

PROJECT SPECIFICATION

DESIGN, SUPPLY, INSTALLATION AND COMMISSIONING OF PROTECTION SCHEMES (IEDs) AT VARIOUS SUBSTATIONS



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SECTION II PROJECT DETAIL SPECIFICATION

1. WORKS INFORMATION AND CONTRACTUAL REQUIREMENTS

1.1. GENERAL

This specification deals with the technical installation aspects relating to this project. Any discrepancy between the Project Specification and Bill of Quantities must be reported to the Engineer who will clarify such contradiction before the tender closing.

NOTE: There are stringent requirements applicable to the entry into sites and the work on sites:

- a) The contractor shall not enter a substation area without the special written permission of City Power. The contractor shall obtain permits from City Power to carry out any work on Substation sites.
- b) Entry into substations, indoor and outdoor, shall only take place in the presence of the authorized representative of City Power and/or the Engineer responsible for Safety and Security. The contractor shall employ an HV Registered person to take responsibility of all substation sites.
- c) Work near open HV/MV bushings of transformers or overhead lines are strictly forbidden.

This document describes the requirements for Design, Supply, Installation and Commissioning of Protection Relays (IEDs) at various Substations.

This document must be read together with all Conditions of Tender, Conditions of Contract, Special Conditions of Contract, Protection Schemes Specifications and Standard of City Power, Bill of Quantities and Drawings as issued for the Works.

The stipulations of this document must be seen as forming part or being complementary to any Conditions of Tender, Conditions of Contract, Special Conditions of Contract, and Schedule of Quantities, must be read together, and shall be regarded as forming part of such documentation for the Works.

If any discrepancies exist between parts of this document, the following order of preference will take place:

- i. Bill of Quantities
- ii. Technical Specifications

Regarding the conditions of the contract, the order of priority is as follows:

- i. Special conditions of contract
- ii. General conditions of contract for Electrical & Mechanical Works
- iii. Tender requirements
- iv. Common Law

Any such conflict shall, however, be brought to the attention of the Engineer, before the closing date of tenders.

The Tenderer shall further evaluate the works and services required in terms of these requirements during the Tender period, with the purpose of determining whether the requirements herein will have an influence on his contract price, and if so, the Contractor shall allow for any costs arising from this document in his contract price.

The Tenderer shall be deemed to have carefully examined all the constituent parts of this document and all other documentation issued to him/her by the Engineer before the Tender

is submitted. Any doubts as to the meaning of any terms, phrases or clauses of the document or any other document, or any missing pages, shall be submitted to the Engineer in writing before a Tender is submitted.

No claims traceable to no compliance with this requirement will be considered after the closing date of Tenders.

If it is found at any stage of a Contract that the Tenderer has deviated from the requirements of this document without the written consent of the Engineer, then the Engineer shall have the right to order the Contractor to carry out the actions required by this document without any adjustment in the Contract price.

The successful tenderer shall within 14 days after being informed of acceptance of the offer provide the following information:

- i. Project Programme (in Microsoft Projects format – version 2010 or later)
- ii. Material and supplier Schedule
- iii. SHEQ file
- iv. Drawings for approval

The Tenderer shall indicate the lead times for his working drawings in the Tender. The program of works in the factories or on site will be determined after due consultation with the Engineer.

Contractors who wish to submit alternatives for the specified installations or items must submit complete documents, including all technical data, for such alternative offers.

Calculations, drawings and all other pertinent technical information and characteristics, as well as modified or proposed Pricing Data for such alternatives must be submitted as an alternative Tender offer to enable the Employer to evaluate the efficacy of the alternative and its principal elements, to take a view on the degree to which the alternative complies with the Employer's standards and requirements and to evaluate the acceptability of the pricing proposals. Calculations must be set out in a clear and logical sequence and must clearly reflect all design assumptions. Pricing data must reflect all assumptions in the development of the pricing proposal.

The installing and servicing company offering their equipment will thus utilize only certified technicians for the purpose of installing access control hardware to include access control equipment, software and wiring, unless otherwise directed or instructed by City Power.

Tenderers shall note that the information shared as part of this tender is highly confidential of nature and shall under no circumstances be reproduced, shared, distributed or be used to the detriment of City Power of Johannesburg By obtaining this document and initialling of this page the tenderer agrees to the above confidentiality terms.

City Power of Johannesburg reserves the right to appoint a single or multiple Contractors for this project as is so decided following the tender adjudication process. Each equipment shall therefore be priced individually and unit rate prices shall not be dependent on order quantities. Minimum order quantities for a fixed price shall therefore not apply to this project.

1.2. BACKGROUND

City Power intend to replace all electromechanical relays on the entire network. Unreliable, aging and inaccurate protection relays contribute to some of the catastrophic damages to

secondary and primary plant equipment at City Power substations. It also leads to prolonged and costly outages. Replacement of damaged substation equipment is very costly, and this can be reduced by implementing more reliable protection systems.

1.3. DESCRIPTION OF WORKS

The description for the works include the design, supply, installation and commissioning of protection schemes at various substation, which will be identified by City Power during the period of the Contract.

The equipments to be supplied, installed and commissioned by the successful tenderer, includes:

- a) Incomer and Feeder Protection Relays
- b) Transformer Protection Relays
- c) Voltage Transformers
- d) Test blocks and Plugs
- e) Miniature Circuit Breakers
- f) Control Cables
- g) Industrial Grades Ethernet Switches
- h) Optic Fibre Patch Leads
- i) Face Plate Panel and Control Panels

The Bill of Quantities contain the materials required for the entire duration of this Contract and cannot be regarded as the full and final quantities of material for this Contract. The Quantities in this document, however, cannot be considered as being the final and full Scope of Works and fixed orders for quantities of small materials shall not be placed forthwith, neither for imported items nor for locally available items. A meeting shall take place between the Contractor and the Engineer to discuss the final Bill of Quantities before procurement of all material and equipment take place. This meeting will take place immediately after award of the Tender and will serve to discuss all technical questions regarding specified or offered equipment, to enable the Contractor to proceed with ordering of equipment.

The Tender Drawings or Bills of Quantities issued with this specification are not to be used for construction or ordering of materials. Exact measurements must be taken on site for the ordering of equipments, as the Contractor will not be paid for un-used materials on sites.

It is a specific requirement of this Contract that the Contractor submits his own general arrangement and equipment layout complete with overall dimensions and finishes of the equipment offered by him, after being awarded the Tender.

It is a further requirement of this Contract that the Employer approve in principle and/or in detail the Contractor's drawings and data before manufacture of any equipment may proceed.

Where the Contractor's Equipment may have an effect or impose forces or restrictions on any part of the buildings or structures of the Employer, the Contractor shall timeously submit details of such items, Works, Plant or designs to the Engineer for incorporation into the detailed design of the Works.

1.4. DEFINITIONS

For the purposes of this document, terms used herein or in enclosed documents shall have the following meaning:

“**Agreement**” shall mean the agreement entered into between the Employer and the Contractor for the execution of the accepted Tender Price or accepted quotation;

“**Schedule of Quantities**” or “**Pricing Schedules**” or “**Bills of Quantities**” shall mean the document attached to a Tender Document or Quotation in which are entered the quantities of work, labour, materials and articles required for the execution of the Contract, together with the rates or prices for such items;

“**Schedule of Prices for Variations**” shall mean the schedules attached to a Contract Document or Quotation in which are entered the amounts to be added to, or deducted from the Contract Amounts according to whether the items mentioned in the said schedule are extra to or omitted from the Contract as may be provided for in the General Conditions of Contract;

“**Contract**” or “**Contract Documents**” shall mean and include the Conditions of Tender, General Conditions of Contract, Special Conditions of Contract, Project Specifications, Schedules of Quantities or Pricing Schedules or Bills of Quantities, Schedule of Prices for Variations, Drawings, Form of Tender, Letter of Acceptance and the Agreement to follow there on and shall include such printed matter or explanatory memorandum submitted by a Tenderer with his tender as may be acceptable to the Employer;

“**Contract Price**” or “**Contract Sum**” shall mean the amount entered in the Form of Tender for the whole of the Works done or materials supplied for the Works, subject to additions or deductions as may be made in terms of the Contract;

“**Contractor**” shall mean the person or persons, partnership, firm or company, whose tender for the work referred to in the Contract has been accepted by the Employer or who has or have signed the Contract, and shall include his or their heirs, executors, administrators, judicial managers, trustees, successors in title and duly appointed representatives;

“**Employer**” or the “**Client**” shall mean the Owner of the completed Works or the official body who acts as the representative of the Owner and shall include their duly appointed representatives.

“**Drawings**” shall mean the drawings, sketches, diagrams, maps, plans, sections and other delineations which accompany or are referred to in the Contract Documents, and which have been signed by the Engineer and such further drawings as may be issued or approved by the Engineer in connection with the works, whether such further drawings indicate variations of the Works, whether by way of addition, alteration or omission, or merely elaborate in greater detail the signed Drawings;

“**Engineer**” shall mean the Engineer duly appointed by the Employer to act on its behalf for the purpose of a Contract.

“**Order in Writing**” shall mean any printed, typewritten or written document or letter signed by the Engineer and addressed to the Contractor for the purpose of his guidance and directions.

“**Site**” shall mean the land and/or place to which Works is to be delivered or where work is to be executed or carried out under a Contract and any other land and/or place acquired or used by the Contractor in connection therewith, and includes any place wherever anything is made, manufactured, excavated or stored for the purpose of carrying out a Contract, together with so much of the area surroundings the said place or places as the Contractor shall with the consent of the Engineer actually use in connection with the Works otherwise than merely for the purpose of access to the said place or places;

“Specification” shall mean the section in the Contract document in which the detail method and standard of executing the Work and the nature of the materials to be used or supplied are described;

“Plant”, “Work” or “Works” shall mean all equipment, plant, materials, articles, matters and things comprised by, described in, or referred to in the Contract Documents and which are to be manufactured and/or delivered, constructed, erected and completed. These shall include all those details which are not particularly mentioned in the aforesaid Documents, nor shown upon the Drawings, but which are requisite for the perfect completion of each and every one of the several parts, and all additional Works that may be ordered to be executed according to the true intent and meaning of the Contract plus the maintenance for the prescribed period;

“Standard Practice” shall mean the methods and means of working normally as employed by the Employer;

“Tests on Completion” shall mean such tests as are prescribed by the Specification to be made by the Contractor before the Works is taken over by the Employer;

“Construction Equipment” shall mean all the materials, machinery, implements, tackle, vehicles, barrows, tools, etc. provided by the Contractor, for the due performance of the Contract, but not essentially forming part of the Contract.

Words imparting the singular only shall also include the plural and vice versa where the context so requires. The headings or notes in these General Requirements shall not be deemed to be part thereof, or be taken into consideration in the interpretation or construction thereof or of the Contract.

“In writing” shall mean type written script or printed communication matter transmitted via land mail or via e-mail, or delivered by hand, to the Engineer.

1.5. ABBREVIATIONS

For the purposes of this document, abbreviations used herein or in enclosed documents shall have the following meaning.

| | |
|--------------|---|
| IED | Intelligent Electronic Device |
| OEM | Original Equipment Manufacturer |
| AVR | Automatic Voltage Regulator |
| REF | Restricted Earth Fault |
| O/C | Over Current |
| E/F | Earth Fault |
| D/C | Direct Current |
| SEF | Sensitive Earth Fault |
| SCADA | Supervisory Control And Data Acquisitions |
| IDMT | Inverse Definite Minimum Time |

1.6. TECHNICAL SPECIFICATIONS

Note: Unless otherwise specified the material shall be in accordance to the specifications listed in the section of this document containing all General and Equipment Specifications.

CP_TSSPEC_066

Specification for Medium Voltage Rackable
Voltage Transformers

REV 1

The following but not limited to National or International specifications will be applicable to this project:

| | |
|---|--|
| SANS 1019 | Standard voltages, currents and insulation levels for electricity supply |
| SANS 1091 | National colour standard |
| SANS 1186 | Symbolic safety signs |
| SANS 10142 | The Wiring of premises |
| IEC 60794-1-E4 | Optical fibre cables |
| IEC 60794-1-F4 | Optical fibre cables |
| IEC 60794-1-E4 | Fibre optic Cable Testing Methods |
| EN60529 | Degrees of protection provided by enclosures (IP code) |
| The Electricity Act Machinery and Occupational Safety Act | Republic of South Africa - The Electricity Act, No. 40 of 1958 Republic of South Africa - Machinery and Occupational Safety Act 85 of 1993 with special reference to Section 1 (Act & Regulations), Section 2 (Administrative Regulations), Section 6 (Electrical Installation Regulations) and Section 16 (General Safety Regulations) |

1.7. SITE INFORMATION

The sites are the premises of City Power. Space within most of the site are extremely restricted and access to and from sites are difficult due to high volumes of vehicular traffic.

Unless otherwise specified in the technical data sheets of this enquiry, all equipment offered against this contract, shall be suitable for use under the following climatic and service conditions:

- Altitude 1,600 to 1,800 meters
- Ambient temperature -10° C to 40 °C
- Average humidity Not exceeding 95 %
- Wind pressure Not exceeding 1050 Pascal
(Equivalent 40 m/s)
- Level of atmospheric pollution High (Indoor application 31 mm/kV)
- Lightning ground flash density Up to 8 flashes per km²/year

Contractors shall note that due to the space limitations on the substation sites, there is not sufficient space for storing of equipment for extended periods. The Contractors shall plan and allow sufficiently to ensure that equipment is delivered just in time for installation.

1.8. ENVIRONMENTAL CONDITIONS

Except when otherwise specified, all equipment and materials shall be designed and selected for the following climatic and environmental conditions:

- a) Operating temperature range: -10°C to +55° C.
- b) Relative humidity: maximum 95% below 35°C and maximum 75% above 35° C
- c) Height above sea level: 1500 meters.

d) Wind borne and air borne dust

Corrodible metal parts of installations installed indoors in humid conditions or outdoors shall be manufactured from brass, aluminium, stainless steel, powder coated 3CR12 steel. Other steel and alloy materials used for commercial equipment such as camera brackets shall be powder coated

1.9. INSULATION LEVELS

Due to some work to be carried out in high voltage environments, the appointed contractor(s) shall have in its employment at least one person with ORHVS certification, who will supervise all work being carried in in or near live chambers or yards. It shall be the responsibility of the contractor to ensure safe working clearance of all people on site during construction/installation as well as statutory clearance after installations are completed. Any possible violations shall immediately be brought to the attention of the Engineer for instructions to be issued.

Table 1: Electrical Clearance

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|--------------------------------|------|------|-----|------|------|------|------|------|------|
| Rated voltage, kV | <1,1 | 7,2 | 12 | 24 | 36 | 48 | 72 | 100 | 145 |
| Electrical clearance, m | – | 0,15 | 0,2 | 0,32 | 0,43 | 0,54 | 0,77 | 1,00 | 1,45 |

NOTE 1 The safety electrical clearance is referred to as the "M value".

NOTE 2 No electrical clearance is specified for voltages below 1,1 kV because exposed live LV parts are considered safe if there is no direct contact with the live part.

Table 2: Working Clearance

| 1 | 2 | 3 |
|-----------------------------|--------------------------------|------------------------------|
| Rated voltage kV | Working clearance m | |
| | Vertical (2,40 + M) | Horizontal (1,40 + M) |
| ≤ 1,10 | – | – |
| 3,60 | 2,55 | 1,55 |
| 7,20 | 2,55 | 1,55 |
| 12 | 2,60 | 1,60 |
| 24 | 2,72 | 1,72 |
| 36 | 2,83 | 1,83 |
| 48 | 2,94 | 1,94 |
| 72 | 3,17 | 2,17 |
| 100 | 3,40 | 2,40 |
| 145 | 3,85 | 2,85 |

NOTE 1 The working clearances do not include any provision for additional object clearances (see 4.7). Where screens or barriers are interposed, the clearance should be taken as a taut-string measurement around the edge of the screen or barrier.

NOTE 2 This table does not apply to compact tower clearances. Live line techniques should be applied in respect of compact towers.

All equipment offered shall be properly screened or insulated and shall not be susceptible to any electrical or magnetic interference for voltage levels up to 400kV.

Where it is impossible to work near live equipments, the Contractor shall request an isolation of the live equipment in order to undertake their works and return the plant to its normal working condition when the works is completed.

2. SCOPE OF WORKS

The scope of works for this contract includes the following:

- a) The detailed schematic design, supply, installation, decommissioning and commissioning of the new protection schemes at various substations as specified in this document.
- b) Where modification of the protection scheme is required, the contractor shall design this scheme, configure the protection scheme (logics and settings) and add wiring additional functions i.e. controls, alarms and indications, to ensure correct operation;
- c) Supply, install and commission protection relays (IEDs) according to the technical specification CP_TSSPEC_214;
- d) Supply and install of new test blocks;
- e) Supply and install of new miniature circuit breaker.
- f) Decommissioning of the old protection scheme i.e. Disconnection and removal of the old relays, test blocks, fuses or miniature circuit-breakers and any other related equipment to be transported to City Power Protection Stores;
- g) Removal of the old switchgear panel faceplate, in the case of switchgear circuit breaker and protection relays are on the same switchgear panel, and supply and install the new panel faceplate according to the size and colour of the existing switchgear panel;
- h) Decommissioning and Removal of old standalone protection panel in the control room, in the case of transformer protection, and supply and install of new protection and control panel with its associated accessories. The old protection panel to be transported to City Power stores;
- i) Supply and install of Voltage Transformer (VTs) according to the technical specification CP_TSSPEC_066, where applicable;
- j) Supply and install Industrial Grades Ethernet Switches and interface with the protection relays as well as RTUs for SCADA and Telecommunication equipment for remote engineering, where applicable, means of electrical optical fibre Ethernet networks;
- k) Supply and install optic fibre patch leads for telecommunication between the protection relays and Industrial Grades Ethernet Switch, where applicable; Telecommunication scope covers the communication from the relay to the Ethernet switch, SCADA etc. where applicable.
- l) Contractors shall ensure that all alarms and indications that goes to SCADA are wired and commissioned. For those station where there is no SCADA, contractor shall ensure that wiring is done up to the terminal block for future implementation of SCADA;
- m) Where differential protection is required the contractor shall be responsible for the supply, installation and commissioning of the differential scheme in the remote station;
- n) The panel shall be cleaned and all hanging wires shall be neatly arranged and tied.
- o) Upon completion of the works, the Contractor will be required to provide As-built schematics drawings, logics and settings indicating the full protection scheme for the equipment.

3. PROTECTION SCHEMES

The protection schemes for this Contract shall employ numerical protection relays or IEDS according to the technical specification CP_TSSPEC_214 as discussed below. All control and protection devices shall be required to have full type test certificates. The following general requirements shall apply:

- a) Trip circuit supervision shall be performed independently for the two CB trips coils, if applicable, and cover the entire circuit between the trip contacts up to and including the trip coils. Where two relays are included in a scheme, trip coil supervision will be done independently in the two relays (one per relay). Where there is a single relay both coils will be monitored in the one relay, but by independent circuits.
- b) The tripping circuits for the relay protection belonging to Main 1 and Main 2/ back-up protection relays shall be separated both electrically and mechanically. This implies that they must not include common switching devices, connectors, terminal blocks, cables, auxiliary relays, etc.;
- c) Cross-tripping will be applied. This implied dedicated trip contacts in the main 1 relay to trip the main 2 / back-up trip coil and vice versa.
- d) Breaker fail signals will be initiated in the protection schemes but executed in the Buszone protection relay, where applicable.

3.1. INCOMER FEEDER PROTECTION SCHEME

The incomer feeder protection scheme shall contain protection functionality as shown in Table 3 and shall consists of an IED of type MAINI as specified in CP_TSSPEC_214.

Table 3: Incomer Protection Relay Functionality

| (ANSI) | DESCRIPTION |
|--------|--|
| 51/51N | IDMT Over-current and Earth Fault |
| 67/67N | Directional Over-Current and Earth Fault |
| 67NS | Sensitive Earth Fault |
| 50BF | Circuit-Breaker fail detection |
| 50C | Switch Onto Fault |
| 60FL | VT MCB Trip/ Fuse Fail |
| 27 | Under and Over Voltage Protection |
| SBM | Low DC Monitor |
| 79 | Auto Reclosing (Optional) |

3.2. RADIAL FEEDER PROTECTION SCHEME

Radial feeder protection scheme shall contain non-directional overcurrent and earth fault functionalities as shown in the Table 4. The protection relays shall be an IED of type RADIALF as specified in CP_TSSPEC_214.

Table 4: Radial Feeder Protection Relay Functionality

| (ANSI) | DESCRIPTION |
|--------|-----------------------------------|
| 51/51N | IDMT Over-current and Earth Fault |
| 67NS | Sensitive Earth Fault |
| 50BF | Circuit-Breaker fail detection |
| 60FL | VT MCB Trip/ Fuse Fail |
| 79 | Auto Reclosing (Optional) |

3.3. MAIN/PARALLEL FEEDER PROTECTION SCHEME

The scheme shall be applicable to main feeders i.e. incomers and parallel feeders. The IED shall provide the following functionalities in one unit: differential protection, directional (overcurrent and earth fault) and non-directional (overcurrent and earth fault) protection. Parallel feeder protection scheme shall contain directional overcurrent and earth fault functionalities, and differential protection elements as shown in Table 5. The protection relays shall be an IED of type MAINFO as specified in CP_TSSPEC_214.

Table 5: Main Protection Relay Functionality

| (ANSI) | DESCRIPTION |
|--------|--|
| 51/51N | IDMT Over-current and Earth Fault |
| 67/67N | Directional Over-Current and Earth Fault |
| 87L | Current Differential Protection |
| 67NS | Sensitive Earth Fault |
| 50BF | Circuit-Breaker fail detection |
| 60FL | VT MCB Trip/ Fuse Fail |
| 79 | Auto Reclosing (Optional) |

The differential protection shall function as main protection where telecommunication is available between local and remote station, and directional overcurrent and earth fault as backup protection in-case of a telecommunication failure to the between the local and remote station. Directional overcurrent and earth fault shall function as main protection where telecommunication is not available between local and remote station. Additionally, a VT will be required to supplied and installed with the direction protection scheme.

3.4. BUS-SECTION AND INTERCONNECTOR PROTECTION SCHEME

The bus-section and interconnectors for standby feeder-board shall have an IED of MAINI type and shall contain the protection functionality as shown in Table 6.

Table 6: Bus-Section and Interconnector Protection Relay Functionality

| (ANSI) | DESCRIPTION |
|--------|--|
| 51/51N | IDMT Over-current and Earth Fault |
| 67/67N | Directional Over-Current and Earth Fault |
| 50C | Switch Onto Fault |
| 50BF | Circuit-Breaker fail detection |
| 60FL | VT MCB Trip/ Fuse Fail |

3.5. TRANSFORMER PROTECTION SCHEME

The power transformer protection scheme for the substation's will have IEDs that provide transformer Current Differential protection, low Impedance Restricted Earth Fault protection and backup overcurrent and earth fault protection (HV and MV). The protection relays shall be an IED of type DIFFT as specified in CP_TSSPEC_214.

3.5.1. MAIN PROTECTION AND FUNCTIONALITY

- **Differential Protection:** In addition to numerical low impedance differential protection with inrush blocking and compensation, the relay shall provide thermal overload protection with selectable tripping characteristics.
- **Restricted Earth Fault (REF) Protection:** shall be integrated into the transformer protection low impedance relay and where applicable, also be achieved by separate relays (high impedance):

- High impedance circulating current protection schemes will be applied to the HV and MV windings. The schemes shall be connected to dedicated CT cores on the HV, MV, the neutral connection of the transformer and the Neutral Earthing Compensator (NECRT). The high impedance REF relay need not to be of the numeric type, but operation shall be monitored by the main IED via digital inputs.

The protection functions to be included are as shown in Table 7.

Table 7: Main Protection Relay Functionality

| (ANSI) | DESCRIPTION |
|--------|---|
| 87T | Transformer Current Differential with low impedance REF for MV windings or where applicable, HV windings and/or both. |
| | Inrush Blocking |
| | Over Excitation |
| 49 | Thermal overload protection |
| 51/51N | IDMT Over-current and Earth Fault |
| 50HS | Instantaneous Over Current |
| 67/67N | Directional Over-Current and Earth Fault |
| 67NS | Sensitive Earth Fault, (Stand-by) and where applicable, HV E/F |
| 50BF | Circuit-Breaker fail detection |
| 60FL | VT MCB Trip/ Fuse Fail |
| 87R | High Z HV & LV REF |
| SBM | Low DC Monitor |

3.5.2. TRANSFORMER MECHANICAL PROTECTION

The following mechanical transformer protection functions shall be integrated to the main protection relay:

- Buchholz Surge and Gas for main transformer tank trip;
- Buchholz Surge and Gas for tap changer compartment;
- Winding Temperature High Alarm;
- Oil Temperature High Alarm and Trip;
- Low/ High Oil Level Alarm;
- Main Tank Overpressure Device Trip.

A mechanical Master trip / lock-out relay of type LO1 & LO2 & MTR according to CP_TSSPEC_214, shall be installed for transformer trips. The Master trip reset should not be possible via SCADA. The transformer mechanical protection must energise individual digitals on the main protection relay and operate the master trip relay via de-coupling diodes. The relay digital input count must make provision for each individual alarm and trip signal from the power transformer and must be limited to functions listed above.

3.6. TRANSFORMER AUTOMATIC VOLTAGE REGULATOR (TAP CHANGE CONTROL)

A transformer automatic voltage regulator IED is required to control the MV output voltage i.e. secondary side voltage of a step-down power transformer. The power transformers of each station shall be able to be operated in parallel and parallel control be performed on the minimum circulating current principle. The IED required shall be of an AVR type according to CP_TSSPEC_214 and shall contain protections functions as shown in Table 8.

Table 8: Tap Change Control Relay Functionality

| (ANSI) | DESCRIPTION |
|---------|-------------------|
| 27/59VR | Voltage Regulator |

| | |
|----|---|
| | Communicating minimum circulating current (for up to four transformers in parallel) |
| 50 | Over-current block |
| | Local / remote and manual / automatic control selection |

4. SCADA

The Contractor shall ensure as minimum, the following protection relays functions are interface with SCADA, where applicable, as summarised in Table 9 and Table 10.

Table 9: General SCADA Alarms and Analogue Functions

| No. | Description |
|------------------|---|
| Alarms | |
| 1 | Station AC Supply Fail |
| 2 | Protection Charger AC Fail |
| 3 | Protection DC Charger AC Fail |
| 4 | Protection Battery Voltage Low |
| 5 | SCADA / Telecomms 32/48/110 VDC Charger AC Fail |
| 6 | SCADA / Telecomms 32/48/110 VDC Charger DC Fail |
| 7 | SCADA / Telecomms 32/48/110 VDC Battery Voltage Low |
| 8 | Intruder Alarm |
| 9 | Fire Suppression Alarm |
| 10 | Ethernet Switch Fail / OFF |
| 11 | Miscellaneous Alarm 1 |
| 12 | Miscellaneous Alarm 2 |
| 13 | Miscellaneous Alarm 3 |
| 14 | Miscellaneous Alarm 4 |
| 15 | Miscellaneous Alarm 5 |
| Analogues | |
| 1 | Protection Total Battery Load Reading (V) |
| 2 | SCADA / Telecomms Total Battery Load Reading (V) |
| 3 | Miscellaneous Analogue 1 |
| 4 | Miscellaneous Analogue 2 |
| 5 | Miscellaneous Analogue 3 |

Table 10: Incomers, Feeders and Bus-Sections Alarms, Analogues and Controls

| No. | Description |
|---------------|--|
| Alarms | |
| 1 | CB Open |
| 2 | CB Closed |
| 3 | Main Busbar Isolator Open – if applicable |
| 4 | Main Busbar Isolator Closed – if applicable |
| 5 | Reserve Busbar Isolator Open – if applicable |
| 6 | Reserve Busbar Isolator Closed – if applicable |
| 7 | CB Isolator Open – if applicable |
| 8 | CB Isolator Closed – if applicable |
| 9 | Line Isolator Open – if applicable |

| No. | Description |
|------------------|---|
| 10 | Line Isolator Closed – if applicable |
| 11 | Line Earth Isolator Open – if applicable |
| 12 | Line Earth Isolator Closed – if applicable |
| 13 | CB Earth Isolator 1 Open – if applicable |
| 14 | CB Earth Isolator 1 Closed – if applicable |
| 15 | CB Earth Isolator 2 Open – if applicable |
| 16 | CB Earth Isolator 2 Closed – if applicable |
| 17 | Bay ON/OFF Supervisory |
| 18 | Spring Charged/Discharged |
| 19 | Main Protection Trip |
| 20 | Backup Protection Trip – if applicable |
| 21 | Auto Reclose On/Off – if applicable |
| 22 | LO2 (MTR) Trip |
| 23 | CB Slow |
| 24 | CB Fail Alarm |
| 25 | SF6 Low – if applicable |
| 26 | MCB Fail / Trip |
| 27 | Goose / Comms / IEC61850 Fail |
| 28 | Miscellaneous Alarm 1 |
| 29 | Miscellaneous Alarm 2 |
| 30 | Miscellaneous Alarm 3 |
| 31 | Miscellaneous Alarm 4 |
| 32 | Miscellaneous Alarm 5 |
| | |
| Analogues | |
| 1 | Red Phase Current (A) |
| 2 | White Phase Current (A) |
| 3 | Blue Phase Current (A) |
| 4 | Red Phase Voltage (V) |
| 5 | White Phase Voltage (V) |
| 6 | Blue Phase Voltage (V) |
| 7 | 3 Phase Real Power Magnitude (kW) |
| 8 | 3 Phase Apparent Power Magnitude (kVA) |
| 9 | 3 Phase Power Factor (Cos ϕ) |
| 10 | Miscellaneous Analogue 1 |
| 11 | Miscellaneous Analogue 2 |
| 12 | Miscellaneous Analogue 3 |
| | |
| Controls | |
| 1 | CB Open |
| 2 | CB Close |
| 3 | Main Busbar Isolator Open – if applicable |
| 4 | Main Busbar Isolator Close – if applicable |
| 5 | Reserve Busbar Isolator Open – if applicable |
| 6 | Reserve Busbar Isolator Close – if applicable |

| No. | Description |
|-----|-------------------------------------|
| 7 | CB Isolator Open – if applicable |
| 8 | CB Isolator Close – if applicable |
| 9 | Line Isolator Open – if applicable |
| 10 | Line Isolator Close – if applicable |
| 11 | Auto Reclose On – if applicable |
| 12 | Auto Reclose Off – if applicable |
| 13 | Miscellaneous Control 1 |
| 14 | Miscellaneous Control 2 |

5. WIRING

The wiring shall consists of cables according to the summary below:

- The control cable wiring shall be 1,5mm² copper with grey multi-strand wire of at least 40 strands.
- The CT and VT cores of multi-core cables shall be 2.5mm² and phase colour coded (Red, white, blue and black).
- Panel DC and AC supply cables have 4mm² cores and phase colour coded.

The terminals and wires shall not be jointed or teed between terminal points.

6. TEST BLOCKS

Test blocks type PK-2 or similar will be applied for on every CT and VT circuit to enable testing maintenance of the protection schemes. Type PK-2 test blocks are essentially 4-pole and 6-pole jacks, provided with molded Textolite covers that have internal plug contacts, which a through connection when the cover is in place. The contacts in the blocs are of the line-pressure type and provide positive contact with minimum contact resistance. For all circuits, auxiliary strips are used which automatically short circuit the current transformer when the cover, or plug is removed.

7. VOLTAGE TRANSFORMER

Where applicable, VT is required will be a 5 limb according to the specification CPTSSPEC_066.

8. PROTECTION AND CONTROL PANELS

8.1. PROTECTION SCHEME ON SWITCHGEAR PANEL

In the case where the existing protection relays are on the switchgear panel, the Contractor shall remove the old switchgear panel faceplate with the relays and associated accessories, Then, supply and install the new panel faceplate according to the size and colour of the existing switchgear panel including protection relay and associated equipment i.e. Cabling, PK-2 Test Blocks, cabling, MCBs

8.2. PROTECTION SCHEME ON A STAND-ALONE PANEL

In the case where the existing protection relays are on a standalone protection panel in the control room, especially transformer protection scheme, the Contractor shall decommission and Remove the old standalone protection panel in the control room. Then, supply and install new protection and control panel with its associated equipment. The old protection panel to be transported to City Power stores.

The existing protection cubicles including the protection devices shall be discarded and the functional protection devices shall be taken to City Power Protection department to be kept as

spares. The new protection cubicles or panels shall all be front entry swing frame, with provision for the following as a minimum:

Each Panel shall be Swing Frame Entry with a size of 2400mm x 800mm x 600mm. Example layout of 11kV Protection and Control Panels for Feeder Boards e.g. Panel 1 – 3 is depicted below.

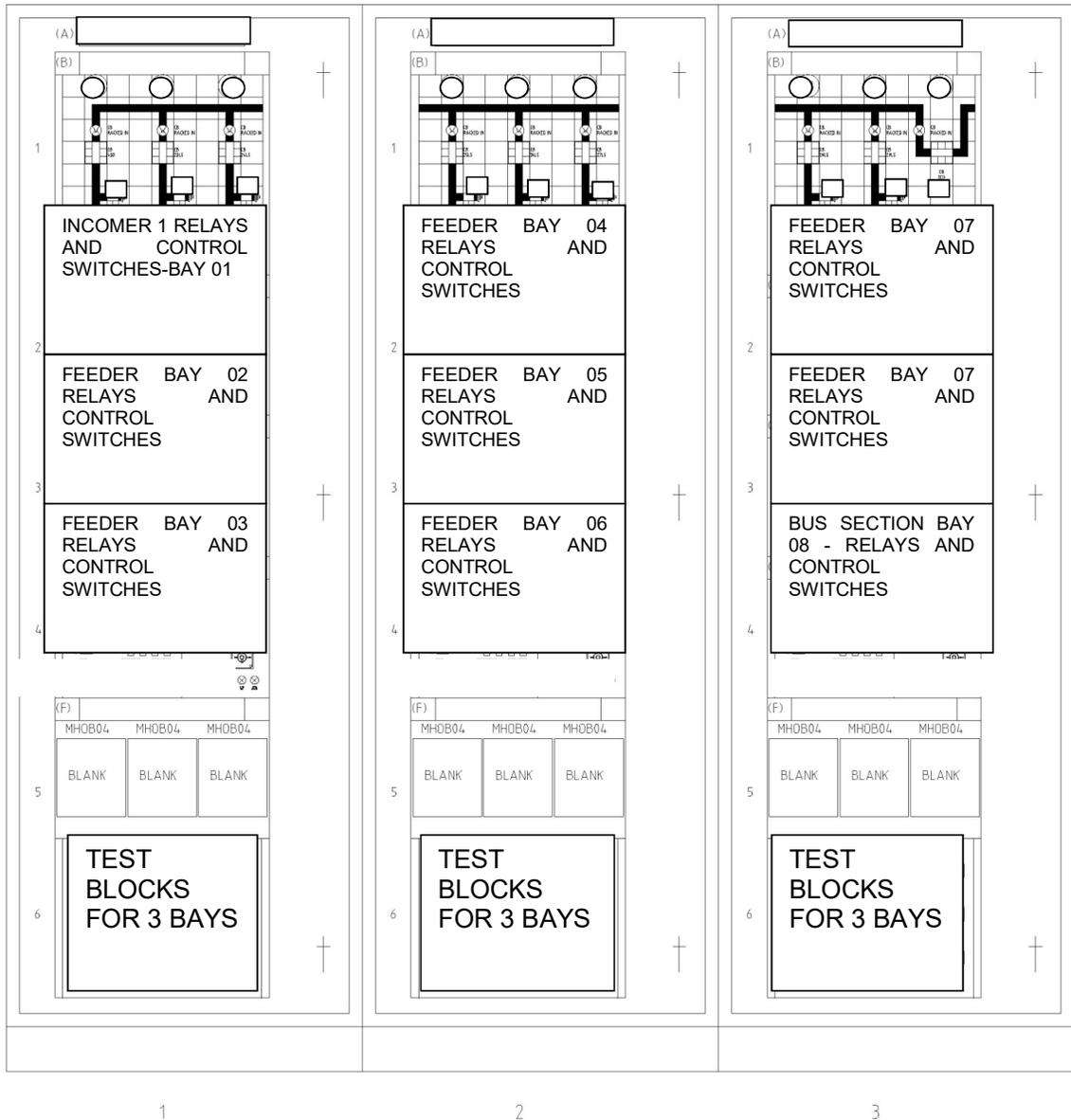


Figure 1: Typical tiled mimic layout detail for 11-kV Feeder Board Protection and Control Panels

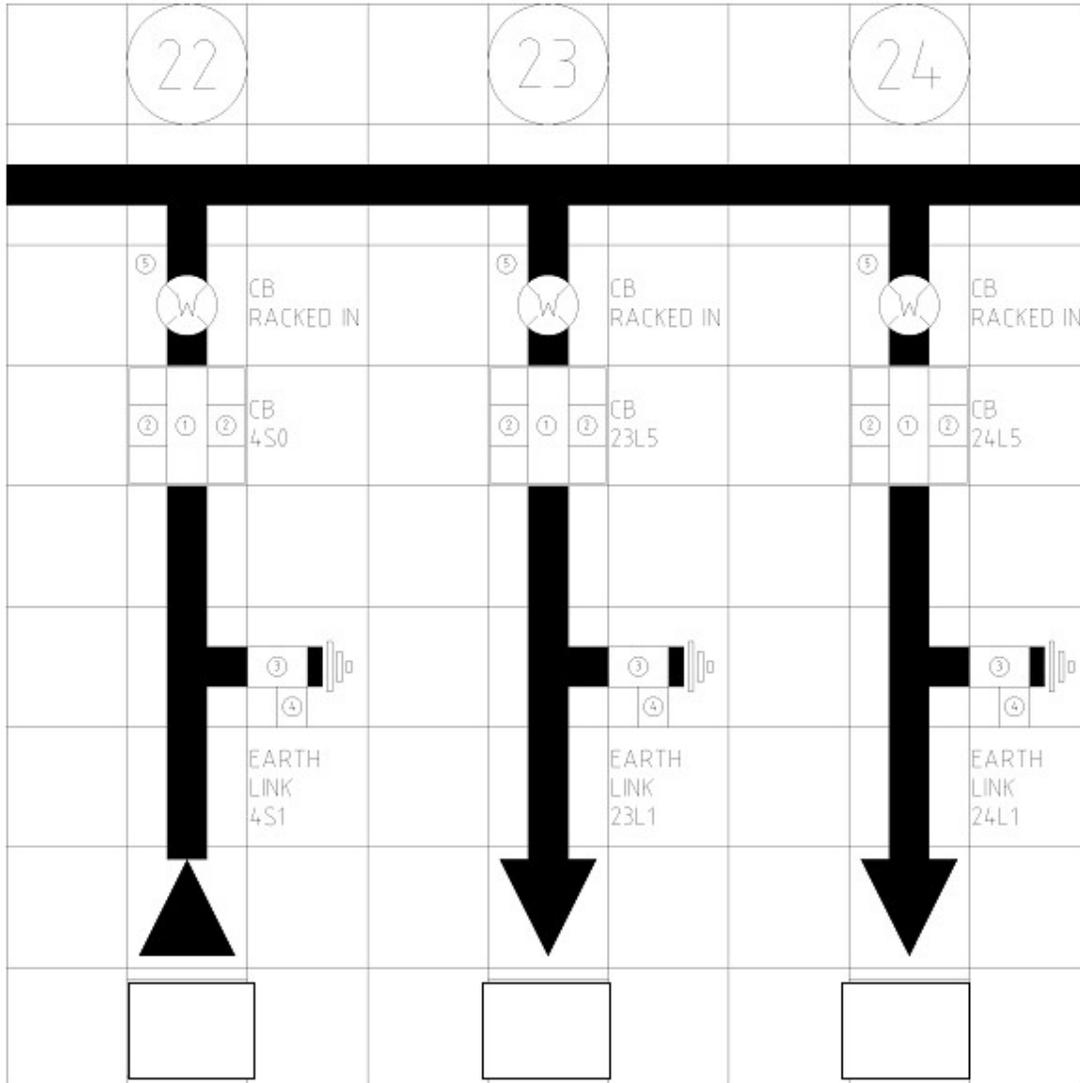


Figure 2: Mimics showing equipment's status

Table 11: Legend for Equipment Status Mimics

| Item | Description |
|------|----------------------------------|
| 1 | Red LED Bar (Long) Vertical |
| 2 | Green LED Bar (Short) Horizontal |
| 3 | Red LED Bar (Long) Horizontal |
| 4 | Green LED Bar (Short) Vertical |
| 5 | White LED Lamp |

All the steel cabinets to be provided shall be equipped with an internal panel energy efficient light that shall be triggered by a door switch i.e. door OPEN (light ON) and door CLOSED (light OFF).

It is also a requirement that an overall mimic display of the entire switchboard shall be incorporated as part of the control panels as shown in Figure 1. The mimic shall be incorporated at the top of the panels and shall clearly indicate the open/close status of circuit breakers including breaker racked in/out status, isolators and earth switches as shown in Figure 2.

Full testing functionality (AC and DC circuits) with the use of test blocks must be available i.e. it must be possible to test the full functionality of any protection relay, without disconnecting any wiring and/or removing any unmonitored terminal links. This will be achieved by supplying and installing the PK-2 type test-blocks. PK-2 type test-blocks for protection CTs and VTs shall be used.

Each circuit shall have its own MCB and the MCB's shall be suitably rated for the circuit to which they are applied. MCB grading calculations shall be submitted for approval together with the detailed design. All MCB's shall have auxiliary output contacts to indicate to SCADA and to an LED indication (whether on IED or Annunciator) when they have tripped or have been switched off.

Provision shall be made for separate dedicated control switches for "Circuit Breaker Control", for "Local/Remote" selection as well as for "Automation Enable/Disable" functionality, either on the panel or protection relay.

All proposed labelling for the panels and equipment shall be submitted for approval together with detail designs. Detailed layouts shall be submitted for approval by the successful Tenderer prior to commencement any manufacturing. For the detailed construction requirements of these cubicles, refer to the relevant part of this enquiry document. Actual quantities of panels and the contents therefore are indicated in the Bill of Quantities.

9. INSTALLATION, TESTING AND COMMISSIONING

The Contractor shall install all the associated equipment as per the requirements on the identified substation and shall test all protection and control functions that were requested and agreed in the Contract or by the Engineer, and shall be tested as an integral unit with all communications infrastructure connected and operational.

9.1. TESTING

The Contractor shall carry all testing as follows:

- All tests shall be carried out in the presence of a representative from City Power;
- The Contractor shall submit to the Engineer in writing the name of the person(s) who is/are the designated person(s) on site in terms of Occupational Health and Safety Act;
- During the commissioning, all tests result sheets shall be signed by the Contractors' and a City Power representative who witnessed the tests;
- Contractors must give City Power representative at least one week notice before commissioning date;
- The contractor shall submit to the Engineer after completion of the tests two copies of the test certificates, which shall contain details of each test performed and shall be prepared as per Engineer's requirements.

9.2. DETAILED TESTS

9.2.1. SUBSTATION INSPECTION AND TESTS

Substation inspection and tests shall be as follows:

- Visual inspection of all equipment shall be undertaken.
- Mechanical checks on all panel wiring, cable glands, lugs and relays.
- Proving all circuit wiring.

9.2.2. CT'S FUNCTIONAL TESTS

The CTs connected to the protection relays shall be tested, and the Contractor shall provide the following results for all CTs:

- Magnetizing curves.
- Ratio tests (Primary and Secondary).
- Insulation resistance tests.
- Resistance tests.
- Polarity tests.

9.2.3. SITE ACCEPTANCE TESTING (SAT)

Site Acceptance Tests shall be conducted to verify correct functioning of the installed control and protection system, and shall include:

- a) Relays
 - Relay function tests shall include: secondary injections on the relay to:
 - ensure the relay is tripping during fault conditions,
 - ensure the relay is programmed and configured correctly,
 - ensure the relay is tripping the breaker,
 - wiring is done properly.
- b) Indications
 - Indication tests shall include switching on/off of the indication to ensure status are configured for the correct indication.
- c) Circuit breaker tests
 - Circuit breaker tests includes: speed test to check tripping time of the breaker.
- d) SCADA and telecommunication
 - To ensure that the configured indications and functions are through to SCADA.

9.3. TEST RESULTS AND REPORTS

Tests results and reports will be required to be provided for all inspections and tests carried out as summarized in Table 12.

Table 12: Summary of all Tests and Reports Required

| |
|--|
| Visual inspection |
| Mechanical checks |
| Circuit Wiring |
| Magnetising curve |
| Ratio tests |
| Insulation resistance tests |
| Resistance tests |
| Polarity tests |
| Secondary Injections |
| Indication tests |
| Breaker speed test |
| Tripping and closing of the breakers |
| SCADA tests (sending signals to SCADA) |

10. TRAINING

Training shall be given to protection staff, operators and other departments (i.e. technology, planning etc.) staff. The number of the attendance shall be determined by City Power.

10.1. INTERMEDIATE PROTECTION TRAINING

Training shall entail IED logic and settings configuration and testing.

10.2. OPERATORS

The operator shall be trained to be able to read/report on the classification of indication and interlocking on the IEDs.

10.3. OTHER DEPARTMENTS

The basic protection training shall be conducted to other departments.

11. SOFTWARE

All the IED's software necessary for administrating and changing the configurations and settings must be freely available from the OEM (Original Equipment Manufacturer). All present and future revisions of the software must be freely available for download from the OEM (Original Equipment Manufacturers) website. Alternatively six licensed sets of the software must be supplied as part of this contract and must include at least two future software revisions. The supplier must make sure that communication cables are supplied to five City Power employees to work on these types of IED's at any-time.

12. WARRANTY

The IED offered shall have a minimum of 5 year warranty against faulty material and workmanship from the day of delivery. If the contractor is not the Original Equipment Manufacturer (OEM), tenderer shall have an agreement with the OEM for the guarantee and support service of the equipment. The contractor shall submit the agreement signed by the contractor and the OEM as a supporting document.

13. MANUALS AND DATA RECORDS

All data pamphlets packed with equipment and other pamphlets, handbooks of equipment, operating instructions of equipment, drawings, etc., shall be kept in safe storage by the Contractor during the Contract period.

The Contractor shall also keep accurate records of all tests carried out on equipment and of the test results so achieved. Records shall be kept of setting values of instrumentation and all readings taken during testing and commissioning, as well as records of all final adjustment readings.

A comprehensive operational- and maintenance **hard copy manual** shall be built up by the Contractor.,

Any changes which may be necessary to the contents of the manual after the commissioning of the Works shall be done by the Contractor and sufficient copies of the altered data shall again be submitted to the Engineer for binding into the manuals. Wherever manufacturer's manuals refer to types of equipment other than the exact type as installed, the exact type shall be highlighted throughout such manuals.

14. DOCUMENTATION AND DRAWINGS

All documentation and drawings as specified in the general or equipment specification shall apply to this contract.

All drawings and diagrams shall be done in AUTOCAD 2010 (or later) format and all text shall be submitted in the latest edition of Microsoft Word format. All tabular data shall be submitted in the latest edition of Microsoft Excel format. All pamphlet and brochure data shall be submitted in PDF format.

Contractor shall modify and update the existing drawings where available. **Where the drawings are not available, the contractor shall design and produce new drawings that include the complete scheme of the panel.** As built drawings shall be provided in soft copies and hard copies, the contractor shall supply the final as built drawings on standard CD media suitable for use with *.dwg format and three (3) A3 files. DXF files of other CAD programs can also be submitted, if these are suitable for conversion to AutoCAD format, without scrambling of text or graphics upon conversion.

The drawings shall be approved by an engineer. A stringent requirement of a Contract is to have "as built" data.