EXTENSION TO NEYRIZ 66/20KVSUBSTATION

SPECIFICATION FOR CONTROL AND PROTECTION

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1 INTRODUCTION

1.1 Purpose

This document has been prepared to specify and establish the minimum technical requirements for the design, supply, installation, and commissioning of the Extension to Neyriz 66/20 kV Substation.

1.2 Definitions

Within the context of this document, the following definitions will be applicable:

Project: Extension to Neyriz 66/20 kV Substation

Client: Petro Kavian Sanat Pars Co.

Owner: Fars Regional Electric Co.

Consultants: Aria Niroo Jam Co.

EPC Contractor: Any firm who is responsible for providing any service and material with respect to detailed engineering, procurement, construction of all items and material in accordance with the contract between the CLIENT and him.

Vendor/Supplier: The company, which has been selected to supply the equipment and material and products technical documentation mainly, related to the production of the ordered supply.

The word "shall" indicate a requirement. The word "should" indicate a recommendation.

Contractor shall be responsible for vendor goods.

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2 DESCRIPTION

Control and relay panels shall mean steel panels complete with recorders, relays, meters, including lights, switches, annunciators, interpose C.T.s and V.T.s, fuses, etc. Work of this section shall include:

Design, supply, manufacture, testing, transportation, supervision over installation and commissioning of control and relay panels.

The extent of work shall also include the preparation and furnishing of schematic, wiring, internal wiring and external cable connection drawings.

The contractor shall be responsible for obtaining information regarding parts of the installation not covered by the order, which can affect the design of the protection and control equipment and modifications thereto.

3 TERMINOLOGY

Technical terminology is to be as defined in latest edition of IEC 50, I.E.E.E. 100 and/or ANSI C42-100 standards.

4 STANDARDS

Work of this section shall comply with the requirements of latest edition of IEC, BS, DIN, ANSI, NEMA and Tavanir standards within which IEC standard is preferred, minimum technical guidelines:

IEC 60297 Dimensions of panels and racks

IEC 60947 Control switches

IEC 60359 Expression of the functional performance of electric measuring equipment

IEC 60547 Modular plug-in unit and standard 19" mounting unit

IEC 60255 Electrical relays, especially:

IEC 60255-3 Single input energizing quantity measuring relays with dependent Requirement and Tests

IEC 60255-5 Insulation coordination for measuring relays and protection equipment requirement and tests

IEC 60255-6 Measuring relays and protection equipment

IEC 60255-9 Dry make contacts

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IEC 60255-11 Interruptions to and alternating component (ripple) in DC auxiliary energizing quantity of measuring relays

IEC 60255-12 Directional relays and power relays with two input energizing quantities

IEC 60255-13 Biased (percentage) differential relays

IEC 60255-14 Endurance tests for electrical relay contacts – preferred values for contact loads

IEC60255-15 Endurance tests for electrical relay contacts - Specification for the characteristics of test equipment

IEC 60255-16 Impedance measuring relays

IEC 60255-21-1 Vibration, shock, bump and seismic tests on measuring relays and protection Equipment-Section 1: Vibration tests (sinusoidal)

IEC 60255-21-2 Vibration, shock, bump and seismic tests on measuring relays and protection Equipment-Section 2; Shock and bump tests

IEC 60255-21-3 Vibration, shock, bump and seismic tests on measuring relays and protection Equipment-Section 3: Seismic tests.

IEC 60255-22-1 Electrical disturbance tests for measuring relays and protection equipment -Section 1: 1 MHZ burst disturbance test.

IEC 60255-22-2 Electrical disturbance tests for measuring relays and protection equipment - Section 2: Electrostatic discharge test

IEC 60255-22-3 Electrical disturbance tests for measuring relays and protection equipment - Section 3: Radiated electromagnetic field disturbance test

IEC 60255-22-4 Electrical disturbance tests for measuring relays and: protection equipment - Section 4: Fast transient disturbance test

IEC 60255-23 Contact performance

IEC 60255-25 Electromagnetic emission tests for measuring relays and, protection equipment

IEC 61850 Communication in substation

IEEE C37.94 Fiber optic interface

SEL-311L-1-7 Protection and automation system

IEC 62271-100 AC circuit-breakers

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All the amendments and references listed with the above standards must apply, also other relevant IEC standard should be considered by the engineer's approval. Other standards, in case of lack in IEC, can be considered by the engineer's approval.

In addition, the protection equipment must comply, where necessary, with standards of other related equipment in fault clearing equipment, e.g. CB, CT, CVT and etc.

5 DESIGN

5.1 General

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

The electrical control and protection scheme for the substations shall be as shown on the drawings.

If possible the time current characteristic curve and setting range of operating current of inverse time over-current relays shall be so designed and selected to permit direct connection of the relays to the main current transformers with no necessity of interposing current transformers.

The design of the relay protection shall be such that high tripping reliability will be achieved. This applies to a particularly high degree in cases where the remote back-up function provides unselective tripping of the primary fault.

The relay protection shall be designed in such a manner and shall have such functional values that operational reliability of the plant will not be significantly affected. In this connection special consideration shall be given to the risk of spurious tripping as a result of e.g.: Inrush currents, etc.... It is not acceptable for switching in to require several attempts, or to cause tripping of parts of the network which is in operation.

Strict demands are made on selectivity in isolation. Only the minimum possible part of the plant shall be tripped to isolate the fault or clear the abnormal conditions, in addition, the fault must be tripped within the time necessary for equipment protection, personal protection, reasonable restriction of material damage, etc., and before damage has had time to occur in the event of abnormal operating conditions. Tripping of a faulty part of the plant shall take place before mechanically and electrically adjacent parts of the plant are damaged.

Mal operation of the relay protection as a result of the characteristics of current transformers shall be taken into account in conjunction with the design of relay protection and dimensioning of the auxiliary wiring. Unless otherwise specified all functional requirements

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on the relay protection function shall be satisfied for short circuit powers and associated zero-sequence impedances at the maximum, minimum and intermediate values.

The measurement and tripping zones shall be coordinated with breaker-failure protection, so that primary faults between the breaker and the current transformers will be tripped by the breaker-failure protection function, with the possible degree of selectivity.

All protection shall be divided into sub 1 (main) and sub 2 (backup).

Relay protection belonging to sub 1 (main) and sub 2 (backup) must, as far as possible, be electrically and mechanically separated from each other.

The function of control panel is to collect all information necessary for the operation personnel to supervise the operating conditions of the plant and whenever necessary to initiate changes to the operating conditions.

The control panel is dominated by the mimic diagram. The mimic diagram shall provide a simple and clear representation of the plant showing the interconnections between the objects, the supply paths and the connection facilities with the symbols and control devices of the various objects incorporated into the diagram.

The mimic diagram shall agree with the operating and station diagrams and shall also agree as close as possible with the layout. Furthermore, at the extension substations the mimic diagram shall be coordinated with existing ones.

The control panel shall be so dimensioned that it can be adapted to the maximum extension possibilities for the switchyard.

In addition, it shall be so designed that no drilling on site is necessary when carrying out such extensions.

5.2 Synchronizing (N.A)

Synchronizing facilities shall be provided for manual and automatic closing of the breakers.

Separate synchronizing panels complete with all accessories shall be provided for each voltage level.

The voltage, frequency and phase angle conditions must be checked before the closing signal is supplied to the breaker. The synchronizing equipment shall be used for local and remote closure of the circuit breaker.

It is required for the synchronizing equipment that voltage information be supervised so that the equipment will be blocked if fuse should fail for the measuring transformers.

Selectors and terminals shall be provided for testing. The selector shall also serve as an isolating switch.

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Voltage-check relay shall be provided in order to permit the C.B. to be closed on live line/dead bus and dead line/live bus conditions. The relay shall recognize live condition for voltages above and equal to 80% of rated voltage (Un) and dead conditions for voltages adjustable between 30%-80% of rated voltage.

Synchronizing "on/off" switches located on control panels shall be used for connecting the voltages to be synchronized to the synchronizing unit. The individual switch shall be connected so that only one circuit breaker at a time can be synchronized. The unit shall be designed in such a manner that it will not be possible to interconnect inadvertently the voltage circuits.

The automatic closing (synchronizing) of the breaker shall be called from the control panel and by remote control.

Man/off/Auto selector switch shall be provided on synchronizing panel to facilitate the appropriate mode of operation to be selected. As a general rule, when the selector switch is on Auto position, all breaker closures from the control panel and remote control equipment with the exception of automatic reclosing of transmission lines, shall take place automatically via the synchronizing equipment provided that the circuit breaker control switch is pushed to close and left in close position.

Scope shall be provided for shunting the synchronizing equipment via selector switch when it is on off. Position, so that direct operation of the breaker due to defective synchronizing equipment can be carried out: In manual position of the selector switch the closure of C.B can take place when during the satisfied synchronizing condition, the breaker control switch is pushed to close. On manual closure the synchro scope unit shall be employed as an aid. This shall consist of a double voltmeter synchro scope and double frequency meter, placed on the synchronizing control panel. Synchronizing panel shall be so positioned to give easy view to operator.

For existing substations where the manual synchronizing facilities have already been installed, the possibility of connecting the extended voltage circuit to the system shall be the first priority.

Exception shall be allowed where digital and integrated control & protection system with built in synchronizing feature with possibility of software selectivity shall be offered.

When the synchronizing equipment is switched "on" this shall be indicated on the synchronizing control panels and remotely for the relevant breaker.

For closing during auto reclosing mode, the scheme shall be as described under auto reclose clause.

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The auxiliary power shall be taken from a MCB 110V or 125V dc. If the equipment requires an ac supply, this shall be taken from the station service 400/230 V AC.

For allocating the 110V or 125V DC voltage for each substation please refer to "section" summary of work.

5.3 Inter-Tripping (Transfer Tripping Scheme) (N.A)

The inter tripping function shall generally be achieved by using dual channel transfer trip scheme using audio-frequency shift tones on P.L.C. except for radial lines without remote end generation.

This function is required to clear the abnormal conditions at local substations and a definite or provisional tripping whichever the case may be of the remote end C.B's

These abnormalities shall generally be including the followings, but other unforeseen condition depending upon particular scheme shall be provided by the contractor after proper approvals of the Engineer.

a) Line overvoltage due to excessive MVAR generations.

b) Transformers and reactor feeders without C.B on HV side.

c) Circuit breaker failure conditions and pole discrepancy protection.

The scheme shall provide reliable and secure high-speed remote tripping of line terminals. Normally the trip and output contacts of the two receivers are connected in series to provide maximum security. Each tone shall be connected to a different voice channel of the power line carrier. In the event of failure of a channel an alarm signal will be given and tripping can be affected by reception of the healthy channel only, after a set time.

The use of the dual transfer trip scheme described above allows testing of either channel without losing the power line carrier transfer trip capabilities of the system.

5.4 Relay Panel D.C. Circuit Supervision

The D.C. supply for each protection in each relay panel supplied shall be supervised via an under voltage relay and lamp. An alarm shall be initiated on the loss of the D.C. supply.

The relay shall be so positioned to detect the failure of interconnection circuit of D.C. supply to all the relays and protection devices within the panel.

Degree of protection is IP42 for indoor panels and IP55 for outdoor panel.

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5.5 Circuit Breaker - Isolator Interlocks

All circuit breakers, isolators and, earth switches etc. within the substation shall be interlocked in a manner to ensure that they are not permitted to perform an unsafe operation. The system employed shall be designed such that it satisfies two distinct categories as mentioned below:

Operational interlocking: An interlocking associated with normal system operation and switching, and intended to ensure that a predetermined switching sequence is satisfied. Such interlocking shall be achieved by electrical means interlocks etc. in a manner that permits the equipment to perform any safe operation, i.e.: complete flexibility of operation is provided.

Maintenance interlocking: An interlocking associated with a series of switching operations designed to render the equipment or sections of the substations safe for access and maintenance by personnel. Such interlocking shall be achieved by mechanical interference type interlocks.

In designing a satisfactory scheme of interlocking following assumptions shall be made.

Isolators are capable of switching the capacitive current of associated connections immediately adjacent, with the exception of that of the overhead lines, capacitor banks etc.

Isolators have no load making or breaking capacity.

Isolators are not capable of making or breaking transformer magnetizing current.

Isolators are capable of the duty imposed when operated under parallel switching conditions.

It shall not be possible to close or open any earth switch unless the point of application is isolated from all possible sources of supply.

It shall not be possible to operate any isolator if an associated earth switch is already closed.

5.6 Common Breaker Control and Protection Schemes

All the control/protection schemes finally operate the circuit breaker. The following relays/systems shall generally be followed for each circuit breaker.

5.6.1 Auxiliary supply

The auxiliary and control supply of the breaker for the following circuits shall be protected by separate set of fuses or other appropriate protective devices:

- Closing coil.

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- Trip Coils No. 1
- Trip Coils No. 2 (N.A)
- Motor operating mechanism
- Lighting and heating

The D.C. control supply protective devices shall be installed in respective control panels, whereas for AC supply they shall be installed in respective circuit breaker operating mechanisms.

5.6.2 Breaker-failure protection (N.A)

The breaker-failure protection shall safeguard the breaking of fault current in the event of a circuit breaker failing to operate.

The plant shall be equipped with breaker-failure protection for 230 kV systems in accordance with single line diagrams.

The protection shall be arranged to trip all the nearest circuit breakers contributing to fault current.

The breaker-failure protection function shall be started from the protection of the corresponding object in main protection as well as back-up protection. The breaker-failure shall not be started by other breaker-failure protection or by manually initiated operations. Individual breaker fail logic must be provided for each pole where single pole reclosing has been employed.

The purpose of this protection is to operate for the following basic fault conditions:

- Stage 1 (TD1) - A fault which has been correctly detected by the appropriate circuit protection but the associated circuit breaker(s) has (have) failed to open.

At his stage the breaker failure main protection using the auxiliary contacts of circuit breaker shall operate to isolate the fault.

- Stage 2 (TD2) - A fault in the zone between the circuit breaker and the associated current transformers

The breaker failure back-up protection shall function at this stage.

The breaker failure back-up protection shall consist of current relays, which determine whether or not the intertripping has been satisfactorily carried out. Current relays shall be capable of carrying twice rated current continuously with a setting not greater than 20 percent of rated current. The breaker-failure protection shall be capable of withstanding continuously the on-load current and maximum short-circuit current.

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The actuating signal for the breaker-failure protection shall be sealed-in, so that correct operation will not be jeopardized if the actuating relay protection should reset before the primary fault has been isolated due to current transformer saturation etc.

Inter trip functions have to be achieved through proper carrier system. The breaker-failure shall be designed with a high degree of safeguard against spurious operation.

5.6.3 Pole-discrepancy protection (N.A)

All breakers with single pole mechanism shall be equipped with pole discrepancy protection. The pole discrepancy protection shall use the auxiliary contact of circuit breakers in the different poles both for closing & opening conditions.

The function of this protection shall be time delayed in two steps. The first step shall only trip by C.B. trip coil No. 1. The time delay shall be sufficient to avoid malfunctions due to differences in operation time of different poles. Should the defective circuit breaker fail to trip at first attempt? The second step of this protection shall initiate trip signals to all adjacent breakers to isolate the fault. The second stage of protection shall have sufficient time to check the breaker condition after the first attempt.

If the first step of pole discrepancy protection is successful, the function from the second step is inhibited. Inter trip function (if required) can be achieved through breaker failure protection.

5.6.4 Trip circuit supervision relays

Trip circuit supervision relays for supervising trip coils of each breaker both during precluding and after closing of the breaker shall be provided. It shall also be provided with a hand reset flag indicator. The trip coil supervision relays coil shall be rated at D.C. control voltage and the relays shall operate satisfactorily between 80% and 120% of the rated voltage.

The time between failure of the trip circuit and operation of the alarm and trip contacts shall be such as to preventable operation due to transient voltage condition. The pick-up and drop off current of the relays shall not be so small such that relay will drop due to deposit of some dust particles etc. in the breaker auxiliary contacts and thereby giving false indications for breaker trip coil faulty.

The trip circuit supervision scheme shall involve passing a low level current through the trip circuit (including the breaker trip coils) and shall be so wired to supervise all wiring of the trip circuit.

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5.6.5 Close coil supervision

Where required in the drawings and based on specific design of each substation the close coil shall be supervised by pilot lamps.

5.7 Tripping circuits

The Tripping circuits for the relay protection belonging to sub 1 and sub 2 shall be entirely separate electrically and mechanically. This implies that they must not include common switching devices, connectors, terminal blocks, cables, auxiliary relays etc. The function must not be jeopardized if both coils receive a trip impulse simultaneously. The design in sub 1 and 2 shall conform with the following stipulations.

Contacts or terminals for tripping must not be used for auxiliary functions - exclusive contacts or terminals for the tripping function. However, starting of the breaker-failure protection is permissible from contacts or terminals for tripping.

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

The tripping circuits shall be of single-pole design. Only the positive poles shall be closed at tripping. The negative pole is permanently connected to the tripping coil of the breaker.

Tripping coils in the breaker shall be supplied via tripping relays, which must have an operating time not in excess of 5ms.

Tripping contacts shall also be capable of breaking the circuit to the solenoid even if the auxiliary contact in the breaker should fail to open.

Relays in tripping circuits electrically located after the testing devices of the relay protections shall be equipped with testing devices. The entire trip function from the relay protection to the outgoing cable of the switchgear shall be capable of being tested without the breaker being operated and with no other action for isolating the circuit than operation of permanently installed test devices.

In each relay cubicle for relay protection provision shall be made for isolating the outgoing tripping signal by means of easily operated isolating devices on the front of the cubicle without the relay protection circuit being blocked.

Individual electrically reset type lockout relay should be provided for each breaker to lock its closing circuit in the event of permanent faults.

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5.8 Testing facilities

All relay protection shall be capable of being tested individually (even during normal operation) with adequate safety of the test personnel and without the risk of spurious tripping. Various partial protection functions for a given primary object shall include facilities for individual testing with the other protection in operation. When testing the protection in sub 1 or 2 it is not acceptable that the protective functions in the other sub system are blocked or activated.

The design shall be such that external test equipment can be connected to the protection at a permanently mounted connector. All quantities necessary for measuring the functional values of the protection as well as the tripping function shall be connected to this. In addition, the design shall be such that (after testing) the protection will safely revert to operational condition.

All actions, necessary in normal maintenance testing shall be capable of being carried out from the front of the relay cubicle, where the switching devices for testing shall also be located.

For replacement of faulty relays “plug-in” or “draw-out” systems are preferred.

5.9 Transmission line protection (N.A)

230 & 400 kV transmission line protection shall be divided in sub 1 and sub 2 categories comprising of the following main protection relays, however for accurate protection requirement reference shall be made to protection single line diagram of each substation.

SUB I (MAIN) and SUB II (BACKUP) protection relays for 230 and 400 kV voltage levels

* Tele-protection scheme for HV and LV will be finalized by consultant or client engineer.

** These items can be provided in circuit breaker protection.

5.9.1 Sub 1 (Main)

Sub 1(Main) protection shall consist of following features whether integrated or separate:

1. Distance protection (21P+21NP)
2. Instantaneous P.L.C. assisted directional earth fault protection (67 NP).
3. Stub protection (50 STB)
4. Under voltage relay (27)
5. Over voltage relay (59)
6. Trip order devices (94)

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7. Fuse failure relay (97)

5.9.1.1 Device (21P+21Np)" Distance protection

Three phase, with minimum three zone, numerical with built - in fault locator equipped with directional earth fault (67N), with event recorder, disturbance reorder, fuse failure protection, power swing blocking and switch on to fault non switched distance scheme shall be provided for primary protection of HV transmission lines.

The relays are used to trip for all interfuse and ground faults.

The setting ranges of the relays shall be continuously adjustable when used with current and capacitor voltage transformers with ratios indicated in single line diagrams.

The relay shall have restricted reach for three zones on the either side of solid faults to discriminate against through load and power swing conditions and against healthy phase impedance's etc. The relay shall cover the following reach:

First zone to protect 80% to 90% of the line. The operating time shall be less than 20 Ms.

It shall provide high stability against tripping for all faults behind the relay location and for those beyond the remote termination in direction of forward reach.

Second zone to cover whole of protected line section plus up to 50% of the next shortest line section.

Third zone to cover adjacent line sections plus 25% into the longest third line.

The protection scheme shall be achieved by permissive under reach type inter trip scheme. Extension of under reach step acceleration is acceptable on receipt of the signal.

Distance relay shall be provided with separate high set instantaneous over current protection for clearance of 3 phase bolted faults (close-up fault) while line is energized. This protection shall be available only up to 3 seconds from the instant of energizing the line.

All zones shall be provided for zero sequence impedance and mutual impedance compensation features.

In view of induced disturbances in control and measuring signal cables (DC, CT's, CVT's) which come from the switchyard to the relay house and control house, the relay shall be designed with utmost stability against these transient disturbances although effective measure shall be taken in cable shielding, grounding and its laying etc.

Power swing blocking feature for all zones shall be provided. However, in order to make relay system available for very slow power swings, facility for overriding the power swing blocking conditions shall be provided.

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The distance relay shall be designed for both single pole and three pole tripping and shall have repeat contacts for interfacing with external communication channels, auto reclose (single and three phase) equipment, fault locator, alarms, fault recorders and remote alarm etc.

Relay shall be provided with hand reset type operation indicators or LED displays.

Distance protection shall be provided with blocking feature due to single, double and three-phase C.V.T. secondary fuse failure.

The relaying shall be suitable for the communication channel in tripping, blocking or unblocking mode using built in interfuse relays.

Reverse current blocking feature to securely block the tripping of the healthy line of a paralleled line section shall be provided when due to tripping of end breaker of the faulty feeder of the paralleled section reversal of current in the healthy section is provided.

The relay should have suitable characteristic and accuracy for minimum fault current condition. The contractor can propose alternative protection instead of distance relay for short line after the approval of the Engineer.

In case of short and medium lengths of lines, distance relay with suitable operating characteristics shall be provided to cope with large fault resistance. The setting range shall be such that the short lines can be selectively protected and that is resistance compensation, R/X should be set accordingly. For extremely short line an overreaching transfer trip system should preferably be used.

5.9.1.2 "Device (67NP)" Instantaneous P.L.C. Assisted. Directional Earth Fault Protection

Owing to probable non-operation of distance relays for high resistance earth faults, line protection shall be provided with high-speed reliable instantaneous directional earth fault (D.E.F) protection.

D.E.F. relaying protection shall be specially designed to provide very high degree of security against false tripping operation even at the cost of slightly slower speed.

The D.E.F. Relaying shall preferably be achieved by the use of overreach permissive transfer trip scheme using power line carrier as pilot information link between two stations.

In this protection scheme the difference in the ground fault magnitude between close-up faults and far-end faults shall be carefully considered.

It shall be possible to set the relay to be less than 50% of the minimum ground fault current but not below 12% of the C.T. secondary.

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The D.E.F. units which are supplied from C.V.T.s shall generally be adequately delayed until C.V.T.'s secondary transient are subsided.

The DEF unit shall operate in the event of single or double phase to earth faults.

The time delay unit shall sufficiently be ranged to provide relay stability and prevernal operation due to current reversal situation in the case of parallel lines.

In order to cater for the ground faults under remote end C.B. open conditions, special feature to monitor this condition shall be provided. In cooperation with zone 2 unit of distance relay it shall be possible to initiate single phase auto-reclose relaying. If zone 2 unit does not operate, the D.E.F. scheme logic shall automatically issue a 3 phase trip impulse after a short time delay, furthermore if the high set D.E.F. logic scheme fails to initiate tripping the DEF unit in cooperation with low-set current detector shall be able to send direct 3 phase trip after a preset definite time delay to cater for the high resistance ground fault relaying under any conditions.

5.9.1.3 "Device (97)" Fuse Failure Protection

Fuse failure condition shall be monitored by P.T. secondary voltage supervision so that following function shall be initiated in the event of open circuit of one, two and three-phase fuse failures. Alarm function cannot be accepted in the event of primary three-phase loss of voltage. The equipment for this function shall be located in respective sub 1 & sub 2 panels or common cubicles as the case may be, thus also incorporating into this monitoring or cables from switchyard, panel fuses/MCBs' etc. for all places where only metering is provided, merely annunciation is sufficient. However, for all other location e.g.: line distance protection, transformer & reactor impedance protection, zero -voltage protection, live line / dead bus & live bus-/dead line voltage checks conditions etc. the fuse-failure relaying shall be used to annunciate and block the respective functions from tripping by them. Apart from above, since this relaying can malapert under voltage unbalance conditions due to line charging and single-phase auto-reclosing conditions, the functions to bypass the impedance relay blocking from fuse failure relaying for 200 milliseconds from the instant of manual line charging and dead-time of auto-reclose relay shall be provided.

5.9.1.4 "Device (50STB)" Instantaneous Sensitive (stub) Protection relay

This protection is required to protect the stub connection when the line isolator is opened and no adequate fault voltage is fed to the distance protection. The relay shall be blocked when line isolator is closed.

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The stub protection shall consist of three instantaneous over current relays with a setting range of 20% to 80% of rated value. The stub protection must not be operated by through fault currents in 1.5 CB arrangement due to errors caused by transient saturation.

5.9.1.5 "Device (27)" Under Voltage Relay

In order to facilitate re-establishment of the grid after disturbances. Transmission line protection shall be included with three phases under voltage relay, which isolates the line after 7 sec. following a drop of all phase voltages to less than 50% of rated value.

In the event of a low voltage in only one or two phases the under voltage relay shall be blocked after 2 sec. and an indication shall be provided.

The operation of under voltage relay shall be blocked when the line isolator has been opened or C.V.T. fuses are failed.

5.9.1.6 "Device (59)" Line Overvoltage Protection

The overvoltage relaying shall generally consist of definite time over voltage unit and have a setting from 100% to 120% of rated voltage with very high pick up to drop off ratio of 95% and continuously adjustable time delay of 2 to 20 sec. Thus protection shall trip the line and send inter trip signals to remote end.

The flag operation indicator shall be provided on time delay function.

5.9.1.7 "Device (94)" Trip Order Devices

Trip order devices, shall be provided to trip the respective C.B.s upon operation of protection relays. These devices shall generally be of two categories, one of single and three phase type which will function during transient fault conditions and the other of three phase type functioning under permanent fault conditions. To prevent damages to the plant due to subsequent re-energization under permanent abnormalities, the respective C.B.s shall be tripped and their lock out relay initiated.

5.9.1.8 "Device (79)" Line Auto reclosing

High speed single shot automatic reclosing relays shall be provided with both single and three pole reclosing. The auto reclosing should be switch selected manually for appropriate mode of operation. When each mode has been manually selected; the distance protection should automatically select the required mode depending on the type of fault. Reclosing shall be initiated on first zone tripping of distance and high speed transmission line protection, and shall automatically block for other protection where required. It shall also

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block manually closing on to a short circuit. Auto-reclose equipment shall operate by specified sub 1(main)-protection relays.

For the lines having shunt reactor compensations, special precaution due to Electromagnetic and Electro-couplings from sound phases shall be considered for single-phase auto reclosing.

Auto reclosing shall not take place for a time duration of 3 to 5 sec. while charging the line.

The auto reclosing by A.R. schemes shall take place for all the C.B.s in a specified manner. If they were closed at the moment of the tripping, an "open" breaker shall not be closed in the event of auto re closer.

Provision shall be made for blocking from local control and by remote control.

The A.R. scheme shall provide a hand reset lock out for permanent line faults and it shall not be possible to reclose the C.B.s once.

Four numbers of A.R. scheme operations shall be provided. The A.R. scheme shall be locked for C.B. maintenance condition and limiting condition of C.B.

The relay shall be equipped with the main features such as C.B. memory functions and C.V.T. voltage check and live line/dead bus. Deadline/live bus, synchronous check relay (for checking voltage, frequency and phase angle condition before closing).

The C.B. close pulse from the auto re closer shall be provided for definite time. Special features shall be provided to ensure that only one close pulse shall be given at the end of each dead time. The scheme monitor shall be provided to lock out the scheme if it has not completed its cycle by the end of preset time (e.g.: due to necessary line/bus voltage. conditions not being preset to permit reclosing). The scheme monitor timer shall have long range to accumulate maximum dead time plus maximum reclaim time setting.

5.9.2 Sub 2 (Backup)

Sub 2 protection consists of:

1-Distance protection (21S+21NS)

2-Instantaneous P.L.C assisted directional earth fault protection (67NP)

3-Fuse Failure relay

4-Trip function devices (94+ 86).

5.9.2.1 "Device (21S+ 21NS)" Distance protection

As item 5.9.1.1

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5.9.2.2 "Device (67NP)" Instantaneous P.L.C assisted directional earth fault protection

As item 5.9.1.2

5.9.2.3 "Device (97) Fuse failure protection

As item 5.9.1.3

5.9.2.4 "Device (86 & 94)" Trip Devices

As item 5.9.1.4

5.10 Power Transformer Protection (N.A)

The protection scheme for power transformers are shown on relevant typical protection diagrams. The salient transformer protection relays are specified below:

Main and backup electrical protection relays for transformer protection

Main	Differential protection (87) Restricted earth fault protection for Primary and secondary sides (REF)* Overvoltage function (59) Zero-voltage function (27) Over flux protection (24)
Backup	Overcurrent protection for primary and secondary sides (50/51) Ground / neutral fault protection (51N/50N) Ground / neutral fault protection for ground/ auxiliary transformer (51N/50N) ** Sensitive and Earth fault protection (51NS/50NS) Overload protection (49)
Tertiary side	Overcurrent protection (50/51) Ground / neutral fault protection (51N/50N) Ground / neutral fault protection for ground/auxiliary transformer (51N/50N) High set and low set over-current (LV)

* These items shall be provided in a separate relay from main differential relay.

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5.10.1 Sub 1 (main)

Sub 1 is comprising of:

1. Differential protection (87 T)
2. Restricted earth fault protection (64P, 64S)
3. Over flux protection (24)
4. Under voltage protection (27)
5. Trip order devices (94 + 86)
6. Distance protection (21)

5.10.1.1 "Device 87T" Differential Protection

The differential relay (87T) for the transformers shall be triple pole, three winding, and percentage differential type with through fault stability and second harmonic restraint features.

The differential relay shall be preferably provided with 5th harmonic restrain instead of 5th harmonic blocking. It shall have three bias windings per phase having percentage bias setting range of 15% to 45% and operating setting of 10% to 20% of C.T. secondary rated current under zero-restraint conditions. Power transformers are equipped with on - load tap-changers and the relay offered shall be such that there will not be any necessity of changing the setting of the relay whenever the transformer taps are changed. The relay shall be of high-speed type.

It shall also incorporate a high set instantons overcurrent element set at around eight times the rated current in each phase.

Universal type interposing current transformers in all three sides shall be included for matching C.T. secondary currents. Fixed ratio I.C.Ts. Shall not be preferred.

The relays shall be provided with hand reset flag indicator.

5.10.1.2 "Device (64P, 64S)" Restricted Earth Faults Protection

Restricted earth fault relay shall be of single pole, instantaneous high speed and high impedance; voltage operated type to provide earth fault protection.

It shall have a sensitive setting to detect faults at 10% of the transformer winding from neutral.

It shall be tuned to supply frequency and shall remain stable for through faults.

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Non - Linear resistors to protect the relays from high voltages shall be offered, if required. The operating time of relay shall not exceed 25m sec.

The C.T.'s secondary connections for this protection shall be done in the relay house.

5.10.1.3 "Device (24)" Over Flux

This relay will provide trip and alarm due variation of voltage and /or frequency. It may be combined with differential relay.

5.10.1.4 "Device (27) "Under voltage protection

Similar to that mentioned in line protection

5.10.1.5 Follower Relays

Follower relays are necessary to multiply the signal of the transformer guard relays such as:

Gas pressure protection, fire protection; tap changer, Bochholz relay and winding temperature in sub 1.

These auxiliary relays shall have sufficient contacts for trip, alarm, recorders, etc. It is essentials that relay shall be very quick and should be provided with operation flag indicators.

"Device (94 +86) "Trip Order Devices

Trip order devices shall be provided to trip the respective CBs upon operation of protection relays. These devices shall generally be of two categories, one which functions during transient fault conditions and the other functions under permanent fault conditions. To prevent damages to the plant due to subsequent energization under permanent abnormalities the respective CB's shall be tripped and its lock out relays initiated.

5.10.2 <u>Sub 2 (backup)</u>

Sub 2 is comprising of:

1. Overcurrent and Earth fault protection (50/51+50N/51N)
2. Neutral over-current protection.
3. Trip order devices (94)
4. Over load protection (49)

5.10.2.1 "Device (50/51+50N/51N)" Overcurrent and Earth fault Protection

The transformer protection shall be provided with three phase overcurrent and Earth fault relay where shown on the diagram.

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The relay shall be equipped with second harmonic restrain feature. This protection shall generally consist of two sub units - one having extremely inverse time characteristics in accordance with IEC document 255-4.

The other unit of the overcurrent protection shall be comprising of high set instantaneous unit.

Second harmonic stabilization feature shall be provided in the relay at primary side of power transformer.

The characteristics of overcurrent relay at secondary side of transformer shall be such that to match with transformer-winding thermal curve as far as possible.

5.10.2.2 "Device (51N) "Neutral Over-Current Protection

The transformer protection shall be equipped with a non-directional earth fault current protection supplied from the transformer neutral point.

The protection shall have extremely inverse time characteristics in accordance with IEC document 255-4. For stabilizing the earth fault current protection for inrush current when energizing the transformers second harmonic stabilization feature shall be provided in the relays.

5.10.2.3 "Device (94) "Trip Order Devices

Trip order devices for sub 2 shall be provided as specified in sub 1.

Follower relay

For Bochholz and oil temperature protection follower relays as mentioned in sub 1 should be provided.

5.10.3 Earthing Auxiliary Transformer Protection

The protection of auxiliary transformer shall be chosen from the following relays:

5.10.3.1 "Device (50N/51N)"

The auxiliary transformer shall be equipped with earth fault current protection. The protection shall have suitable current - time characteristics in accordance with IEC 255-4.

5.10.3.2 Follower Relays

Follower relays as mentioned in transformer protection for all guard relays of auxiliary transformer such as: Buchholz and winding temperature etc. (if any shall be provided)

5.10.3.3 Fuse

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Properly selected HRC fuses at 20 kV and 400 Volts sides of the auxiliary transformer shall be provided. The rating and interrupting curve and other characteristics shall be such as to isolate secondary fault maintaining the required selectivity.

5.11 Reactor Protection (N.A)

Reactor must be equipped with protections, divided to SUB I & SUB II (Main and Backup).

Main protection consists of differential and some mechanical protections with tripping and closing circuit devices.

Backup protections consist of over-current and earth-fault, circuit breaker failure, lock- out protection and some mechanical protections with tripping and closing circuit devices. The protection relays must be connected to instrument transformers as shown in appended drawings.

If the reactor is connected directly to the transmission line the reactor protections should trip the line breakers, otherwise they must trip CBs of the reactors.

5.11.1 Restricted Earth-fault Protection

High or low impedance restricted earth-fault protection schemes are required for reactors. It must be connected to dedicated phases bushing CT cores and neutral bushing CT.

The relay must have an operating time of less than 20 ms.

The relay must remain unaffected in harmonics and D.C components existing in the current input of the relay.

For high impedance type, the related CTs must be at equal ratios, identical magnetizing characteristics and identical secondary resistance. The magnetizing current must be minimized practically in order to maximize the sensitivity of this protection.

Externally connected nonlinear resistor must be used at the CT summation point to protect the CTs from high peak voltage during internal faults. Also, external resistor shall be used for stabilizing during external faults which are calculated by contractor and approved by the consulting engineer.

5.11.2 Over-current and Earth-fault Protection

A three phase over-current and earth-fault relay with definite time elements must be provided for this protection. These elements must comply with IEC 60255.

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Each over-current and earth-fault element must be supplemented with an instantaneous element having a range 5 to 20 time's nominal current. It must also be capable of being set to infinity.

Provisos must be considered to avoid mal-operation of this protection under various reactor energization and switching conditions.

Transient overreach of instantaneous element with high X/R ratio of primary system must be small enough (less than 5%) and drop off to pick up ratio must be high enough (greater than 95%).

5.11.3 Mechanical Protection

Different types of mechanical protection are required for protection of reactors, based on their voltage levels and nominal powers. Generally, these protections consist of two-stage operation in which at the first stage of mechanical protection, it begins to alarm and in the second stage it trips to the circuit breakers and simultaneously lock them. These protections are divided to two categories SUB I and SUB II (Main & Back-up) according to consultant engineers' recommendation.

Since mechanical protection trips are in form of latch contact, it is essential that the contractor utilize a timer for both SUB I & SUB II (Mail and Back-up) trips for the purpose of self -reset. In order to repeat mechanical protections, it is necessary to use a flag auxiliary relay. For high-speed mechanical protection such as Buchholz, pressure relief and etc, it is essential to use high speed and flag auxiliary relay, in which it should be finalized according to consulting Engineer's recommendation at design stage. In the excitation circuit of lock-out relay, it is essential to use a mechanical protection relay contact directly, (not a timer contact). To prevent a lock-out relay coil from-continuous energization, it is necessary to use a normally close contact of the lock-out relay in the excitation circuit of set coil in series form.

In case of reactor connected to line directly, if it's necessary to energize the line without reactor (during maintenance), it is essential to use a normally-open contact of reactor dis connector switch in excitation circuit of lock-out relay set coil.

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5.12 MV Line Feeder and Bus Section protection

The MV outgoing feeder and bus section protection are shown in relevant drawing and consists of main following relays.

5.12.1 Device (50/51) Over Current Relay

For each outgoing feeder three phase over current relays having suitable current - time characteristics with instantaneous over current attachment are required. In case of capacitor feeder, the inverse time unit shall be stable during system transient, so that tripping command shall have adequate delay. Instantaneous unit shall have small settable, delay to overcome against capacitive inrush current.

5.12.2 Device (50N/51N) Earth Fault Relay

Ground over current relay with suitable current time characteristics and instantaneous element are required for each feeder. This protection in capacitor feeder shall have suitable setting for preventing mal-operation due to manufacturing variations in the capacitance components.

5.12.3 Device 79 Auto - Reclose Relay

Automatic reclosing relays with three-pole delay reclosing for those feeders which will be connected to MV overhead lines.

5.12.4 Device (94+86) Trip Order Devices

Three phase trip order devices shall be provided to trip the respective C.B.s upon operation of protection relay. These devices shall be of two categories one function during transient fault condition and the other function under permanent fault conditions to initiate lock out relay.

5.12.5 "Device (27+59)" Under and Over Voltage Protection Relay

An integrated three-phase voltage relay to operate on under and over voltage conditions of 63kv system. The over voltage relay shall have two independent adjustable stages for alarm and trip commands. Time delay for alarm shall be in the range from 0.1 to 1 sec, Voltage time characteristic of over voltage relay shall preferable be of inverse type whereas of under voltage relay adjustable definite time is required. The trip function of this relay, but, instead via self-reset relays with heavy-duty type contacts.

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5.13 Busbar protection (N.A)

5.13.1 Low impedance type Busbar Protection

The Busbar Protection shall be of the low impedance type and provide protection for both phase and ground faults for each zone of protection. The Busbar Protection shall be very selective and isolate only the faulty zone. It shall provide proper discrimination and isolation of faults on any busbar in the station or sections of busbars if bus sectionalists are used. The Busbar Protection shall be so designed that it isolates the minimum possible number of sections of the busbars under fault conditions. Full selectivity shall be achieved for every busbar zone; hence every feeder isolator, bus isolator or busbar sectionaliser shall be incorporated in the busbar image.

It shall have a fast operating time. The operating speed shall be independent of the number of bays and protection functions configured in the Busbar Protection system.

If the normally open and normally closed auxiliary contacts of an isolator remain closed or open for more than a certain settable time, an isolator alarm shall be given and the affected zone of the Busbar Protection shall be blocked. This monitoring of the integrity of the isolator auxiliary contacts shall be performed in software form without the use of external relays and timers.

The Busbar Protection shall be insensitive to transients and harmonics and be fully reliable and selective even under CT saturation conditions.

The Busbar Protection shall be capable of operating with CT's of widely different ratios with different rated secondary currents. The matching of CT ratio's in each bay shall be done by a simple setting via the relay front panel without the use of external auxiliary CT's.

The numerical busbar protection shall be with extensive self-supervision and diagnostic facilities.

The current transformer circuits shall not be switched directly via auxiliary contacts of the busbar isolators. The CT circuits shall be continuously supervised and in the event of an open circuit in the CT secondary circuit, an alarm shall be initiated and the affected zone of the Busbar Protection shall be blocked.

It shall be capable of picking up under the minimum busbar fault conditions. It should be possible to set the sensitivity of the protection greater than 120% of the full load current or less than the minimum system fault, whichever is smaller. Stability for external faults shall be ensured under the following conditions:

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Up to the short circuit ratings of the switchgear, irrespective of the distribution of the current between individual circuits.

Under full CT saturation of any of the outgoing feeders.

The Breaker Failure Protection shall be started by the trip commands (phase segregated and three phase) of all protective relays associated with the respective breaker and shall initiate, via two independent settable, breaker dedicated timers:

Selective tripping of all adjacent breakers using, where required, the busbar image as used in the Busbar protection.

Inter trip of the remote and feeder circuit breaker via communication-aided direct trip signaling channel or Inter trip breakers at all voltage levels for transformer feeders.

The Busbar Protection shall include an End Fault function for detecting faults between the CT used for Busbar Protection and the circuit breaker when it is in the open position. Under such conditions, the Busbar Protection shall not operate and trip the other feeders connected to the affected busbar zone. On detecting an end fault, the End Fault function incorporated in the Busbar Protection shall immediately send a trip signal to the remote end of the feeder to clear the fault.

When the bus tiebreaker is equipped with one set of CT's only and when the bus tiebreaker is in open position, the Busbar Protection shall exclude this CT in the evaluation of the Busbar Protection measurement. This will ensure that, when the bus tie breaker is in open position and a fault occurs between the CT and the bus tie breaker, the faulted bus section is selectively tripped and isolated without any delay. The healthy bus section will not be tripped.

It shall be possible to prepare the Busbar Protection to include, in the protection scheme; future bays as and when they are added. Such extension work shall not require any other wiring changes to the existing system.

5.13.1.1 "Device (87) "High Impedance Type Busbar Protection (If Applicable)

The high impedance busbar protection shall generally be consisting of triple pole, high speed; voltage operated circulating current type differential relay.

The relay shall be provided with adjustable setting range which shall provide an effective minimum relay setting equivalent to 30% (or less, not more) of minimum fault level.

The complete relay shall generally be comprising of relay itself and an externally mounted, continuously adjustable resistors in series with the relay coil of each phase. These resistors shall be wire-wounded type and be of adequate wattage ratings.

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The nonlinear resistors (metrosil type) shall be used (if required) across the relay circuit in order to limit the peak voltage developed by the C.T.s under internal fault conditions, to value below the insulation level of the C.T.s relays and inter connoting pilots.

5.13.1.2 "Device (95, 57)" Bus-Wire Supervision and Associated Shorting Relays

Suitable 3 phase bus wire supervision relays shall be offered for each protection zone to safeguard against faults in the C.T.'s secondary wiring such as broken/open or crossed pilots. It shall be connected across ac bus wires in the panel and shall close its contacts when the voltage appearing across the bus wires exceeds the relay voltage setting.

The voltage setting range shall be continuously adjustable between 2 to 14 volts 50Hz. It shall have continuous thermal rating of 300 volts ac (phase to neutral) or more. It shall also withstand 2 kV r.m.s. AC for minimum 3 sec.

After being actuated, the supervisory equipment shall initiate and alarm after adequate time delay.

Bus wire shorting relays with heavy-duty contact shall be offered with bus supervision relays.

These on operation shall short the C.T.'s secondary wires.

5.13.1.3 "Device (94)" Tripping Relays

Individual high-speed tripping relay shall be offered for each circuit for tripping the breaker on busbar protection relay operation.

The relay coil shall be rated for D.C. control voltage and shall have adequate contacts for tripping the breaker through both trip coils, locking auto-reclose schemes, initiation of local breaker back-up protection scheme, respective lock out relays in addition to meet the other requirements of this specification.

The contractor shall include any other relay equipment required for the satisfactory operation of the scheme. Typical drawings showing busbar protection A.C., D.C. and C.T. switching circuits shall be furnished along with the tender.

5.13.2 Measuring center

Measuring center shall be digital, suitable to be used in HV substations (feeders) and capable of measuring true RMS, per phase and total for the followings:

a. Voltage line-to-neutral and line-to-line for each phase and average of all phases.

b. Current of each phase and average of all three phase.

c. KW for each phases and total of all three phases.

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d. KVAR for each phase and total of all three phases.

e. KVA for each phase and total of all three phases.

f. KWh delivered, received or by quadrant.

g. KVAR h delivered, received or by quadrant.

h. KVAh delivered, received or by quadrant.

i. Power factor for each phase and total of all three phases.

j. Frequency.

k. Cumulative demand total.

l. Fixed and sliding window demands for any parameter with user-programmable length of demand period and number of sub-periods to match local utility billing method.

m. Programmable via the communications port using a portable remotely located computer terminal.

n. Possibility to apply at least 2 tariff for revenue metering.

Watt - hour - meters and var. hour meters shall be suitable for measurement of loads in three phase, three wire circuits. They shall be suitable for semi-flush mounting on vertical panels with only flanges projecting outside with back connected terminals.

Meters shall be suitable for operation from the secondary's of C.T.s. and V.T.s. They shall be provided with separate 3 phase, 4-wire type test blocks without disturbing the C.T. and V.T. connections.

Number of digits provided for energy metering shall be adequate to cover at least 1000 hours of operation.

Meters shall have a continuous overload capacity of 200% for accuracy as well as thermal limits. Also it shall withstand at least 10 times rated current for 3 sec. without loss of accuracy.

Accuracy specification for kWh shall comply with IEC 687 class 0.2S. All other parameters shall have a minimum Accuracy of 1 percent of reading.

The meters shall have retransmitting contacts the impulse rate of which shall be suitable for remote indicating or summating system as follows analogue ports suitable for kWh imported, KWh exported, KVARh imported, KVARh exported programmable digital output port.

5.13.3 Fault Recorder

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The fault recorder system shall permanently monitor analog and logic (digital) signals, which are connected to its input channels.

It shall consist in principle of several acquisition boards and a central evaluation station.

The fault recorder shall have programmable characteristics based on a microprocessor-controlled system and be able to operate with several interfacing modules.

The main function of recorder shall be acquisition of electrical AC input quantities (voltages and currents) and DC quantities of events. These quantities to be recorded shall be scanned continuously converted to a suitable digital format and filed in the prefault memory.

The latest scanned values shall over write the oldest in a cyclic form. By internal / external triggering, mentioned values (prefault) the input data and certain subsequent value (post fault) shall be stored in an event memory before transferring to a display unit (printer, monitor, magnetic mass memory, etc.) or sending the information via a communication channel to remote control center.

Evaluation of data stored in this way shall take place at a local point and / or separately at the central evaluation station. Fault recorder systems shall have following features:

- Self monitoring of acquisition station with fault indication and report signal.
- Event identification with year, month, day, hours, Minutes, seconds, and percent of second.
- Local and central evaluation reproducible as often as required.

Central evaluation with format selection, sectional enlargements on computer controlled output units (x/y plotter, video display, and matrix printer) with high quality presentation.

The events length to be stored shall be selected within a reasonable number of seconds and adapts to the event. Further data for the evaluation are filed in the event memory for each event, such as time and date of start, cause of start, number and type of inputs, as well as length of pre-fault record. The event memory shall have capacity for a necessary member of events before transfer to the mass storage unit.

The exact moment of the fault (event) occurrence shall be recorded by an internal accurate clock, which indicates date and time.

5.13.3.1 Acquisition Units

Each acquisition station shall contain a control unit, which initiates the following function:

- Indication of time, date, fault code, number of event in event memory.
- Setting of time and date.

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- Indication of specific status conditions, such as system faults, memory full, mass storage unit full.

- Start of data transfer from event memory to its mass storage unit.

5.13.3.2 Evaluation Station

The mode of operation of evaluation station shall be determined by suitable program package contained in the computer. The program shall function on any I.B.M. compatible computer, using windows operating system.

Stored events shall be graphically represented by software. By this program magnification of time scale shall be possible. The selection of input parameters for this purpose can be performed by user.

The event identification and name of station shall be shown by at least 10 character.

The language for dialog between user and recorder shall be English.

The specification and manufacturer and its origin country of computer and colored video display and printer shall be approved by Engineer.

5.13.3.3 Technical requirement

The following technical requirement shall be fulfilled.

5.13.3.3.1 General

Input voltage rated value (PH-N)	V (AC)	110/√3
Input current rated value	A (AC)	1
Digital input voltage	V (DC)	110/125
Max input current	A	> 30
Accuracy maintain:		
Minimum continuous Permissible O/C	% In	200
Minimum continuous Permissible O/V	% UN	120
Insulation test	kV/1 min 50 Hz	2
Impulse test (1.2/50 us)	kV	5
High frequency test (1mhz)	kV	2.5

5.13.3.3.2 Data acquisition station feature

Minimum number of channels for	analog	16
Data acquisition station	digital	32

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Sampling rate for all channels	kHz	2
Resolution of analog input	byte	12
Minimum total recording time	sec	10
Minimum pre fault recording time	sec	0.3
Self-diagnostic and indication	yes	
Level change binary input		0-1 and 1-0
Level change external input	yes	
Trigger input from other devices	yes	
Minute pulse for synchronization	yes	
Remote transmission	yes	

5.13.3.3.3 Evaluation Station Feature

Power supply	(V AC. 50Hz)	230 (1 PH)
Disk mass storage		yes
Diskette mass storage		yes
I.B.M. compatible		yes
Colored display		yes
Graphic on display		yes
Graphic on matrix printer		yes
Print out on normal paper		yes
Remote data transmission		yes

5.13.3.3.4 Software

Operating system	yes
Menu driven system	yes
Presentation in color	Preferred
Magnification of the plot	yes
Single channel printing	yes
Print screen facility	yes
Controlled data acquisition	yes
Text facility	yes

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5.13.4 Annunciators

Annunciators shall be installed in each substation control room to alert the operators that trouble in the installations is developing and / or had developed and that corrective action shall be taken immediately. The alarm annunciator equipment shall be mounted on the control panel adjacent to the mimic diagrams, capable of accepting all the alarms required within the substation, and compatible for operation in conjunction with the relay equipment provided. The annunciator windows shall be engraved. The size of engraving to be advised later to the successful bidder.

Number of alarm points shall be sufficient to identify and locate where the trouble exists. The alarm annunciator equipment shall be designed in such a way that the necessary corrections or repairs can be performed in the shortest possible time. At least 20% of the windows shall be provided as spares.

In case of static annunciator schemes, special precautions shall be taken by the contractor to ensure that spurious alarm conditions do not appear due to influence of external magnetic fields on the annunciator wiring and switching disturbances from the neighboring circuits within the panels.

Separate annunciation system for each voltage level shall be provided and typical alarm point shall include but not be limited to the following.

A. General Alarm Points (mounted on a common annunciator panel)

- 110/125 VDC supply high or low voltage.
- 110/125 VDC battery charger - no or low AC power supply.
- 110/125 VDC panel main breaker tip.
- 110/125 VDC ground fault.
- 48 VDC supply high or low voltage.
- 48 VDC battery charger - no or low AC power supply.
- AC station service low bus voltage.
- 400/230 VAC station service trouble.
- AC station service on emergency source.
- Fault recorder - trouble.
- Synchronizing Pt. fuses trouble.
- Standby Diesel No start.
- 48 VDC ground fault.

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B. Transmission Lines ALARMS

- Carrier fails (from PLC equipment provided by others).
- Primary protection operated.
- Secondary protection operated.
- Primary relaying - loss of DC supply.
- Secondary relaying - loss of DC supply.
- Under voltage alarm (for distance relays and 230kv lines).
- Carrier send / receive.

C. Circuit Breaker Alarms (General)

- Auto reclose initiated.
- Auto reclose block.
- Trip coil NO.1 circuit Loss- of DC supply.
- Trip coil NO.2 circuit -Loss of DC supply.
- Trip coil circuit -Loss of DC supply.
- Circuit breaker tripped by relaying.
- Low-pressure alarm.
- Low pressure trip or block.
- Loss of AC power.
- General alarms.
- Pole discordance trip.
- Breaker failure relaying operated
- Breaker failure relaying - loss of DC supply
- Trip circuit faulty.

D. Line alarms

- Phase over current relay trip.
- Ground fault trip.
- Auto reclose initiated.
- Auto reclose block.
- Loss of DC supply.

E. 20/33 kV Capacitor Bank

- Phase over current relay trip feeder.

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- Ground fault trip.
- Loss of DC supply.
- Capacitor Bank disturbed.

F. Power Transformers Alarms

- Loss of DC supply.
- Loss of AC supply.
- Primary PT fuse failed.
- Secondary PT fuse failed.
- High winding temperature alarm/trip.
- High oil temperature alarm/trip.
- Oil low level and/or low flow.
- Buchholz alarm/trip.
- Cooling system fail.
- Pressure relief device trip.
- Fire protect on trip.
- Tap changer fail.
- Tap changer drive trip.

G. Ground over current protection trips (HV and LV side of power transfer)

- Phase over current protection trip.
- Secondary under voltage alarm/trip (where indicated on the drawings).
- Differential protection trip.
- Primary under voltage alarm/trip (where indicated on the drawings).
- Secondary restricted earth fault trip.
- Directional over current trip (secondary side).
- Earth fault trip (where indicated on the drawings).
-Directional earth fault trip (where indicated on the drawings).

H. Auxiliary Transformers Alarms

- Bochholz alarm / trip.
- Temperature alarm / trip.
- Pressure relief device trip.

L. Bus Alarms

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- Bus protection relays loss of DC supply.
- Bus differential relay trip.

I. Bus Coupler Alarms

- Phase overcurrent trip.
- Ground fault trip.
- Bus CVT's fuse failed.

The annunciators shall be furnished with audible and visual alarms with acknowledge push button. The annunciator shall be suitable for accepting D.C. power supply as specified in section of technical specification. The type with repeating contacts for each alarm point is required for future supervisory alarm indication. The voltage rating and other specification of repeat contacts shall meet SCADA and / or interface requirements.

Two different types of audible alarms shall be provided for distinction between critical and non-critical alarms.

In case of loss of DC supply of annunciator, it shall be possible to give an alarm to operator by AC supply.

In case of static annunciator schemes, special predation's shall be taken by the contractor to ensure that spurious alarm conditions do not appear due to influence of external magnetic fields on the annunciator wiring and switching disturbances from the neighboring circuits within the panels.

Separate annunciation system for each voltage level (400-230kV & 132-63kV) shall be provided.

5.13.5 Fuses Links and Ancillary Apparatus

Each protection and control circuit shall be provided with necessary arrangement for receiving, distributing, isolating and fusing of D.C .and A.C. supplies for various circuits such as protection, control, signaling lighting etc. The incoming and sub circuit shall be such as to ensure selective clearance of sub circuit faults. Potential circuits for relaying and metering shall be controlled by fuses.

Carriers and bases for fuses and links shall comply with IEC recommendations and color coded to permit identification of the circuit rating.

All fuses shall be of H.R.C. cartridge type mounted on plug in type fuse bases and adequately shrouded. Fuses shall have operation indicators for indicating blown fuse conditions. Fuse carrier base shall have imprints of fuse rating and voltage.

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All incoming circuits in which the voltage exceeds 110 Volts shall be fed through insulated fuses and / or links, the supplies being connected to the bottom terminal, which shall be shrouded so that accidental contact with live metal cannot be made when the moving portion is withdrawn.

VT and CVT secondary circuits should be equipped with fuse or MCB.

If M.C.B.s are used in VT secondary circuits, they shall have two normally open and two normally closed auxiliary contacts for blocking trip circuits of voltage dependent protection and for annunciation. Where high-speed protection is involved, the speed of operation shall be less than 5milli seconds.

6 SUBMITTALS

6.1 Calculation Sheets

Submit four (4) copies of all calculations to establish adequacy of the control and protection devices selected in any respect, for the specified duties under all power system operation conditions (from normal to the most severe fault conditions envisaged) in accordance.

6.2 Contractor's Drawing and Design Data

Submit electrical, design, fabrication and erection drawings of this section in accordance with the "Submittals" of technical specification.

The following shall be considered as a minimum:

- Outline dimension drawings and installation instruction of the equipment to be mounted in or on the panels.
- Detail drawings of the printed circuit boards.
- Commissioning test instruction of protection relays.
- Internal wiring and connection diagrams of all apparatus.
- Manufacturer's descriptive and maintenance Literature.
- Commercial data of elements which have beam used for construction of any relay.

6.3 Test Reports

Submit four (4) copies of all final type and routine test reports together with the certification of the compliance of the equipment with the type and routine tests stipulated in the applicable standards.

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6.4 Maintenance Date and Operating Instructions

Submit maintenance manuals for this section in accordance with article entitled "operating and maintenance manuals".

6.5 Relay Setting

Owner will provide sufficient system data to the contractor to enable him to perform the following works included in this contract.

- Ranging of relays and calculation of relay settings.
- Setting of relays and commissioning of the control and protection system supplied.

The contractor shall submit to Owner 2 complete sets of calculation and proposed relay setting data of each substation for their information and approval, before the installation of the control and protection equipment.

7 FABRICATION AND MANUFACTURE

7.1 Construction of Boards and Panels

The panels, except where otherwise noted, shall be of unit type construction forming a rigid self - supporting, self - contained housing. The panels shall have hinged doors at the back of the panel for rear entry. The doors shall be provided with handles suitable for locking, Panels shall be provided with a steel channel base and mounting bolts.

(A 150 mm deep wiring space, formed by the steel channel base, will be left below the bottom having removable cutouts to permit working in the wiring space. Cables shall enter the panels from the bottom through cable glands where armoring will be terminated and grounded. The panels shall be constructed of cold rolled steel 3.0 mm in thickness welded and reinforced where necessary.

The switch - board panels used for control and metering shall be designed to facilitate switching and supervision by the operators to minimize the probability of accidental tripping of circuit breakers and motor operated switches as a result of human error. The control switch - boards shall be designed and installed in accordance with future requirements in order to enable installation of future additions with a minimum of changes to existing installations.

Relay panels shall be provided with relays in accordance with those shown on the drawings of the substation single line diagrams. The relays used for circuit protection shall conform to the details listed in this section of the specification.

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All surfaces shall be cleaned free of all rust and foreign material, painted with a rust resistant paint, primed, sealed (seller required on exterior only) and painted ANSI # 61 or the same color as existing panel. Panels shall be bolted together; they shall not be welded. All panels shall be fitted with an interior light which is operated by a door switch, a 230-volt single phase socket outlet.

The panels shall be bolted to the floor. Each panel shall be supplied with a heater and thermostat to prevent the formation of condensation and all control and protection panels (Indoor panels) shall be have degree of protection IP42.

7.2 Panel Terminals

Stud type terminal blocks of unit construction shall be provided to accommodate all circuits entering or leaving the panels.

Test links shall be provided on the current leads of each protective relay. The test links shall be designed such that the current leads are short-circuited when the test links are open. A minimum of 10% spare terminals shall be included for spare or future circuits. The terminal blocks shall be arranged vertically, mounted at the sides of the cubicle and set towards the rear so that the ferrule numbers may be easily read. Terminals shall have insulating barriers between points. The terminals shall be grouped and labeled according to their duty by strips securely attached to each terminal block.

Terminal blocks shall be 600 V grade, 10 A rated.

400/230 V circuit terminals shall be segregated from other terminals and fitted with self-extinguishing transparent plastic covers to prevent contact with live parts. They shall have warning labels mounted thereon in a conspicuous position.

There shall be a minimum clearance of 250 mm between the first row of terminal blocks and the associated cable gland plate. Also the clearance between two rows of the terminal blocks shall be a minimum of 150 mm.

Ferrules identified with appropriate wire numbers shall be provided at both ends of each wire within panels.

Removable covers of clear transparent insulating material shall be provided over terminal blocks on which connections are provided for a circuit of greater than 110 volts' potential.

Terminal blocks shall not be used as junction points for cables, which are not required in the panel.

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7.3 Wiring and Connections

Control wiring shall be thermoplastic insulated stranded copper of a size not less than the following:

- Panel wiring single conductor. 1.5 mm^2
- Wiring internal panels excluding Current and voltage transformer circuits. 1.5 mm^2
- Current and voltage transformer secondary wiring. 4 mm and 2.5 mm above

Extra flexible wire shall be used for connections to equipment on hinged frames. Wiring in panels shall be covered with a self-extinguishing cotton braid. All wiring shall be carried out without intermediate splicing. All cables shall enter the panels from the bottom. Self-extinguishing plastic wiring ducts shall be provided at the sides and bottom of the panels to carry wiring vertically to the terminal blocks. The ducts shall be perforated and shall be provided with a detachable cover.

Wire ends shall be fitted with crimped ring type terminals. Not more than two wires shall be terminated on any one stud or terminal. Each terminal point on the terminal block shall be indelibly labeled in accordance with wiring designations.

The D.C. trip, A.C. voltage supplies and wiring to the main protection shall be segregated from those for back-up protection and also from protective apparatus of special purpose.

The incoming power supply to each panel shall be through fuses in such a manner that the supply to any one panel can be isolated from the remaining panels. Fuse holders shall be the dead front types.

The control circuits for power circuit breakers, motor operated switches, power transformer, metering, etc., Shall be designed for future supervisory remote control and position indication, contacts on switches and relays as needed for future supervisory alarms shall be provided.

7.4 Ground Bus

A 40 mm × 3 mm copper ground bus shall extend along the length of each panel. Clamp type connectors shall be provided for directly connecting together the ground bus of adjacent panels. The bus shall be so arranged that it does not interfere with the removal of any panel from a panel assembly or with the access to or operation of equipment within a panel.

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7.5 Nameplate and Mimic Bus

Beveled sheet mica nameplates shall be provided.

Ampere ratings for fuses or circuit breakers and also nameplates with descriptive functions for switches or similar items where these may not be assigned a specific standard device function number shall be provided.

Nameplates are to be mounted 1.0 cm above relay cases, 0.5 cm above indicating lights, control switches and push buttons, and on the bottom front of meter cases.

A mimic bus shall be mounted on the front of the station control boards. The bus shall be metallic or plastic and shall be similar in appearances, to the existing. It shall be fastened by stick fasteners and shall be easily removable. Buses shall be color coded identical to which already installed.

The mimic bus shall indicate the actual arrangement of the installation bus and shall be designed for easy modification to future arrangement.

7.6 Relays

All relays shall conform to the BS 142 or relevant IEC standards and such national standards as may be appropriate in the country of manufacture. However, the requirements of the standards (of country of manufacture) shall in no case be inferior to their counterparts in BS or IEC. In any case, the copy of the specification should be furnished along with the tender for Engineer's approval.

Considering the relay equipment, method of mounting and accommodation, account shall be taken of the fact that Iran lies in an "earthquake belt" and for design purposes, it shall be assumed that all of shocks at ground level can achieve 0.5 g.

Individual relays shall, as a minimum, satisfy the numerical values quoted in appendix "F" of BS 142, and the contractor shall furnish type test certificates for each equipment as appropriate.

All protective relays shall be in drought cases with built in test facilities. Necessary test plugs shall be supplied loose and shall be included in contractor's scope of supply. Test blocks and switches shall be located immediately below each relay for testing. Unless otherwise specified, all auxiliary relays and timers shall be supplied in non-drought cases.

All A.C. relays shall be suitable for operation at 50 Hz for V.T. secondary and C.T. secondary as specified in single line diagram. D.C. auxiliary relays and timers shall be designated for the D.C. voltage specified in the respective single line diagram and shall operate

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satisfactorily between 80% to 110% of the rated voltage, voltage operated relays shall have adequate thermal capacity for continuous operation.

All protective relays shall be provided with at least two pairs of potential free output contacts. Additional contacts shall be provided where required. Auxiliary relays and timers shall have pairs of contacts as required for the function. Contacts shall be silver faces with spring action.

Protective relays shall be provided with operation indicators, externally resettable from the front of the relay. Loading resistors shall be furnished where needed to ensure reliable target operation. Auxiliary relays shall be provided to permit duplicate targeting at a remote location.

Timers shall be of the Electro - magnetic or static type. Pneumatic timers are not acceptable.

No control relay, which shall trip the power circuit breaker when the relay is de-energized, shall be employed in the circuit.

Provision shall be made for easy isolation of trip circuits of each relay for the purpose of testing and maintenance.

Auxiliary seal - in units provided on the protective relays shall preferably be shunt reinforcement type. If series relays are used, the following shall be strictly ensured.

The operating time of the series seal - in unit shall be sufficiently shorter than the trip coil or trip relay in series with which it operates to ensure definite operation of the flash indicator of the relay.

Seal - in unit shall obtain adequate current for operation when one or more relays operate simultaneously.

Impedance of seal - in unit shall be small enough to permit satisfactory operation at the trip coils or trip relay when the D.C. supply voltage is minimum.

7.7 Recorders, Meters, Annunciators and Instruments

All instruments for front mounting on the panel shall be semi-flush mounted, back connected rustproof, switch - board type with rectangular cases, removable covers, transparent windows and with provision for sealing where applicable.

Meter elements, especially those requiring testing and adjustment shall be provided in draw out type cases fitted with devices to automatically short circuit the current circuits and where applicable, to provide for interruption of the tripping circuit.

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All meters required for revenue metering shall have metering accuracies of at least 0.5 percent. All statistical meters supplied shall have a minimum accuracy of 1.5 percent of full scale. All meters for revenue purposes shall be unidirectional type.

The dimension of the recorder (voltage, frequency and power recorders where required should be such that a minimum of one tenth of nominal rated values can be read easily, but however it should not exceed 20 cm × 20 cm. The pointer of the recorders should be sensitive enough to respond that is give an indication, to a magnitude of the initiating signals equal to and less than 2% rated values.

Wiring of all components and contacts to the terminal blocks, for external connections, is included.

AC inputs can be isolated from the relay and test equipment connected without open circuiting the current supply.

Trip circuits are opened but the D.C. supply is maintained, where applicable, for testing of the relay.

AC quantities can be injected into the relay from portable test equipment.

All meters shall be large dial rectangular type with dimension of 96 mm × 96 mm and covers shall be of a non-reflecting glass type.

Final scales and ranges of instruments, where such scales are not already detailed in this Specification are to be given later.

Annunciators for the control boards shall be relay type suitable for N/O and N/C alarm condition and have the following operational sequences.

(1) Normal

The annunciator windows dark and the audible alarms silent.

(2) Alarm

On contact operation of a remote alarm-sensing device, the annunciator system shall provide the following alarm indicators even when the contact operation is only momentary.

- The audible alarm shall sound and the master alarm indicating lamp below the associated annunciator shall flash.

- The associated window lamp shall flash.

(3) Acknowledgement

The alarm shall be acknowledged in the following manner.

- Operate the audible alarm acknowledges button, which shall silence the audible alarm.

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- Operate the accept knowledge push button which shall cancel the flashing master alarm lamp and the flashing window and cause the annunciator to produce a steady light.

- Operate the reset acknowledge push button which shall reset the annunciator window to normal state if the alarm contact has returned to normal, otherwise the annunciator will not change its state.

(4) Lamp Test

Upon closing of the lamp test button contacts, all lamps on the associated annunciator and control panel shall be energized. Lamps shall be de-energized upon release of the test button.

7.8 Switches

Circuit breakers and disconnect switches shall be controlled and indicated by discrepancy control switches forming part of the mimic diagram. The change of state of circuit breaker or disconnect switch shall cause its discrepancy control switch light to flash. The indication of change of state will be accepted by turning the discrepancy switch manually into the position in agreement with the substation switch.

All switches shall be of the rotary type with silver plated self-cleaning contacts and rectangular dials on which function positions are clearly indicated.

Switches shall be suitable for interrupting the trip and close currents of the circuit breaker control circuits without requiring the use of interposing relays. Position indicator for disconnect switches shall be similar, but visually differentiated from, the circuit breaker control switches.

A local / supervisory switch shall be provided and mounted on a control panel to perform the following duty:

(1) When in the local position:

Disable all operations initiated by contacts in supervisory equipment provided by others.

(2) When in the “supervisory “position:

a. Disable all operations initiated by control switches in the station control room (operation)

b. Disable all audible alarms in the station control room.

c. The switch lights should indicate these positions.

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8 INSPECTION AND TESTS

Perform all inspection, type and routine tests stipulated in applicable standards to ensure that the material and workmanship conform to the specification and drawings.

Give access to Owner's representative to the works to determine or assess compliance with the provisions of this specification or to witness the contractor's inspection.

Produce a certification of the compliance of the equipment with the type and routine tests stipulated in the applicable standards.

Include the following tests:

(1) Operation of all meters and relays using single phase or three phase supply as required; operation of relay contacts using the appropriate D.C. supply.

(2) Energizing of all low voltage control circuits using the appropriate voltage supply, and testing for operation and sequence of operation including polarity tests where required.

(3) Di - electric strength test according to IEC standard.

(4) Continuity of all low voltage circuits.

Satisfactory evidence of the successful performance of such tests is required.

Owner reserves the right to have representative present during final shop and functional testing. The contractor shall advise the date of test at least sixty (60) days in advance.

9 SUPERVISION OVER INSTALLATION AND ERECTION

Supervise over installation, erection and commissioning of metering control and relay panels in accordance with the drawings and manufacturer's instruction to ensure satisfactory and proper operation in every respect.

Perform visual inspection to insure that there is no damage. This supervision and inspection shall cover but not be limited to the following:

(1) Install, level, align panels and fasten to floor and adjacent panels.

(2) Remove shipping blocks and braces.

(3) Clean interiors.

(4) Examine Connections to ensure that they are not loose, tighten as required.

(5) Interconnections to install cables.

(6) Touch up all damaged paint work.

(7) Inspect, make necessary adjustments, field test, and place the equipment in commercial service.

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(8) Notify Engineer in writing as soon as installation of the equipment is complete.

(9) On completion of the installation carry out testing of the equipment which is in accordance with a program that has been approved by owner. Carry out all tests in co-operation with and in the presence of Engineer subject to the requirements and operating conditions of the owner system.

(10) Perform field tests to include but not limited to the following:

a. Continuity test of all low voltage circuits.

b. Meggering on all low voltage circuits.

c. Energizing of all low voltage circuits.

d. Check of the operation of all meters, relays, instruments, alarm and trips.

e. Timing tests

f. Functional testing of all equipment.

Provide all instruments and equipment required for the site acceptance tests. These instruments will remain the contractor's property and can be removed after the successful completion of the tests.

10 SPARE PARTS

Mandatory spare parts shall be provided as per relevant schedule of prices for this section. The tenderer shall recommend any additional spare parts considered necessary.

11 MEASUREMENT AND PAYMENT

Payment of this section excluding its spare parts will be a lump sum and will be made in accordance with schedule of prices. For spare parts of this section payment will be unit price and will be made in accordance with schedule of prices.

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