or necessary to complete the works shall be included in the bid proposal.

The work to be done under this section shall comprise the furnishing of all labor, tools, equipment, supply of appurtenant materials and other incidentals including installation/erection and test of all mechanical works enumerated hereunder in accordance with the Specifications contained herein and as shown in the drawings or otherwise directed by the NPC, which shall consist of but not limited to the following:

a) Well drilling, Well development and pumping test with a minimum depth of approximately 20m, 50mm ∅ well casing and pump suction pipe installation and well disinfection;

b) One (1) unit of convertible jet pump, 2.6 m^3/hr (11.5 gpm);

c) One (1) unit of elevated water tank with a capacity of not less than 900 liters (237 gal);

d) Two (2) units of Wall Mounted Split Type, Inverter Type, Air Conditioner of 12,000 kJ/hr minimum cooling capacity for Switchgear/Auxiliary Room, complete with its mounting accessories and controls;

e) Two (2) units of Wall Mounted Split Type, Inverter Type, Air Conditioner of 20,000 kJ/hr minimum cooling capacity for Control/Relay Room, complete with its mounting accessories and controls;

f) One (1) unit of Wall Mounted Exhaust Fan, 150 m^3/hr minimum capacity for Restroom, complete with its mounting accessories and controls;

g) One (1) unit of Wall Mounted Exhaust Fan Explosion Proof, 450 m^3/hr minimum capacity for Battery Room, complete with its mounting accessories and controls;

h) One (1) lot of Domestic Water Supply Piping materials, valves, including pipe fittings, gaskets, flanges, bolts and nuts, pipe supports, excavation and backfilling works for embedded pipes and other incidentals to complete the domestic water supply piping system;

i) Four (4) units of Portable Type Fire Extinguisher, Clean Agent (HCFC or Halotron I Type), 7.1 kg. (15.5 lbs), wall-hung type and shall be in certified/ approved by the certifying body specified in MW-6.1 to be installed in designated areas as shown on the drawings;

j) Submit all necessary permit such as drilling permit; and

k) All other works and services required to complete the project.

MW-3.0 MATERIALS AND EQUIPMENT

MW-3.1 General

All materials, equipment, devices and accessories shall be new and unused, free from all defects and imperfections, and best suited for the purpose intended. Materials used in the manufacture and installation of all equipment to be furnished shall be of the required quality used in commercial products of reputable manufacturers. All equipment or substitute materials to be used shall conform to the latest specifications and provisions of approved standards of engineering societies or other equivalent standards approved by NPC.

All materials, parts and assemblies to be used shall be tested conforming to the latest specifications and provisions of approved Standards of Testing Materials. Results of the test shall be made to provide means of determining compliance with the applicable specifications. When requested, all tests or trials shall be made in the presence of NPC's duly authorized representative.

If the equipment fails to meet the guaranteed performance as determined by the test, the Contractor shall promptly make the necessary modifications at no cost to NPC.

Brochures, catalogs and other related technical data of materials and equipment to be supplied by the Contractor under this contract shall be submitted by the Contractor for NPC's review and approval prior to fabrication. Equipment or articles installed or used without such approval shall be at the Contractor's risk of subsequent rejections.

MW-3.2 Applicable Codes and Standards

The design, materials, equipment, manufacturing, construction, installation, and testing of all works under this contract shall be in strict accordance with the latest edition of all applicable codes and standards, national and local laws, codes and regulations, statutes and ordinances.

The latest edition of each standard shall mean the latest edition available at the date of contract signing.

All units, dimensions and calculations shall be in metric system.

MW-3.3 Test of Materials

All materials, parts and assemblies to be used shall be tested conforming to the latest specifications and provisions of approved Standards of Testing Materials. Results of the test shall be made to provide means of determining compliance with the applicable specifications. When requested, all tests or trials shall be made in the presence of NPC's duly authorized representative.

If the equipment fails to meet the guaranteed performance as determined by the test, the Contractor shall promptly make the necessary modifications at no cost to NPC.

MW-3.4 Submittals

The Contractor shall submit the technical specifications/data and brochures/catalogs of all equipment and materials to be supplied for NPC's review and approval prior to purchase and/or implementation including other necessary documents as required or specified in the relevant sections of this specification. Equipment or materials installed or used without such approval shall be at the Contractor's risk of subsequent rejections.

MW-4.0 DOMESTIC WATER SUPPLY SYSTEM

MW-4.1 General

This section provides the essential information for the design, supply, delivery, installation, construction, test and commissioning of the complete Domestic Water Supply System to provide the water requirement for the 10 MVA Masbate (Malinta) Substation Project including excavation and backfilling works for the piping system.

The work shall include the supply, installation and test of the following equipment and materials but not limited to:

a) One (1) lot of Drilling and Well Development, Casing Installation, and Well Disinfection;

b) One (1) set of 2.6 m^3/hr (11.5 gpm) Convertible Jet Pump and accessories;

c) One (1) set of Elevated Water Storage Tank with a capacity of not less than 900 liters (237 gal);

d) One (1) lot of Spare Parts (as specified and/or per manufacturer's recommendation) for the Convertible Jet Pump for one (1) year operation;

e) One (1) lot of piping, fittings, valves and necessary accessories including the required excavation and backfilling works for the domestic water supply piping system; and

f) Disinfection of water supply line from deep well to distribution systems.

MW-4.2 Drilling, Developing and Testing of Deep Well

MW-4.2.1 General

The Contractor shall furnish labor, materials and equipment and perform all operations in connection with the drilling, placing of casing, well development, pumping test and disinfection of the well which shall be drilled to an appropriate size and depth.

Depth of well shall be approximately at 20m or at a water level suitable for drinking purposes. The Contractor shall be responsible for the geological/ground water study as to where the well will be drilled taking into consideration the location of the elevated water tank and convertible jet pump shown on the drawing.

The Contractor shall secure a Drilling Permit from National Water Resources Board (NWRB) and submit copy to NPC, together with the well-drilling data. A duly registered well driller shall undertake the drilling pursuant to the Amended IRR of PD 1067 (Water Code of the Philippines).

MW-4.2.2 Drilling

Drilling of the well shall be done by an appropriate method most suited to the conditions of the deep well site to be drilled. When necessary, temporary casing shall be used in sections in the hole through over burden or unstable materials to prevent caving-in of the well.

Drilling shall be extended until such depth wherein at least 2.6 m^3/hr well capacity is obtained and at a water level suitable for drinking purposes.

Location of the well drilling site shall be as near as possible to the place of the elevated water tank.

MW-4.2.3 Well Completion and Development

The Contractor shall develop the well by an appropriate method most suited for the conditions of the well site and placing ready for installation of the convertible jet pump.

The Contractor shall undertake all operations pertaining to completion and development of the well which shall consist of installation of casing, installing well screen in a sand and gravel formation, developing toe water bearing, surging and back washing.

All permanent casing materials shall be new. The well casing to be installed shall be 50mm Ø GI steel pipe, while the pump's suction pipe is 32mm Ø steel pipe conforming to ASTM A 53 seamless hot dip galvanized, schedule 40 pipe. Opening of the well screens shall have dimension to avoid the sediments to pass into the well and shall be designated to prevent clogging and shall be free from jogged edges, irregularities, etc. that will accelerate clogging or corrosion.

The Contractor shall provide and install formation stabilizer or gravel pack which shall consist of well rounded, water-worm siliceous grains. Angular chippings or road stone must under no circumstances be used as formation stabilizer/gravel pack material.

The method of placing the formation stabilizer/gravel pack in the annulus shall be such that separation of the gravel and bridging is avoided. The formation stabilizer or gravel pack shall be of approved type.

The formation stabilizer/gravel pack shall immediately upon completion of casing installation, be placed in the annulus between the borehole and the casing, in the screened section(s) of the casing by the use of tremie pipe to ensure proper installation.

MW-4.2.4 Pumping Test

Pumping test shall be performed by the Contractor to determine the well capacity and other hydraulic characteristics of the water bearing strata.

The Contractor shall furnish and operate a pump for this purpose that is capable of continuous operation at sustained delivery of 2.6 m^3/hr (11.5 gpm) capacity or more in a duration of a least thirty (30) minutes of pumping test operation. Measurements of the volume of water pumped per minute, the depth of static water level before pumping started, the depth of piping level at one or more constant rate of pumping, the rate of recovery of water level after pumping test stopped, and the length of pumping time of each pumping rate shall be made by the Contractor in the presence of NPC or its representative.

The Contractor shall construct ditches or other structures necessary to conduct water away from the well.

All the necessary equipment and measuring devices for testing the well shall be calibrated and provided by Contractor at his own expense.
After developing and testing operations are completed to the satisfaction of NPC, the Contractor shall measure the depth of the well and record the total open depth of the well and casing. Sterilization of the well is done by pouring a solution of one (1) pound of high-test calcium hypochlorite in ten (10) gallons of water or as recommended by the Manufacturer subject to approval by NPC.

MW-4.3 Convertible Jet Pump

MW-4.3.1 Scope of Work

The scope of work covers the supply, delivery, installation and test of one (1) set of convertible jet pump with sufficient horsepower rating capable of delivering a rated capacity of 2.6 m^3/hr (11.5 gpm) at 35m head complete with all controls and necessary accessories, equipment foundation and anchor bolts including spare parts required during the 1 year warranty period as recommended by the pump manufacturer.

The supply shall include but not limited to the following:

a) One (1) unit of 32mm ∅ Gate Valve @ pump's suction;

b) One (1) unit of 25mm Ø Gate Valve @ pump's discharge;

c) One (1) unit of 25mm Ø Check Valve @ pump's discharge;

d) Two (2) units of Pressure Gauges @ pump's suction and discharge;

e) One (1) set of 32mm∅ Stainless Steel Screen with 5mm ∅ Slots and Brass Foot Valve @ pump's suction pipe; and

f) One (1) lot of Standard spare Parts for convertible jet pump as recommended by the manufacturer for one (1) year operation.

MW-4.3.2 Operating Conditions

The convertible jet pump shall be installed in a well suitably drilled and developed under Section MW 4.2 of this specification. The pump shall be capable of automatically operated by a level switch installed in the elevated water storage tank or manually from a local control panel installed in the jet pump house.

MW-4.3.3 Materials and Construction

a) Pump Assembly

Pump shall be centrifugal type capable to discharge not less than 2.6 m^3/hr (11.5 gpm) of water against a total dynamic head of not less than

35 meters. The pump shall be designed to operate continuously or intermittently with no fear of damage to the motor.

The materials used shall be cast iron body with corrosion and abrasion resistant impeller made of glass filled Noryl plastic or approved equivalent. Shaft shall be of high grade stainless steel, designed for maximum load-carrying capability.

The pump shall be of convertible jet pump, packer type designed to handle source water up to a depth of approximately 15 meters at reduced capacity. The pump shall be complete with necessary fittings and accessories to provide the safe and reliable operation of the pumping system.

Pump shall be directly coupled to the electric motor which complies with the latest NEMA standards.

The motor shall be operated on 230V, single phase, 60hz suitable for continuous operation. The motor shall be equipped with built-in overload protection and automatic reset to assure safe motor operation under normal field conditions.

Motor shall be provided with suitable electrical control and complete protective devices. The control relays of the motor starter shall be contained in the steel metal enclosures or control panel. The pump shall be operated in conjunction with the level controller that is to be installed with the above ground Elevated Water Storage Tank.

b) Power Cable

Power supply and control cables shall be included in the supply. Power supply shall be sourced from the field office and terminated in the pump's local control panel installed in the convertible jet pump house. The cables shall be sized suitably for the proper pump operation conforming to the requirements specified in the relevant Electrical specifications.

c) Controls

Motor shall be provided with suitable electrical controls and complete protective devices. The control equipment shall be of level switch actuated control type. The control relays shall be contained in the steel metal enclosures/control panel of the motor starter. The pump shall either be operated automatically in conjunction with the level switch installed in elevated water storage tank or manual-local control push buttons provided at the pump's local control panel installed in the jet pump house.

The local control panel shall include pump starter, circuit breaker, motor overload protection, pump control relay, internal 230-24 volt control transformer for supplying power to the instruments and control system, start/stop push buttons with indicating lights, power supply indicating light, failure or trouble alarm and other components required for proper operation of the convertible jet pump. The change over switch for AUTO-LOCAL operation shall be provided in the control panel.

MW-4.3.4 Jet Pump House

The Contractor shall construct the Pump House which will house the Convertible Jet Pump in accordance with the attached Civil Work drawings. The pump house shall be provided with lighting and other amenities to conform with the requirements specified in the relevant Electrical and Civil works Technical Specifications and drawings.

MW-4.3.5 Submittal

The following documents shall be submitted by the Contractor for NPC's review and approval:

a) Technical data, specifications and catalogues;
b) Outline, assembly and installation drawings showing all the dimensions;
c) Operation and maintenance manuals; and
d) Complete test reports.

MW-4.3.6 Spare Parts

The Contractor shall supply recommended spare parts for one (1) year operation of the convertible jet pump which include but not limited to the following:

a) One (1) set of bearing for each kind/type
b) One (1) set of special gaskets
c) One (1) lot of spares per Manufacturer's recommendation

MW-4.4 Elevated Water Storage Tank

The Contractor shall supply, deliver, install and test one (1) set of Water storage tank. The water storage tank shall have a minimum capacity of 900 liters (237 gal) and shall be of triple layer polyethylene type. The water storage tank shall be complete with manhole, inlet and outlet nozzles with valves, overflow pipe, strainer, drain nozzle with valve, pipe supports, access ladder and supporting steel structures.

Tank foundation and supporting steel structures shall be in accordance with requirements of relevant Civil Works specifications and drawings.

MW-4.5 Domestic Water Supply Piping System

MW-4.5.1 Scope of Work

The Contractor shall supply, install and test the Domestic Water Supply and Distribution Piping System including piping supports, fittings, all required excavation and backfill of pipe trenches.

The work shall include the installation of valves, valve boxes if necessary, gauges and other accessories to complete and make ready for safe and reliable operation of the system, but not limited to the following:

a) Two (2) units of 25mm Ø Gate Valve @ tank's outlet and drain line;

b) One (1) unit of 20mm Ø Isolation Valve @ guard house supply line;

c) One (1) unit of 20mm Ø Isolation Valve @ comfort room supply line;

d) Two (2) units of 20mm Ø Garden Hose Valve or Hose Bibb @ different locations outside the Control House and Guard House; and

e) One (1) lot of domestic water piping, pipe fittings and other necessary accessories.

MW-4.5.2 Pipe, Fittings and Accessories

Domestic water supply piping to be used shall generally be made of Unplasticized Polyvinyl Chloride (*uPVC)* pipe, Class 150, conforming to ASTM D-1784 or approved equivalent, unless otherwise specified.

Unplasticized PVC pipe connection joints 80 mm (3") Ø and above shall be joined by rubber ring or solvent cement type connection per manufacturer's standard. Smaller sizes shall be of solvent cement type connection. Flanged connections may be used for connecting to flanged surfaces and shall be of the same material with the connected pipe with a rating of Class 150 or ANSI 150.

Hot-dip galvanized steel pipe shall be used for deep well casing conforming to ASTM A 53 Gr. A, Schedule 40 including pump suction pipe and discharge pipe up to pump outlet gate valve.

The piping shall generally be laid underground. All trenches shall be provided with a cushion pad of at least 100mm sand and sandy soil bedding materials. All pipeline excavations shall be backfilled up to the level of the finished grade surface in layers of 150 mm and each layer shall be thoroughly compacted. Backfill materials shall be compactable soil taken from trench excavation and approved by NPC.

All pipes that cross roadways shall be provided with pipe sleeve made of steel material or RCP pipe to protect the pipe from various loads imposed by vehicles and shall extend 600mm beyond shoulder of each pavement side. Embedded water supply pipes in open areas shall be laid not less than 300mm from the ground surface to the bottom of pipe.

PVC pipe installed aboveground shall be properly supported to avoid pipe sagging. Pipe covering made of steel or metal shall be provided in case there is high risk of damaging the pipe during normal operation and maintenance.

All trench excavation and backfill works shall be done in accordance with pertinent provisions specified in the Civil Works Specifications.

MW-4.5.3 Valves and Accessories

All gate and globe valves, 65mm and over shall be of OS & Y, solid wedge type disc for gate valves and plug type disc for globe valves, bolted, bonnet, bolted gland and have flanged ends with the following materials of components:

a)	Body & bonnet	-	Cast iron
b)	Stem	-	Bronze or brass
c)	Seat ring & seat	-	Bronze or bronze faced
d)	Wedge or disc	-	Bronze or bronze faced

Gate and globe valves, 50mm and smaller shall be made of bronze, rising stem, union bonnet, inside screw, solid wedge or plug type disc, and screwed ends. Valves installed in valve boxes shall have flanged ends for easy replacement or if valves with screwed ends are used, appropriate unions shall be installed.

Check valve shall be of swing disc type, cast bronze body for 50mm Ø and below and designed for mounting in horizontal piping runs.

Valves of all sizes shall have a rating of not less than Class 150.

Garden hose connection valves or hose bibbs shall be of bronze material, 20mm size and outfitted with male thread hose connections.

Strainers, if required, shall be of Y-type with cast iron or PVC body material and flanged or screwed ends. Screen elements shall be of stainless-steel construction with minimum of 40-mesh size.

The pressure gauge shall be of bourdon tube type with design measurement range to be selected so that normal pressure measured shall lie between 50 to 75% of the designed range. The gauge shall have a solid front case with at least 80mm Ø minimum size of dial gauge. Each pressure gauge shall be provided with cast bronze material isolation valve.

A level switch shall be supplied and designed for proper operation of the jet pump to control water level in the tank.

It shall be of magnetic type with a float carrying a permanent magnet that sets on switch mounted on tank top. The control shall be supplied with normally closed contacts. The operation shall be such that two (2) controls shall be used to control operation of the jet pump. One control is set for turn-off level and the other is set for the turn-on level which is approximately 60% capacity of the tank. A magnetic starter or contactor with a holding contact shall be supplied, which hold circuit-in after level drops below turn-on control. The level switch shall have stainless steel chamber and float with 2-level set points (adjustable).

MW-4.5.4 Installation

The Contractor shall install the piping system in a thorough manner and with good workmanship in accordance with the construction drawings and specification or as directed by NPC. No installation work for underground pipe shall commence unless trench excavation has been approved by NPC.

All pipes, fittings, valves and appurtenances shall be free from dirt or other foreign matters before it is laid. In the installation of the pipes, care shall be taken to prevent the pipes from becoming clogged during the progress of the work. Should any pipe become either partially or wholly clogged before final completion of the work, it shall be cleaned out by the Contractor in a manner satisfactory to NPC or shall be replaced by and at the expense of the Contractor. Open ends shall be temporarily plugged, otherwise suitably closed when necessary.

Special care shall be taken in carrying out the installation of joints, branches, valves and other fittings.

All piping works shall be coordinated with any other work at site and with existing installation so that interference between piping and other structural features will be avoided. In case interferences occur, NPC will decide which work is to be relocated.

Where pipeline are laid, the trench shall be provided with a cushion pad of at least 100 mm sand and sandy soil bedding materials.

Embedded water supply pipes in open areas shall be laid not less than 300mm from the ground surface to the bottom of pipe.

All pipeline excavation shall be backfilled up to the level of the finished grade surface in layers of 150 mm and thoroughly compacted. Backfill materials shall be compactable soil taken from trench excavation and approved by NPC.

All pipes that cross roadways shall be provided with pipe sleeve of steel material or reinforced concrete pipe to protect the pipe from various loads imposed by vehicles and shall extend 600mm beyond shoulder of each pavement side.

PVC pipe installed aboveground shall be properly supported to avoid pipe sagging. Pipe covering made of steel or metal shall be provided in case there is high risk of damaging the pipe during normal operation and maintenance.

All existing facilities affected and damaged during the installation of piping shall be replaced and/or restored to its original appearance by the Contractor at his own expense.

Transportation, storage and erection shall be in strict accordance with manufacturer's recommendations. Erection shall be such as to prevent stress in the piping.

All trench excavation and backfill works shall be done in accordance with pertinent provisions specified in the Civil Works Specifications.

MW-4.6 Testing and Cleaning

MW-4.6.1 General

After installation of the equipment and piping system the Contractor shall perform necessary tests at site to determine its compliance with the requirements of the specifications. All costs for testing shall be borne by the Contractor.

The Contractor shall submit the following for review and/or approval by NPC prior to the conduct of test for all equipment and system supplied by the Contractor:

a) Test procedures prior to test; and
b) Test and inspection reports.

All equipment and appurtenances necessary to carry out the tests and any repair, if required, including water potability test shall be borne by the Contractor.

MW-4.6.2 Convertible Jet Pump

The pump and motor shall be subjected to factory tests to determine its conformance with the requirements of the specifications and approved test procedures which shall include but not limited to the following:

a) Pressure hydrostatic proof of the casing to 1.5 times the maximum pressure for 30 minutes;

b) Report of the characteristic curves such as Head vs. Flow and Efficiency vs. Flow, etc.;

c) Test of uninterrupted operation to full flow and maximum height of each pump motor set for one (1) hour;

d) Test of uninterrupted operation without load for each pump motor set for one (1) hour; and

e) Functional test of the control system of the assembly, sub-assembly or parts of the equipment.

MW-4.6.3 Elevated Water Storage Tank

Upon completion of the tank, it shall be filled with water at a proper pressure to fill the tank to the maximum water level. The water shall remain in the tank for at least Twenty-Four (24) hours after which observations for leaks and other defects shall be made.

All defects shall be corrected by the Contractor to the satisfaction of NPC before final acceptance of the work is made. Any leakage that is disclosed in the test shall be repaired by the Contractor.

All equipment and appurtenances necessary to carry out the tests and any repair, if required, shall be borne by the Contractor.

MW-4.6.4 Domestic Water Piping System

The piping system shall be hydrostatically tested at a pressure of 1.5 times the operating pressure of the system.

Tests may be applied to sections or the entire system. The test shall be made between valves and sections of not more than 305m (1000 ft.) in accordance with the American Water Works Association (AWWA). There shall be no leakage whatsoever from the pipes, fittings and connections for each section tested while the system is under the test pressure for the period of not less than thirty (30) minutes of the total time to inspect all portions of the waterline under test, whichever is longer. During the test, valves shall be opened and closed. Any leakage or any defect disclosed by the tests prior to the acceptance shall be corrected and repaired by the Contractor at his own expense to the satisfaction of NPC.

Before any test is made, the Contractor shall notify NPC in advance so that such test may be witnessed. All expenses that may be incurred during the tests shall be borne by the Contractor.

MW-4.7 Painting

The Contractor shall be responsible for the adoption of preparation procedures and protective coating systems that are suitable for the environment experienced by the various equipment and piping systems and conforming manufacturer's recommendation and applicable standards. Painting shall generally be applied to metallic surfaces unless otherwise specified.

Where a specific coating system is mentioned elsewhere in the specification, the Contractor shall accept responsibility for the suitability for such system. The Contractor has the option to nominate an alternative coating system that is of equal or better quality subject for the approval of NPC.

All other equipment and steel piping installed outdoors and indoors shall be prime coated with 80 microns DFT zinc rich epoxy paint and 80 microns DFT of chlorinated rubber for each intermediate and topcoat.

MW-4.8 Disinfection of Elevated Water Storage Tank and Domestic Water Piping System

The water storage tank and domestic water piping system shall be disinfected after testing and before being put into use. Before disinfection, the tank and piping should be drained, flushed, re-drained and refilled. In refilling, care must be taken to avoid entraining or entrapping air in the tank. The

Contractor may use any of the methods of disinfection as recommended by the American Water Works Association (AWWA) or any of the following kinds of treatment:

a) Chlorine Gas-Water Mixture;
b) Calcium-Hypochlorite or equal; or
c) Dry Calcium Hypochlorite or Chlorinated Lime and Water Mixture.

Retention period shall be at least 24 hours and shall produce not less than 10 ppm at extreme end of the lines at the end of the retention period. After flushing, residual chlorine must be reduced to less than 1 ppm.

Disinfection of the well shall be done after developing and testing operations are completed to the satisfaction of NPC and shall be performed to conform with the requirements as specified in Clause MW-4.2.4.

MW-4.9 Submittal

The Contractor shall submit to NPC the complete installation details prior to start of works and the complete well-drawdown test results upon completion of the drilling.

The Contractor shall also submit the technical specifications/data and brochures/catalogs of the jet pump, elevated water storage tank, level switches/gauges, piping materials, valves and other accessories for review and approval of NPC prior to purchase.

The following documents shall be submitted by the Contractor for NPC's review and approval.

a) Complete data, specifications and catalogues;
b) Outline and assembly drawings;
c) Field assembly, installation and test procedures;
d) Complete shop and field test reports for convertible jet pump and elevated water storage tank;
e) Operation and Maintenance Manuals of convertible jet pump and elevated water storage tank; and
f) Wiring diagram of the electrical control and termination including arrangement and type of control boxes/panel.
g) Submit the Well Drilling Permit from the **National Water Resources Board (NWRB)**.

MW-5.0 AIRCONDITIONING AND VENTILATION SYSTEM

MW-5.1 General

This section provides the essential information for the Air Conditioning and Ventilation System equipment to be supplied, installed and tested by the Contractor.

All air-conditioning equipment and Ventilation System shall preferably have one Brand name and shall be the standard product of a reputable A/C manufacturer. In case other brand of A/C and Ventilation equipment are to be used to meet with the specific requirements in the bid document, catalogues and other supporting documents shall be submitted for NPC's review and approval.

Power supply for the ventilation and air-conditioning equipment shall be 230V, single phase, 60 hz.

Refrigerant to be used shall be environment-friendly.

All necessary transformers and electrical materials shall be included in the Contractor's supply if power ratings provided are other than the one's specified above.

MW-5.2 Design Conditions

a) Outdoor Conditions:

Dry Bulb Temperature : 35°C
Wet Bulb Temperature : 27°C
Relative Humidity : 80% to 100%

b) Indoor Conditions (for air-conditioned areas):

Dry Bulb Temperature : 24°C ± 3°C
Relative Humidity : 50% ± 5%

c) Area to be air-conditioned shall be:

c.1 Switchgears Room
c.2 Control Room

d) Area to be ventilated shall be:

d.1 Battery Room - 10 air changes per hour
d.2 Comfort Room - 10 air changes per hour

MW-5.3 Schedule of equipment

a) Air-Conditioning Unit

Location	Quantity	Cooling Load/Unit	Type
a.1) Switchgears Room	Two (2) units	12,000 kJ/hr	Inverter Split Type (Wall Mounted)
a.2) Control Room	Two (2) units	20,000 kJ/hr	Inverter Split Type (Wall Mounted)

b) Ventilation Unit

Location	Quantity	Rating/Unit	Type
b.1) Battery Room	One (1) unit	450 m^3/hr	Wall Mounted Exhaust Fan (Explosion Proof)
b.2) Comfort Room	One (1) unit	150 m^3/hr	Wall Mounted Exhaust Fan

MW-5.4 Air-conditioning System

MW-5.4.1 Scope of Work

The Work called for in this specification includes the design, furnishing, delivering, installing and testing of inverter, split type air conditioners to provide a fully ventilated and air conditioned rooms. The work shall include other accessories even though not specifically mentioned in this specification but are necessary to obtain a complete set for the safe and reliable operation of the system as a whole.

All installation works shall include provision of opening on concrete walls, boring through walls, construction of concrete foundations for outdoor units as required, structural supports for indoor and outdoor units, layout of insulated refrigerant piping, piping supports including excavation and backfilling for refrigerant piping as required, and cables/wiring and other necessary accessories to complete the system.

All electrical materials such as circuit breakers, automatic controls, including all power and control wires, supervision, electrical outlets, fittings and conduits for interlocking the operation of the indoor units and outdoor units shall be included and provided by the Contractor including complete system of automatic temperature controls.

All air conditioning units (split type) to be supplied and installed shall have the following features/accessories but not limited to:

- With Remote Controller and Holder
- With automatic and manual swing louver control
- With control switch
- Cool Mode
- Fan Mode
- Automatic Mode

The type and quantity of air conditioning equipment to be supplied shall be as specified in Clause 5.3 (Schedule of Equipment) or shown on the drawings.

MW-5.4.2 Split-Type Air-conditioning Systems

MW-5.4.2.1 Fan Coil Unit (Indoor Unit)

The fan coil units shall be factory-built, factory-tested, and installed in accordance with the manufacturer's recommendations. The unit shall be complete with motor/blower assembly, evaporator coil, low voltage components, frame, cabinet, cleanable air filters, condensate drain, etc.

Unit casing shall be fabricated of heavy-gauge galvanized steel or other approved corrosion-resistant materials reinforced with steel angle framework and shall be insulated with fiberglass or other approved insulated materials for excellent thermal and acoustic insulation.

The centrifugal blower wheels shall be statically and dynamically balanced for smooth and quiet operation. Fan housing and motors shall be designed to minimize vibration inside the unit. Fan and motor bearings shall be easily accessible for maintenance and lubrication.

The evaporator coil shall be factory tested under pressure for leaks and completely dehydrated under vacuum.

Refrigerant control shall utilize thermostatic expansion valve.

Air filters shall be cleanable and removable type.
Condensate drain pan shall be of heavy gauge galvanized steel or other approved corrosion-resistant material. Condensate from FCU shall be drained to the nearest drain line using Polyvinyl Chloride (PVC) material of approved class piping or other approved corrosive-resistant material.

The cooling system shall be provided with safety devices to protect the system against damage from unusual operating conditions.

The Contractor shall provide other accessories such as discharge grilles, return grilles, etc.

Types of indoor units (wall mounted) shall be as specified in the schedule of equipment or shown on the drawings.

MW-5.4.2.2 Condensing Unit (Outdoor Unit)

The condensing units shall be weatherproof, factory-built, factory-tested and installed in accordance with manufacturer's recommendations. The unit shall be air-cooled type, complete with compressor/motor, condenser coils, condenser fan/motor, safety devices, controls, etc.

The unit casing shall be weatherproof constructed of heavy gauge galvanized steel topped with two (2) coats of baked enamel for durability and protection against corrosion or other approved corrosive-resistant material.

Condenser fans shall be direct-driven dynamically balanced propeller type. Fans/motors shall be designed to minimize vibration inside the unit. Fan and motor bearings shall be easily accessible for maintenance and lubrication.

Type of compressor depends on the capacity of the system (see schedule of equipment) or manufacturer's standard. Safety devices shall be provided to protect the system against damage from unusual operating conditions.

MW-5.4.2.3 Refrigerant and Piping System

The Contractor shall design, furnish and install the refrigerant piping from fan coil unit to the condensing unit. Exact location of equipment and piping route shall be coordinated with NPC prior to installation.

Refrigerant to be used shall be environment-friendly.

Refrigerant piping shall be seamless hard drawn copper preferably single piping connection from the indoor unit to the outdoor unit for simple installation.

All parts in contact with copper piping shall be copper plated. Hangers and supports for all piping shall be selected as applicable to suit actual condition of the existing structures.

All suction piping to compressor shall be insulated with pre-sized fiberglass insulation covered with aluminum vapor barrier or other approved insulation per manufacturer's standard. Insulation should be installed on clean and dry surfaces. All insulation shall be continuous through walls, ceilings and sleeves.

MW-5.5 Ventilation Units

MW-5.5.1 General

The Contractor shall furnish, deliver, install and test the ventilation system equipment complete with all the necessary appurtenances for its efficient operation. The scope of supply shall include all mounting supports and fixing materials required to complete the installation and ready for operation.

MW-5.5.2 Wall Mounted Exhaust Fans

Thru-the-wall propeller exhaust fans shall be provided at the areas as specified in the schedule of equipment.

Each unit shall be properly sized to conform with the required air changes per hour at free air for this particular application but in no case be less than those specified elsewhere in this specification. Unit installed/mounted on the wall and directly discharges exhaust outside the building shall be provided with automatic shutter. It shall be of the direct driven type and corrosion resistant to operate on a 230 V, single phase, 60 Hz.

Exhaust fan for the battery room shall be explosion-proof and shall be of corrosion resistant materials considering its exposure to acid fumes.

MW-5.6 Installation and Painting

The Air-Conditioning Units and Exhaust Fans shall be installed as indicated in the drawings or as directed by NPC. After installation, all exposed and unfinished surfaces shall be thoroughly cleaned and washed possibly by chemical of all rust, oil and other foreign matters and shall be repainted in accordance with the manufacturer's standard or as approved by NPC.

Likewise, all surfaces and supports shall be thoroughly cleaned of rust, oil and other foreign matters and shall be painted with epoxy primer and two (2) coats of finish paint.

Painted surfaces which are damaged during installation shall be repaired or touched-up as necessary to prevent rusting, corrosion, etc. until the final finish painting application is made.

MW-5.7 Equipment Marking and Labeling

All equipment and devices to be supplied by the Contractor under this contract shall be provided with a corrosion-resistant nameplate with clearly legible writing of approved size and pattern and shall be permanently attached at an easily visible place. It shall provide all necessary information or brief technical description under which the equipment has been designed to operate and shall include the following: manufacturer's name; type of equipment; serial number; year of manufacture; weight and other relevant information in compliance with applicable standards.

All items of equipment, valves, piping, and instruments are to be provided with labels bearing the Tag Number. The inscriptions are to be approved by NPC.

All labels and nameplates shall be of engraved stainless steel or equivalent non-corrodible material.

Tag Numbers for instruments and other devices shall also be provided as necessary and practicable.

Appropriate labels shall also be provided for equipment and devices mounted on control boards, relay cabinets, desks, and other places as required for proper identification, as well as for operational, functional, and safety reasons.

The labeling, size of label plates, and their location shall be subject to approval by NPC. A sample label-plate (with indication of material used) with lettering shall be submitted for this purpose. The inscription shall be printed or stenciled but in any case, water-proof, oil-proof and wear-resistant.

Each equipment, wherever necessary, shall be provided with cautionary and warning plates and signs.

Nameplates, labels, and warning plates shall be in English.

The nameplates and labels shall be protected during erection especially during painting. Damaged or illegible labels or nameplates shall be replaced by new ones.

No separate payment shall be made by NPC for nameplates and labels. Corresponding costs thereof shall be included by the Contractor in the bid price for each equipment to be furnished under the Contract.

MW-5.8 Spare Parts and Tools

The Contractor shall supply the standard spare parts for one (1) year operation as recommended by the equipment manufacturer. Spare parts required during the warranty period shall be supplied by the Contractor at no cost to NPC.

Special tools for normal operation and maintenance and are not usually available in a standard machine shop or retailing store shall also be provided as recommended by the manufacturer.

MW-5.9 Acceptance Test

Prior to acceptance of the Works, the equipment shall be tested in the presence of NPC to determine whether the requirements of the specifications have been met. Any defects found that are inherent in the equipment shall be remedied at the expense of the Contractor.

MW-5.10 Submittals

Prior to purchase and implementation of the works, the Contractor shall prepare and submit five (5) copies of the following drawings/documents for review/approval of NPC:

a) Dimensional layout drawings of mechanical equipment and associated devices.

b) Manufacturer's catalog sheets, marked as necessary, to indicate materials or equipment being furnished including instruments for control system;

c) Complete control schematic and wiring diagrams for all equipment to be furnished;

d) List of recommended Spare Parts and Special Tools; and

e) Operation and Maintenance Manuals.

MW-6.0 FIRE EXTINGUISHER SYSTEM

MW-6.1 General

This section provides the essential information for the design, manufacture, fabrication, supply, installation, delivery to site and test of the specified Fire Extinguisher System.

All equipment and materials necessary for the complete installation shall be furnished complete, even though not necessarily mentioned in this specification but are necessary for the safe and reliable operation of the Fire Extinguisher System.

All the Fire Fighting System equipment shall be supplied by the Contractor complete with their corresponding technical brochures written in English that would aid in the installation, operation and maintenance of the equipment.

Fire extinguishers shall be designed, installed and tested in accordance with International Organization for Standardization (ISO) norms and/or internationally accepted standards and/or listings or certifications based on Section 10.5.3.2 of the Revised Implementing Rules and Regulation (RIRR) of RA 9514 – The Fire Code of the Philippines, which are any of the following agencies:

CERTIFYING BODY	CERTIFICATION/ COMPLIANCE MARKINGS
National Fire Protection Association (NFPA)	NFPA
Underwriters Laboratories (UL)	UL LISTED
Factory Mutual (FM)	FM APPROVED
American National Standards Institute (ANSI/UL 8)	ANSI
Loss prevention Certification Board (LPC or LPCB)	LPCB
European Committee for Standardization (CE marked or EN 1866-1:2007)	CE
Australia Standards Association (ASA or AS2444)	STANDARDS
Japan Industrial Standard Committee (JIS or JISC)	JIS
Korea Fire Industry Technology Institute (KFI)	
British Standards Institution (Kitemark EN3 or BS EN3)	bsi.

The Contractor shall design, furnish, install and test all the equipment specified below.

MW-6.2 Portable Fire Extinguishers

MW-6.2.1 Scope of Work

The Contractor shall supply the specified number of Portable Type Fire Extinguishers complete and ready for operation and shall be installed at their corresponding place of use as specified below and shown on the drawings.

a) Four (4) units of Portable Type Fire Extinguisher, Clean Agent (HCFC or Halotron I Type), 7.1 kg. (15.5 lbs), non-expiry, multi-shots, wall-hung type and shall be in certified/ approved by the certifying body specified in MW-6.1;

MW-6.2.2 Fire Extinguishers

Fire extinguishers shall be in certified/ approved by the certifying body specified in MW-6.1 and of rechargeable cylinder with five (5) years guarantee against leak. Each fire extinguisher cylinder shall be complete with release valve, dial gauge indicator, appropriate length of hose with nozzle and locking pin.

The 7.1 kg (15.5 lbs.) capacity wall-hung type fire extinguishers shall be complete with carrying handle and wall-mounting bracket.

Portable fire extinguishers shall be suitable for the protection against class ABC fires using Clean Agent (HydroChloroFluoroCarbon or Halotron I Type) that is environmentally safe and leaves no residue.

The fire extinguishers shall be check-weighed at interval of six (6) months from the date of delivery for a period of one (1) year and if found to be undercharged (unless used by an NPC personnel) shall be filled and recharged by the Contractor at no expense to NPC.

MW-6.2.3 Submittal

The Contractor shall submit the technical specifications/data and brochures/catalogs of the fire extinguishers for the approval of NPC prior to purchase.

MW-7.0 DRAWINGS

Prior to procurement of all materials, equipment and auxiliaries to be supplied by the Contractor under this contract, the Contractor shall submit for NPC's review, approval, and/or reference, five (5) copies of prints of technical specifications/data and/or brochures/catalogues. NPC shall review, comment or note corrections to be made and return two (2) copies to the Contractor within twenty (20) calendar days after receipt of the drawings and documents. If corrections are required, the Contractor shall make all necessary corrections and re-submit within fourteen (14) calendar days for NPC's review and approval. However, if the Supplier/Contractor has not received any reply from NPC within the twenty (20) calendar days, said drawings and documents are deemed approved and the Supplier/Contractor may proceed with the design and manufacture of equipment or materials. The Supplier/Contractor however, shall not be relieved to meet all the requirements of this specification nor of the responsibility for the correctness of the Supplier's/Contractor's drawings/documents.

Prints marked "Approved" or "Approved with Corrections Indicated" authorize the Contractor to proceed with the procurement of materials or equipment or construction/fabrication of the work shown on the drawings, with corrections, if any, indicated thereon. When prints of drawings are marked "Approved with Corrections Indicated" or "Returned for Corrections", the Contractor shall finalize the drawings and re-submit same in five (5) copies each for final approval. Every revision shall be shown by number, date and subject in a revision block.

Drawings approved by NPC shall in no way relieve the Contractor from entire responsibility for engineering, design, workmanship, material and all other liabilities under the Contract.

NPC reserves the right to reproduce any drawings or prints received from the Contractor as may be required despite any notice prohibiting the same appearing on the drawing or the print.

The Contractor shall submit construction and detailed drawings as may deemed necessary, as-built drawings and other documents for NPC's review, approval, information and reference as specified in the relevant specifications.

Any supply of materials/equipment or construction of any particular structure or portion thereof prior to the approval of drawings pertinent thereto shall be at the Contractor's risk. The Contractor shall be responsible for any extra cost that may arise in correcting the work already done to conform with the drawings as revised and approved.
Should an error be found in the Contractor's drawings during construction/erection, the correction including any field change considered necessary shall be noted on the drawings and shall be resubmitted for approval.

All data and information to be submitted shall be in the English language and all drawings shall be drawn using the metric system as unit of measurement.

The Contractor shall address all communications pertaining to Contractor's Drawings or otherwise agreed to:

> The Manager, Project Management Department
> National Power Corporation
> BIR Road corner Quezon Avenue,
> Diliman, Quezon City 1100

All drawings and documents to be submitted by the Contractor for NPC's review and approval shall be on A4 size or A3 size folded to A4.

MW-8.0 GUARANTEE

The Contractor shall guarantee the replacement of the supplied equipment or components at his own expense against defect in design, workmanship and materials for a period of twelve (12) months after the equipment has been installed, tested and accepted. However, the warranty coverage for the compressor of the air-conditioning units shall be five (5) years. The Contractor guarantees that the equipment will perform in the manner as set forth in the equipment's manual and the Contract.

The Contractor shall submit a Warranty Certificate effective from the date of acceptance by NPC.

After the lapse of the warranty period, provided that there are no defects found and/or pending repair works, NPC shall release the warranty security/certificate.

MW-9.0 MEASUREMENT OF PAYMENT

Measurement for payment for all works shall be based on the bid price of each item as shown in the Bill of Quantities. The cost shall cover all works required and described in the pertinent provisions of the specifications.

Measurement for payment for pipes shall be based on the bid price of actual length of pipe installed as shown in the Bill of Quantities. The cost shall cover all works required including excavation, sand bedding, backfilling, testing, painting and other works and services described in the pertinent provisions of the specifications.