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1. Introduction

The project entails Substation SCADA Replacement for Kendal Power Station. The switchgear S5 PLCs are used for monitoring, indications, controls and alarms. Each substation is equipped with satellite S5 PLC that collects information from the boards and sends it through to EOD S5 co-ordinator PLC via the redundant H1 communication network. The HV Yard satellite S5 PLC collects information from the HV Yard and sends it through to EOD S5 co-ordinator PLC. The information from the S5 co-ordinator PLC is sent to the COROS System for display and monitoring.

The existing EOD and switchgear S5 PLC are obsolete and the OEM does not offer any technical support to sustain the plant until the Switchgear Replacement project is executed. The E490 modules for time stamping are obsolete. This poses a production risk and makes the plant unreliable as in some instances the switchgear S5 PLCs inadvertently issue commands to open breakers and also plant monitoring is not possible due to faulty modules

2. Supporting Clauses

2.1 Scope

At Kendal Power Station, the existing EOD and switchgear S5 PLC are obsolete and the OEM does not offer any technical support to sustain the plant until the Switchgear Replacement project is executed. The E490 modules for time stamping are obsolete. This poses a production risk and makes the plant unreliable as in some instances the switchgear S5 PLCs inadvertently issue commands to open breakers and plant monitoring is not possible due to faulty modules.

This specification covers the scope & requirements for the design, procure/manufacture, integrating, testing, supply, delivery to site, erection, commissioning, certification, and handover of the Substation Automation System (SAS)

2.1.1 Purpose

The purpose of this document is to clearly define the Technical Requirements, detailing all the activities that are required to ensure the achievement of successful Substation SCADA Replacement and operation.

2.1.2 Applicability

The document applies to Kendal Power Station **ONLY**.

2.2 Normative/Informative References

Parties using this document shall apply the most recent edition of the documents listed in the following paragraphs.

2.2.1 Normative

[1] ISO 9001 Quality Management Systems

[2] *1024325 User Requirements Specification (URS) for Kendal MV and LV Switchgear Replacement

[3] 474-9857 Kendal Electrical Stakeholder Requirements Analysis Review Report (Rev 2)

[4] 379-KEN-ADDB-D00179-5 Engineering Management Plan for Kendal Switchgear Replacement Project

[5] 379-PRJ-1-BDDD-D00185-12 Kendal Switchgear Replacement Project Concept Design Report (Rev 2)

[6] 240-53113685 Design Review Procedure

[7] 240-53114026 Project Engineering Change Procedure

[8] 240-53459028 Perform Power Plant Electrical Engineering

[9] 240-144177358 Perform Electrical Power System Studies within Gx Plant Work Instruction

[10] 240-70164623 Design Guideline for HVAC in the Eskom Coal Fired Power Stations

[11] 240-56227573 Air-insulated withdrawable AC metal-enclosed switchgear 1kV to 52kV

[12] 240-82332407 Generation Fixed Pattern Gas Insulated Metal-Enclosed Indoor Primary Switchgear and Controlgear Standard

[13] 240-56179027 General Safety Measures - Electrical Arc for Switchgear up to 15kV Standard

[14] 240-143485806 Generation Auxiliary Plant Medium Voltage Protection Standard

[15] 240-56227516 LV Switchgear Control Gear Assembly Associated Equipment for Voltage 1000V AC and 1500V Standard

[16] 240-56227443 Requirements for Control and Power Cables for Power stations Standard

[17] 240-62772907 Specification Standard for Stationary Diesel Generator Systems

[18] 240-56227589 List of Approved Electronic Devices to be Used on Eskom Power Stations Standard

[19] 379-PRJ-1-BDDD-D00186-1 Kendal Switchgear Replacement Project Power System Studies Report

[20] 240-55410927 Cyber Security Standard for Operational Technology

[21] 240-106271076 Sub-Station Control System Commissioning

[22] 240-68234842 Sub-Station Gateway and Station RTU/IED Standard Specification for EHV Sub-Stations

[23] 240-100912715 Secondary Plant ERTU, RTU, Bay Processor and HMI Maintenance Standard Revision

[24] 240-55863502 Definition of Operational Technology (OT) and OT/IT Collaboration Accountabilities

[25] 240-56355910 Management of Plant Software Standard

[26] 32-85 Eskom Information Security Policy

[27] 32-214 Remote Access Procedure

2.2.2 Informative

[28] NWM KEIM 100 Kendal Power Station Information Manual Auxiliary Electrical Power System

[29] 379-PRJ-1-ADDB-D00180-2 Kendal Refurbishment Project Design Manual (PDM)

[30] 474-12267 Heating Ventilation and Air Conditioning (HVAC) Group Technology Strategic Report 2020 (Rev 1)

[31] 240-129014618 Generation Cyber Security Compliance Guideline

[32] 240-129693459 Generation PLCM

2.3 Definitions

2.3.1 Disclosure Classification

Confidential: the classification given to information that may be used by malicious/opposing/hostile elements to **harm** the objectives and functions of Eskom Holdings Limited.

2.3.2 Terminology

Definition	Description
IED	Intelligent Electronic device. Generic name given to all microprocessor-based substation secondary devices, e.g. relays and tariff meters.
RS232	An Electronic Industries Association (EIA) standard for the interfacing between Data Communications Equipment (DCE) and Data Terminal Equipment (DTE). It defines the electrical characteristics of the signals from such devices.
RS422	An EIA recommended standard to extend the RS232 50 ft limit to 1 200 m and is electrically compatible with the CCITT V.11 standard.
Substation Control System (SCS)	Defined as an integrated and coordinated system that performs the tasks of Supervisory Control and Data Acquisition (SCADA), substation automation and offers a single point of control and alarm annunciation (Human–Machine Interface (HMI)) to the substation operator.
PLC	A programmable logic controller (PLC) or programmable controller is an industrial computer that has been ruggedized and adapted for the control of manufacturing processes, such as assembly lines, machines, robotic devices, or any activity that requires high reliability, ease of programming, and process fault diagnosis
SCADA	Supervisory control and data acquisition (SCADA) is a system of software and hardware elements that allows industrial organizations to: Control industrial processes locally or at remote locations. Monitor, gather, and process real-time data

2.4 Abbreviations

Abbreviation	Description
DC	Direct Current
DO	Digital Output
DRTU	Distribution Remote Terminal Unit

Abbreviation	Description
DSP	Digital Signal Processing
ERTU	Enhanced Remote Terminal Unit or Data Concentrator
FAT	Factory Acceptance Test/Testing
FOC Fibre-optic Cable	Fibre-optic Cable
GPS	Global Positioning System
HMI	Human–Machine Interface
I/O	Input/Output
IEC	International Electrotechnical Commission
IED	Intelligent Electronic Device
IP	Internet Protocol
ISO	International Standards Organization
RF	Radio Frequency
RTU	Remote Terminal Unit
SAT	Site Acceptance Test
SCADA	Supervisory Control and Data Acquisition
SCS	Substation Control System
SOE	Sequence of Events
A/D	Analogue to Digital
AC	Alternating Current
Bit/s	Bits per second
SAS	Substation Automation System
EOD	Electrical Operating Desk
PLC	Programmable Logic Controllers

2.5 Roles and Responsibilities

The roles and responsibilities relating to the implementation of the document are as follows:

- **Engineering Design Work Lead (EDWL) / Compiler:** This project is led by the Electrical Engineering discipline. The role of the project EDWL is to manage the technical integrity of the design and be accountable for the management of the interfaces within the project. The project EDWL is also responsible for the arrangement of the design reviews of this design document and the updating of the document when required.
- **Lead Discipline Engineer**: Coordination, integration and interfacing of all design related activities and deliverables within their disciplines throughout the project life cycle. To provide input to this design document as well as reviewing the design.
- **Discipline Engineering Manager/Functional Responsibility**: Establish and implement strategy for design work of discipline. Provide technical oversight and resources to support the project. Define resource competence for functions related to lead and system engineers needed for the project. Manage resource in the discipline to meet project staffing level requirements.
- **Group Engineering Manager/ Authoriser**: Review and authorise the Technical Specification

- **Client (Kendal Power Station End Users / relevant departments):** The role of the Clients is to review and give inputs to this document.
- **System Engineer**: An appropriate and qualified site/plant-based discipline or System/Plant Engineer, who has the training, technical qualification and expert knowledge of the plant or systems affected. The System Engineer ensures that design review and design optimisation is performed as per the requirements, technical standards, and regulatory constraints for their assigned system

Furthermore, design review procedure 240-53113685 defines roles and responsibilities which are applicable in the development of this design phase.

2.6 Process for Monitoring

This document will be approved following a Pre-Enquiry Baseline Review that will be performed as per the Design Review Procedure 240-53113685.

2.7 Related/Supporting Documents

Not applicable

3. Scope of Works

3.1 Description of the Works

3.1.1 Executive Overview

The scope of the project entails the following:

- Develop the concept design for the replacement of SCADA
- Identify existing plant constraints and limitations with regards to the SCADA replacement.
- Select best alternative solution (and technology) for the replacement taking into consideration Initial Cost, Reliability, Environmental conditions, Safety and Life-Cycle costing.
- Review of interfaces (C&I and Electrical, Cables, and other discipline if required)
- To cover the comprehensive design as well as perform any Civil, Mechanical, Electrical and C&I engineering work necessary to render a full functional, reliable and compliant work.
- Align all misaligned Protection systems
- Provide a design that covers the following:
    - Design, Manufacture and, Factory Acceptance Test of the new SCADA.
    - Deliver the SCADA to Kendal Power Station
    - Test the SCADA once on site
    - De-commissioning and removal of the existing SCADA.
    - Install new SCADA
    - Interface the new SCADA with existing auxiliaries
    - Commission and test newly installed SCADA

The project will cover the replacement of Substation SCADA which comprises of the following:

- Satellite S5 PLCs located in each substation.
- Input and output modules and interfacing between PLCs and all switchgear panels.
- Interfacing between PLCs and H1 redundant fibre bus.
- EOD coordinator PLCs used for monitoring and display.
- EOD Mimic panel used for display.
- EOD COROS Servers.
- Clients used for control, monitoring and display.

The Scope of Works also sets out the requirements for project management (such as documentation, safety, quality, environmental, programming, training), engineering and the contractor's design, procurement, construction and more.

3.1.2 Employer's Objectives and Purpose of the Works

One of the *Employer's* objectives and purpose of the *works* is to replace selected S5 PLCs at the Power Station. The following is a record of the replacement/equipment/systems that are required:

a) The latest intelligent electronic devices (IED's) protection equipment with designed life of a minimum of 15 years.
b) Provision of SAS to facilitate implementation of communication, interlocking, monitoring, and control of electrical reticulation, enhance and speed up diagnosis of plant errors.
c) Provision for the Control & Instrumentation (C&I) interface on Units and Common Plant.

3.1.3 Existing Plant / System Description

The switchgear S5 PLCs are used for monitoring, indications, controls and alarms. Each substation is equipped with satellite S5 PLC that collects information from the boards and sends it through to EOD S5 co-ordinator PLC via the redundant H1 communication network. The HV Yard satellite S5 PLC collects information from the HV Yard and sends it through to EOD S5 co-ordinator PLC. The information from the S5 co-ordinator PLC is sent to the COROS System for display and monitoring.

3.2 Substation Automation System (SAS)

3.2.1 Scope of the Works

The scope of the Works includes the provision for the engineering, design, procurement, manufacture, factory acceptance testing, supply, delivery, off-loading, storage, erection, installation, site testing and commissioning of all equipment forming part of a Substation Automation System (SAS).

The *Contractor* provides in his tender a conceptual design for the SAS architecture with the description of each component and their specifications. The design for the main offer for the SAS is in accordance with the proposed architecture overview provided in Section 3.2 of the Scope of Works and drawing 0.64/12388. The *Contractor* also submits an alternative offer for the SAS that provides a more reliable and optimised solution, in line with the offered devices.

The Contractor provides in his tender preliminary system descriptions that describe the working of the system.

The Contractor performs detailed Reliability, Availability and Maintainability (RAM) studies of the complete SAS system and submit with his tender, RAM study reports for both the main and alternative offers. The Contractor provides reliability and availability calculations using established methodologies and 240-49230030 to demonstrate the adequacy of the designs. The reliability and availability calculations should be based on reliability block diagrams and indicating any redundant equipment that may be required. In addition to the Price, the tender submission includes life cycle costs of both the main and the alternative offers.

The VisualSPAR latest version reliability simulation software package shall be used in performing the RAM analysis.

During detailed design, the *Contractor* provides a detailed philosophy (system description) document and technical operation manual for the SAS offered. The documents describe in detail, the operation of the automation system and include elements such as the philosophy of the automation system, interlocking, controls provided on each protection scheme, the operation of the HMI etc. The documents are such that engineers and technicians can easily understand the relevant portions of the philosophy of operation of the complete system once he/she has read the document.

During detailed design, the *Contractor* provides a detailed document describing how to configure the system and its components. The document is such that an engineer can easily understand how to configure the complete system once he/she has read the document. The *Contractor* provides a RAM study report of the final system configuration and individual system components.

The *Contractor* provides a detailed specification of the logical nodes with associated data sets supported by each IED offered. The *Contractor* indicates which data sets in their offer are mandatory and which are optional.

No annual license renewal is required for software or operating systems. All licenses that are required are a once-off purchase. The fact that a bug is only found after the warranty has expired does not make it acceptable and therefore all bug fixes are free.

The *Contractor* and the associated supplier/s have at least 5 years' experience in development, design, engineering, and implementation of the SAS. All equipment used in the system will form part of the *Contractor's* current marketed range of equipment and will not be experimental nor prototype in nature. The Contractor provides information regarding reference sites/projects of similar nature where the offered equipment has been installed. If equipment has been launched as a commercial product on the international market but has never been installed at a previously commissioned similar reference site, such equipment will have been tested rigorously and to the satisfaction of the *Employer*.

The *Contractor* provides a disaster recovery process for each communication device (i.e., network equipment, IEDs and the EWSs). This process must be auditable, and a recovery test must be performed during the Factory Acceptance Testing (FAT) to gather recovery times.

The *Contractor* provides for an OPC link to the Station Historian. The *Contractor* provides for receiving a time stamping signal from the Station GPS. The *Contractor* also engineers the SAS to receive information from electrical equipment at the Power Station as per this Scope of Works.

3.2.2 General Specification

The *Contractor* designs and supplies a system of which the architecture is based on the seven-layer model of the International Standards Organisation (ISO) for communication between devices. The design and functionality of the communication system and components is based on IEC 61850 standard. Any solution/s offered by the *Contactor* that do not comply with IEC 61850 or which are not specified in IEC 61850 are based on open standards and are presented to the *Employer* for acceptance.

The architecture, protocols and all equipment are designed for the substation environment and not for industrial process control or office environment. It is implied that all protection, communication, and control equipment comply with the same environmental requirements (i.e., EMC and EMI) as those currently required for numerical protection relays, specifically Class IV as defined in IEC 61000-6-5.

All equipment is designed to work efficiently in the environment where they are installed, without any decrease in performance, reliability, and life expectancy. The temperature range in which all equipment forming part of the SAS can operate is -10 °C to +55 °C, irrespective of HVAC provided for the room(s). The room/s where the servers are housed will be controlled according to Eskom standard 240-56355731: Environmental Conditions for Process Control Electronic Equipment used at Power Stations. The HVAC for all substations is provided in accordance with Section 3.6 of the Scope of Works.

3.2.3 System Design

The Contractor designs the SAS for extremely high reliability and availability, through total redundancy at every level including data busses. The SAS structure follows the electrical reticulation system configuration to minimise the effects of equipment failure on the overall plant. A functional distribution of network switches is designed and installed by the Contractor. Redundant equipment and communication paths do not have common points of failure. The Contractor provides separate cabinets for different redundant equipment. All common modes of failure are considered and eliminated in the design, specifically in terms of power supplies, communication paths, routing etc. The layout, design and configuration of the system is such that no individual fault on the SAS causes the unit to drop below 45% MCR or causes a forced outage or unit trip and no two concurrent faults cause a Multi-Unit Trip.

The offered system has enough Ethernet ports to cater for all the IEDs required as per the Scope of Works, and it is possible to add future devices at all levels of the network when the substation is expanded in future. This implies that the automation system is extendable/expandable.

The SAS is designed for the future reality of eventually replacing the system, without requiring the extensive shut down of plant or running plant without monitoring and control functionality during the replacement.

The communication network equipment is reliable, flexible, and modular. The architecture, design and equipment do not introduce significant risk to the Employer when compared to conventional substation designs. Further, the system, including hardware, firmware, software, configuration, and networking requires minimal maintenance. No moving parts such as fans are allowed since they significantly reduce reliability. It also introduces an onerous maintenance requirement. Substation hardened networking hardware and software is used.

It must be possible to separate defective components from the system, by switching off or blocking the respective communication processes or drivers, so that the rest of the system continues to function properly. Redundant equipment such as network switches and servers are completely independent, and can fail, have parts replaced, have updates installed, be completely replaced, be booted up and shut down independently without affecting the functionality SAS.

Equipment hot swapping between power supplies is seamless and does not have any effect on the equipment such as loss of data or equipment restarting. Data is not lost when there is a complete loss of the auxiliary power supply to the system.

All communication devices are suitable to transfer maximum data between the IED and the other devices in the communication network without any restrictions that might limit speed, capacity and quality of data transferred.

The communication architecture, protocol and configuration is able to provide high speed operation, since peer-to-peer communication requires much data sharing and the communication network is also used for protection purposes, i.e. transferring trip signals. The performance of the system is in accordance with the requirements mentioned in section 8 of this Scope of Works and requires a fast communication network. The communication speed of the network is selected appropriately.

IEDs are addressable, more specifically each data source/receiver or devices have a unique address to identify it in the substation but also in the entire network to which it is connected. This implies that all IEDs have unique user configurable Internet Protocol (IP) addresses.

Substation Configuration Language (SCL) files, based on IEC 61850 Part 6, are used to describe the substation. Since the data model in IEC 61850 is well defined, it is required that the network and all equipment allow for interoperability (i.e., it is possible for IEC 61850 compliant Intelligent Electronic Devices (IEDs) from different manufacturers to efficiently communicate over the SAS).

3.2.4 Functional Specification

3.2.4.1 Substation Automation System

The SAS is dedicated entirely to the purposes of configuration, control, monitoring etc. of the main reticulation system within the Power Station, and there is no sharing of resources with other control systems, e.g., the units, the Common plant, the Outside plant, the water treatment plant, etc. More specifically, no processors, network switches, busses, RTU's, servers, PC equipment etc. may be shared with other control systems.

An interlocking system is implemented by the *Contractor* for the purposes of interlocking different devices to enhance safety during operating done by Power Station operators. The interlocking rules are implemented in the IEDs but are also available in the SAS servers and backup system. Electrical interlocking is implemented using the SAS LAN. GOOSE messages used for interlocking are restricted to the levels at which they are relevant to prevent overloading of the network.

Safety of personnel and equipment are an integral part of the functionality under all conditions. Failure of the network equipment, network cabling, RTU, servers and the EWSs does not negatively impact the safety and interlocking functions in the substation. It is therefore necessary that such devices/functionality is both supported by a second level of redundancy and that such functionality is implemented in a distributed manner (i.e., all logics are not implemented in the servers but on each respective IED).

All equipment provided is able to perform self-diagnostics and alarm failures, both locally at the equipment and remotely at the OWSs. The alarm information is sent to the OWSs over the network. Failure of any device is alarmed via an alternate path of the redundant network.

All the necessary diagnostic tools are 'on board' and are therefore part of the SAS. It is possible to perform diagnostic, monitoring and control functions locally, through the substation LAN and on a portable EWS.

The amount of engineering time spent to configure the system is minimised through the provision of a suitable substation configuration tool that may be used to configure all devices provided by the Contractor and the communication system. Interoperability as defined in IEC 61850 and the offered substation configuration tool minimises the amount of time required to configure a system with different suppliers' IEDs.

A communication network management function/tool that is able to provide the system administrator with up to the minute information about various crucial statuses of the communication network, for example the network size, its operating conditions, alarms, system loading, and error statistics is provided. The network management function/tool is also used to add new devices to the network, configure them and to perform certain diagnostic investigations.

The SAS is an open system so that automation functions (for example command processing, configuration of operating sequences and interlocks as well as generation of derived information) are configurable. Programming functionality on a bay and substation level is provided using the portable EWS with user friendly software. A graphical configuration system is therefore available and operational. It is important to note that what is referred to here is the interface between the user and the programming tool in terms of what is visually seen on the computer screen by the programmer. To simplify the configuration process, a library with system tested function blocks for power automation specific functions is integrated.

Mathematical configurations are also possible, for example to calculate the I^2t summated analogue value and compare it with set points before issuing a derived alarm when the setting is exceeded. As a second example, it is possible to add the respective phase currents from the different bays to each other in real time and to perform a programmed characteristic algorithm on it.

The set of automation functions are developed during the design phase of the project. A final list of automation functions agreed upon between the Employer and the Contractor at the final design review are signed off at the design freeze.

The communication system is capable of transferring data stored on the IED's for condition monitoring purposes, such as the record of events or disturbances as well as measured values (e.g., voltage, current, power, temperature, etc.) for normal running conditions.

All event data, fault records, as well as the continuous daily binary and analogue values are stored on the SAS. The Station Historian will be provided by Others, where some of this information will be stored for the life of the Power Station.

Switchgear must be able to be safely operated even in the case of a communication bus failure, where the communication bus is employed to exchange interlocking data between IEDs. A technical procedure is drawn up, outlining in detail, all the steps that should be executed, in order to safely operate the concerned equipment. The procedure also includes all steps to be executed in order to ensure that IEDs retain their normal state on completion.

It is not allowed for any information pertaining to or required for control, supervision, indication, alarms, metering, measurements, interlocking, event logs, fault records etc. to be transported, stored or archived directly on a business LAN. All networks used for this purpose are dedicated to the SAS. If an interface is required between the SAS and the business LAN, the SAS network is to be separated from the business LAN by a high reliability fire wall provided by the Contractor.

3.2.4.2 Operating Work Station

The prime function of SOR is to control and monitor the main reticulation systems within the Power Station. The technology used for the control, as well as the HMI systems associated with it, needs to be specifically developed for electrical control, and not primarily for the control of other processes and plants like boilers, turbines, chemical plants, etc.

The SAS includes all the functionality required by the Eskom Operating Regulations for High Voltage Systems and the Eskom Plant Safety Regulations, e.g., showing the application of manual earths, permits that are in force, prohibit signs etc.

The Contractor is responsible to employ a comprehensive method of display, access across all types of display is provided, while at all times providing the operator with an overview of high-level plant status. Navigation is clear, simple and unambiguous. Selection of any display should not require more than two keystrokes. In alarm or abnormal conditions only one keystroke is required to access the relevant display. In all cases, a standardised back track facility is available for the operator to escape from displays.

Every reticulation system state change (breaker opening and closing) is recorded, and an active mimic screen have the ability to page sequentially back through plant states.

A comprehensive and integrated alarm handing system is employed, which clearly distinguishes between different alarm types and priorities. Separate alarm lists are developed for electrical reticulation system alarms and SAS alarms. Alarm priorities are developed in accordance with the guideline document EED GTD C&I 006. Alarm responses are developed for each alarm detailing the cause and remedial action in accordance with the guideline document EED GTD C&I 006, are linked to the individual alarms and readily accessible by the operator through a link on the OWS alarm screens. In addition to the alarms and alarm responses, system displays are provided which show the real time health of the entire SAS and location of alarms.

Alarm information is not lost or inaccessible while navigating though displays, and alarm presentation dynamically provides the operator with information matched to the current situation and its criticality. The operator is alerted to new active alarms while navigating through displays, irrespective of which display the operator is on. Alarms from plant on permit may be required to be inhibited. True system errors are fully indicated as to type, cause and remedial action. The history of alarms should be logged on the HMI alarm screens.

Where interlocks prevent the operation of a circuit breaker or switching device, a display is available illustrating the logic requirements with the various conditions that are satisfied and not satisfied, to aid in troubleshooting.

No set or sequence of keystrokes causes the operator monitoring and control functionality to fail or freeze. Any incorrect operation is highlighted to the operator by audible signal or text message.

The scope of SOR from an electrical control and supervision system perspective includes, but not limited to, the following:

- MV reticulation system
- LV reticulation system
- DC reticulation system
- Diesel generators
- Batteries and battery chargers
- Uninterruptible Power Supplies
- Generator protection
- On-load tap changers of the station and generator transformers
- Active and reactive power of units
- High level unit information that needs to be displayed at the SOR operator, such as Unit MW and Frequency
- Status of the hardware comprising the SAS, including information buses as well as power supplies

The diagrams should automatically display and draw attention to the following:

- Breaker, isolator/link and earthing device status

- Prohibitory signs associated with isolated equipment
- Voltages on breakers and cables
- Protection operations
- Currents in feeders (not dead-end load circuits)
- State changes of all switching and state changing devices
- Diesel generator operating parameters
- Remaining battery capacity (estimate if not definitive)
- Activation of the synchroniser of any unit
- DC system status and configuration
- Normal and abnormal operating conditions and alarms

The operator can add a manual note on the diagram display, which flags all operators' attention to the following:

- Abnormal conditions
- Permits in force on plant (according to Employer's Permit to Work System)
- Local access of personnel in restricted areas

The following alarms are required as a minimum in terms of the electrical equipment:

- Protection operations
- Under-voltage conditions
- Automatic starting (or failure to start) of diesel generators
- Diesel generator alarms
- Alarms of batteries approaching exhaustion
- Automatic chop-over activation (and failure)
- Actions not allowed, due to interlocks not permitting the action
- Arming of the remote back-up protection of any unit
- Activation of any fault or disturbance recorder
- Interruption in the normal supply to battery chargers or UPSs
- Alarms originating from major transformer monitoring equipment
- Over and under frequency conditions
- Metering equipment failure or discrepancy

The *Contractor* includes a simulator into the SAS to advise operators as to consequences of switching operations before carrying it out. Expected current, voltage and power values are available. Foreseeable overload or tripping must be flagged. The expected time durations of battery backed up systems and generate alarms of expected failure due to battery depletion are incorporated. Automatic restoration routines that recommend restoration solutions to the operator during abnormal or disrupted conditions are incorporated, which the operator can choose to allow or disregard.

3.2.4.3 Engineering Work Stations

The EWSs are used for the following functions:

- Configuration of IEDs
- Settings of IEDs
- Configuration of OWS Displays
- Fault/event recording
- Archiving

3.2.4.4 Servers

The following functions are provided on the SAS servers:

- Fault/ event recording
- Supervisory
- Control
- Data capturing
- Network configuration
- Self-diagnostics and network management
- Archiving
- Server to OWS Clients
- Server to EWSs

3.2.5 System Architecture

3.2.5.1 Board Level Architecture

The IEDs on the switchgear panels are interconnected via board level network switch(es). Each board has its own board level network switch. Each IED on a board is connected to its board level switch in a star topology.

Board level switches are not shared between IEDs on different boards. The only situation where an IED not residing on a particular board is allowed to be directly interfaced to a particular board's board level switch is the case where there is only a single IED on a board, and that breaker is either directly feeding (e.g., Maintenance Isolator) or is being directly fed (e.g., Incomer or Bus Section on Low Voltage Board) by the board on which the board level switch resides.

Communication between IEDs is via the board level switches. The connection from each circuit's IED to the board level switch is a singular connection and hence no redundancy is available at this level.

The proposed board level architecture can be seen as part of drawing 0.64/12388.

3.2.5.2 Unit Level Architecture

The unit level architecture covers all areas of plant, namely: the units 1 to 6, the Common plant and the Outside plant. The topologies for the areas, however, are not identical. Redundant communication paths are available above the board level switches. Each board level switch is connected redundantly to redundant unit level switches. The proposed network topologies at the unit level for all areas of plant can be seen as part of drawing 0.64/12388.

Provision is made for a dedicated communication port on each unit level network switch for a portable EWS to be connected to the SAS LAN.

3.2.5.2.1 Units 1 to 6

The unit level architecture for units 1 to 6 consists of a redundant star network per unit, formed by fibre optic links and network switches. Each board level switch and RTUs are connected redundantly in a star topology to a pair of redundant unit level switches. Each of the redundant links from each board level network switch and RTUs goes to a different unit level network switch in order to prevent a common mode of failure for both links.

Where a single IED exists that cannot be interfaced to a board level switch as per the principle mentioned in section 5.1, the IED is connected directly to one of the unit level switches.

The *Contractor* supplies IEC 61850 compliant RTU panels with redundant processors, redundant connections to the unit level switches as per Section 3.2 of this Scope of Works. The RTU is required for electrical equipment situated in the units which are not compliant to IEC61850 to interface to the SAS, to allow the SOR operator to monitor and control the equipment. The RTUs provided should be able to interface with Modbus protocol. The estimated number of signals for all 6 units RTUs are 350 BI, 120 AI, 90 BO and 15 AO.

3.2.5.2.2 Common Plant and Outside Plant

The non-unitised plant is to be split into two parts. These two parts are according to their geographical location on the power station. Each part is seen as a unit on SAS network.

The unit level architecture for Common plant and Outside plant consists of a redundant ring network per unit, formed by fibre optic links and network switches. Each of the boards within each substation is connected to each other in a ring topology. Each of the substations are connected to each other and to the redundant unit level switches in a ring topology, per unit. Each end of the ring is connected to different unit level network switch in order to prevent a common mode of failure for the ring. Each of the redundant links from board level network switch and RTU goes to a different unit level network switch in order to prevent a common mode of failure for both links.

The Common plant and Outside plant substations are monitored and controlled by the SOR operator using the substation automation network. The Outside plant substations are distributed far apart and far from the power islands. A star topology would be very cabling intensive for this plant. Hence a ring topology is used for the unit level architecture, which would help to reduce the amount of cabling required, at the same time providing redundancy, which is inherent in the ring topology.

A combination of ring and star topology can be used for plants in close proximity to the power islands, based on a feasibility assessment of the best design approach. Where a single IED exists that cannot be interfaced to a board level switch as per the principle mentioned above, the IED is connected directly to one of the unit level switches on the Common plant.

The Common plant and Outside plant switches at the board level serve a similar function to the unit level switches and reduce traffic flow (necessitated by interlocking requirements) through the station level switches and provide for clear network segregation.

The Contractor supplies IEC 61850 compliant RTUs with redundant processors, redundant connections to the unit level switches on the Common plant and Outside plant. The RTU is required for electrical equipment situated in this area which are not compliant to IEC61850 to interface to the SAS, to allow the SOR operator to monitor and control the equipment. The number of redundant RTUs required and their physical and functional distribution is designed and optimized by the Contractor to achieve functional distribution and redundant communication paths to minimise the effects of equipment failure on the overall plant. The RTUs provided should be able to interface with Modbus protocol. The estimated amounts of signals for one part of the non-unitised plant RTUs is 350 BI, 40 AI, 35 BO and 40 AO, and for the second part of the non-unitised plant RTUs is 330 BI, 50 AI and 15 BO.

3.2.5.2.3 Radio Link Communication

All Common plant and Outside plant reticulation equipment is required to interfaced to the IEC 61850 SAS LAN. Most of the interconnection in the SAS network between Board Level Switches and Unit Level Switches is done using fibre optic cables; however, some substations are located far away (about 5km) from the power station. Use of fibre optic cables for interfacing with such plants will be cable intensive.

Listed below are the boards located in the substations far away from the station (i.e., outside the station perimeter fence):

- 11kV Ash Stacking Board A & B
- 3.3kV Ash Stacking Board A & B
- 3,3kV CSY Substation 4 A & B
- 380V Ash Stacking Board A & B
- 380V CSY Substation 4 A & B
- 380V Ash Dump Pump Station Board A and B
- 11kV Emergency Dumping Board A & B
- 380V Emergency Dumping Board A & B
- 22kV CSY Substation 4 A & B

Radio link communication of this Scope of Works is required for interfacing with the substations listed above. The *Contractor* provides full solution and optimization of the design and equipment required accordingly. The local control rooms located next to these plants will continue to be utilized as primary means of control. SAS will be used mainly for statuses and as a secondary means of control.

3.2.5.3 Station Level Architecture

The station level architecture consists of the connection of all the unit level networks to the station level network switches and of other devices connected to the station level switches.

The station level architecture consists of redundant star connections from each of the redundant unit level switches (units 1-6, Common plant and Outside plant) through dedicated links, to redundant station level switches. Each of the redundant links from each unit level network switch goes to a different station level network switch in order to prevent a common mode of failure for both links.

Two redundant SAS serves, two redundant HMIs, portable EWS Station Historian are connected to the station level switches. Two local printers are required in the SOR. The interface of the SAS to the GPS Time Server and Station Historian is provided at this level. All interfaces at this level are implemented using a star topology.

Each station level switch connects to both the redundant servers. Provision is made for a dedicated communication port on each station level network switch for a portable EWS to be connected to the SAS LAN.

The proposed station level architecture can be seen as part of drawing 8385-18.4-001.

3.2.6 System Interface Specification

The *Contractor* designs the system interfaces as per the requirement stated below in the following subsections.

3.2.6.1 MV Switchgear

MV Switchgear is interfaced to the DCS using a conventional hard-wiring method whereby each signal is allocated a dedicated wire. The interface is facilitated by a dedicated I/O card of the DCS. The control of process switchgear and process interlocking is facilitated by the DCS. The reticulation and process switchgear will be connected to the IEC 61850 based SAS Network.

The control of reticulation switchgear and electrical interlocking is achieved via the IEC61850 based SAS. Selected reticulation switchgear is also interfaced to the DCS using hard wiring for transfer of certain select signals for monitoring purposes.

3.2.6.2 LV Switchgear

LV Switchgear is required to be interfaced with the IEC 61850 SAS LAN. This interface is achieved using IEC 61850 compliant IEDs where available, whereas for switchgear without IEDs, signals are hardwired to an IEC 61850 compliant RTU which in turn interfaces with the SAS network. Only the LV Switchgear reticulation circuit breakers are required to be interfaced with the SAS. The *Contractor* makes provision accordingly.

3.2.6.3 DC Switchgear

The DC Switchgear at the Power Station is required to be interfaced with the IEC 61850 SAS LAN. The existing DC Switchgear signals will be hardwired to an IEC 61850 compliant RTU to interface with SAS network where Modbus communication is not available. Modbus will be used for DC Switchgear with such communication capability, hence all RTUs must be able to communicate using Modbus. All 24V and 220V DC boards reticulation circuit breakers, including board to board feeders are required to be controlled and monitored at the EOD using SAS.

3.2.6.4 Transformers

All Power Station transformers (as per Single Line Diagrams provided as part of this *Scope of Works*) alarms, temperatures and trip signals are required to be monitored via the SAS.

Where transformers are protected by IEDs, the alarm and trip signals are sent via the fibre optic cable to the SAS. The alarm and trip signals for Station Transformer are hardwired to a IEC 61850 compliant RTU. The following signals are sent as a minimum:

- Bucholtz Alarm and Trip
- Oil Temp Alarm and Trip
- Winding Temp Alarm and Trip
- Oil and Winding Temperature Values
- PRD Operated

The 22/11.5kVUnit Transformers 1-6 and 22/420kV Generator Transformers 1-6 makes use of Kelman Transfix and Serveron gas monitoring systems, The Kelman and Serveron gas analysers makes use of a RS485 and RS232 ports respectively. Both of these systems utilises Modbus and DNP3 communication protocols. These systems are required to be interfaced to SAS using an IEC 61850 compliant RTU. The *Contractor* makes provision accordingly.

3.2.6.5 Generator Protection Panels

The SAS is required to be interfaced with the IEC 61850 compliant Siemens Generator Protection IEDs for units 1 to 6 via an Ethernet port. The interface is for the purposes of retrieving information for monitoring the status of the generator protection system only. The SAS will also be required to interface with the tap changers for the 420/22kV Generator Transformers 1-6 and the 132/11kV Station Transformer.

The minimum number of signals that will be required to be monitored will be as per GGS 0770 Eskom Generator Protection Philosophy for Large Fossil Fuel Power Stations with Generator Circuit Breakers.

3.2.6.6 Diesel Generators

The Diesel Generators panels at the Power Station are required to interface with the IEC 61850 SAS LAN. The 3.3kV Diesel Generator relay panel forms part of the 3.3kV Station Diesel Generator Board. The

Contractor interfaces the Diesel Generator panels with SAS by means of an IEC 61850 compliant relays. The other six 380V Unit Diesel Generators do not have IEC 61850 compliant IEDs. These generators are required to interface to SAS by means of hardwiring to an IEC61850 compliant RTU.

The minimum number of signals that will be required to be monitored are as per clause 4.8.4.3 of NRS024.

3.2.6.7 Battery Chargers

The *Contractor* is responsible to interface the SAS with all 24V and 220V Battery Charger units at the power station including BTUs and Battery Banks.

The battery chargers RS485 port with Modbus communication protocol (as per section 6.4 of 36-815) will be interfaced to IEC 61850 compliant RTUs where available. For Battery Chargers without RS485 port with Modbus, signals will be hardwired to an IEC61850 compliant RTU. The minimum number of alarms and indications that will be required for monitoring is as per clause 6.9 of 36-815: Specification for Battery Chargers.

3.2.6.8 Uninterruptable Power Supplies

The SAS is required to interface with all the station UPSs that will be provided by Others. The UPSs RS485 port with Modbus communication protocol (as per section 6.4 of 36-817) will be interfaced to IEC 61850 compliant RTUs. For UPSs without RS485 port with Modbus, signals will be hardwired to an IEC61850 compliant RTU

The minimum number of alarms and indications that will be required for monitoring is as per clause 6.3.4 of 36-817: Static Uninterruptible Power Supplies.

3.2.6.9 Station GPS

The time synchronisation of the IEDs internal clocks are done over the SAS network by synchronising to the existing time server that is linked to the master GPS. The *Contractor* is responsible to design the interface between the SAS and the master GPS. The master GPS is provided by Others. The fibre optic cable to the GPS is provided by the *Contractor*. The link to the time server is provided at the station level using Network Time Protocol (NTP).

The *Contractor* designs the link to the time server and SAS networks to minimise latency and ensures IEDs and RTUs are time synchronized to a 1ms accuracy. Time stamping of events is done at the IEDs and RTUs with a resolution of 1ms.

3.2.6.10 Station Historian

The Station Historian that already exists at the Power Station, acts as a central but secondary point of information storage. Information from the SAS is required to be sent to the Station Historian. The *Contractor* is responsible for sending information from the SAS to the station historian, via a redundant OPC link at station level. The fibre optic cable, all infrastructure requirements, software and configuration requirements on the SAS for the OPC link are provided by the *Contractor*.

The infrastructure requirements, software and configuration requirements on the Station Historian to be able to accept this information will be provided by Others.

3.2.6.11 Stand-Alone System for the HV Yard Control

- A stand-alone system is used for the monitoring and control of the HV yard. This stand-alone system does not have any interface with the SAS. A high-level concept of the HV Yard Control System is illustrated on drawings 8385-18.4-001. Technical requirements of this standalone system are as per the requirements of the following documents:MC931: ICS-MMI Display Colour Coding Standard
- MC932 : ICS-MMI Display Symbol Standard
- Eskom Transmission - Recommended Computer for A CITEC Ver. 5.21 HMI

The *Contractor* provides the HV Yard OWS hardware for the stand-alone system, which consists of one OWS PC with two screens. The software, configuration of the stand-alone system and link to the HV yard is done by Others. The *Contractor* caters for the HV Yard OWS and screens in the design of the SOR desk layout.

3.2.6.12 Power Requirements

The power supplies will be provided by Others. The *Contractor's* SAS equipment will be connected to the power supplies by Others. The *Contractor* provides the Employer with the detailed SAS equipment electrical consumption list.

3.2.7 Technical Specification for Communication Hardware and Applications

The *Contractor* supplies communication hardware and application that conforms to the requirement stated below in the following subsections.

3.2.7.1 Computers

The computers employ industrially hardened PC technology with proven state-of-the-art hardware based on the latest version of Microsoft Windows 10 or more operating system with a RAM of 16GB or more. All computers will have a minimum storage capacity of 4 months.

The engineering system is an open system allowing data to be downloaded and uploaded in the COMTRADE format, which can be converter to PDF or Excel. Further, it is possible to import/export messages to/from Microsoft Excel, PDF and Access for simple manipulation.

It is made possible to save all database and configuration data on both removable and non-removable media for back up purposes without taking the system off-line. It is possible to provide redundant storage media for configuration database. The system supports archive marking for variables. Marked variables are automatically archived.

The engineering software employ an intuitive MS Windows Explorer style interface, which allows the user to manage all aspects of the Input/Output (I/O) signals, Human Machine Interface (HMI), network and hardware configuration. The use of differing, inconsistent user interfaces is avoided as much as possible.

The communication ports are designed to be compatible with the communication bus system used on SAS. Provision is also made to accommodate the interface with other related systems through an Ethernet port. The computers is equipped with the communication software that is compatible with IEC 61850 communication protocol.

The system offers fast compile and download times.

Standard printers are connected to the fixed EWSs for the purpose of printing reports, configuration files, HMI screen drawings, etc. A PDF printer software is also installed to allow for soft copy prints on all computers supplied.

All software is in the English language.

An installation procedure with the required installation files is to be stored at the Power Station, where any computer which has a major failure can be re-placed, configured and fully operational with-in 6 hours.

3.2.7.2 Servers

The SAS server is of a redundant active-passive type and has high availability. The data between the redundant servers is always kept in synchronism.

The health and status of the servers are continuously monitored, and any failure is alarmed via the alternate path. The loss of a single server does not affect the operation of the SAS, nor does it result in any data loss. No data corruption occurs in the event of a server crash or restart.

Individual servers can be removed and replaced without adversely affecting the operation of the SAS.

The server supports both client-server as well as peer to peer modes of operation. All the applications required for a fully functional SAS run on the same platform. The software used in the server is compatible with the software used on the EWS. All software applications that are required to run 24/7 run as operating system services.

The SAS server is required to have a dedicated screen that can be switched between the redundant servers.

Provision is also made for the SAS Server to interface with communication devices on other related systems such as LV Switchgear, Standby Power (DC system), Generator Protection, etc. In other words, the SAS Servers are expandable in a way that during design, provision is made to add information storage devices as required (i.e., a minimum of 60 days of all historical plant information is stored and available on-line for all the above-mentioned systems). If such a link is required, it can be facilitated by a Remote Terminal Unit (RTU) that has protocol conversion functionality, if necessary.

3.2.7.2.1 Communication Interface

The following interface ports can be considered for communicating to auxiliary systems:

a) RJ45, RS-232C, RS-422, and RS-485 with full and half-duplex operation, and selectable baud rates (19200, 38400, 57600, and 115200)
b) IEEE 802.3 Ethernet port with 100 Mb/s speed. Communication protocol is IEC 61850 standard
c) Using IEC 60870-5-101 via a fibre optic coupler

3.2.7.2.2 Database and Information Management

The *Contractor* provides an intelligent database that is maintained by the SAS server and access is provided to all EWSs. The purpose of the substation database is to collect and manage non-real time data in the substation environment.

It is also able to handle data archiving and trending, data compression and organisation of internal data flow. It must send data to the right place where it is required, for example Quality of Supply (QoS) data to the power quality database and non-real time data to the regional engineering database.

The data that is collected and stored consists of event records, disturbance records, statistical metering data, condition monitoring data, quality of supply data, back-up of settings, back-up of automation algorithms, wave form recordings, etc. other data that is also stored is IED technical manuals, software manuals, network data, etc.

The database is able to receive solicited or unsolicited messages/data from IEDs. It implies that the EWS is not only able to receive unsolicited data, but also solicit/extract data from the IEDs connected to it, by sending relevant messages to each IED.

Compact flash memory is used for storage of software and data instead of a hard disk drive. Hard disk drives are only used in addition to flash memory and are only used as an absolute last resort. Hard disk drives may only be used if *approved* by the *Employer* in writing.

The system supplies tools for automatically backing up the database to removable media or to an alternate storage location. The backup utility executes the database backups automatically based on either of the following configurable criteria:

- Time-based (e.g., every 24 hours)
- Based on the size of the database (e.g., after the size reaches 1 MB)

All disturbance records are uploaded automatically to the substation database within 30 seconds of it being recorded. It is made possible to select whether the original records in the IEDs' memory is deleted or kept after transmission, in order to prevent the substation database memory from filling up.

It is possible to upload the engineering database contents (for example disturbance records, event records, condition monitoring data, etc. but excluding SCADA data) to an enterprise database once a day. Only changes in the database (and not the complete database) are uploaded. The time at which these uploads are performed is user settable.

The system is able to perform the back-up operations both off-line and on-line.

3.2.7.2.3 Archiving Capability

The *Contractor* ensures historical subsystem has the following specifications:

- Provides the ability to define archiving rates in increments of milliseconds, seconds, minutes, hours, or days.
- Is able to store all analogue tags at a resolution of 1 second or better, and all events at a resolution of 2 ms or better.
- Stores a minimum of 6 months of all historical plant information on-line. The recording function stores data on the First in First out (FIFO) basis.
- Allows an individual archive rate to be programmatically modified and/or utilised as part of the control logic requirements.

3.2.7.3 Engineering Work Stations

Two fixed EWSs are provided by the *Contractor*, one at EOD and the other should be at Electrical Engineering office. Four portable EWSs are supplied by the *Contractor* in addition to the fixed EWSs, which can be fully operational if connected to any point on the IEC 61850 network.

The Human Machine Interface (HMI) level is derived from the project created on the EWS, automatically, to avoid duplicate input of information. Multi-layer technology is available for picture designing to enable clear engineering. The engineering supported with graphical resources; pure programming is not acceptable.

It is made possible to optionally obtain an application for analysis of historical data. This application must always use the original data as a base for further calculations or analysis. It is made possible to visualise variables in a user-friendly graphical format. Furthermore, it is made possible to export this data into a comma separated value file format for further analysis in other software packages, for example Microsoft Excel. It is also possible to perform all these functions online as well as offline.

It is made possible to handle the system engineering even without in-depth knowledge of object-oriented programming. Block programming sources is accessible to users. The system is able to detect errors in the configuration, test the connection between two different data types and reject them when applicable.

3.2.7.4 Operator Work Stations (OWSs)

Redundancy of these two OWSs will ensure continuation of station electrical control even if one OWS fails. A third HV yard OWS independent of the two station MV reticulation OWS's is provided. This OWS will be for HV yard reticulation only.

The *Contractor* designs the OWS is designed on the EWSs and stored on the SAS Server. The OWS is displayed and controlled from client PCs based at the SOR.

The *Contractor* provides the number of OWS's and provides screens with minimum sizes of 40 inches.

The following reports should be generated by the OWS:

- Sequence of Events Log
- List of all active simulations.
- Operator Log (key stroke)

The OWS is also enabled to be used for the following:

- Synchronisation Check (phasing)
- Metering and measurements
- Quality of supply (NRS048) (with alarms)
- Fault (event) recording

3.2.7.4.1 Screen Development

The *Contractor* is responsible for the development of the operator screen, the *Project Engineer* accepts the designs.

Displays is configured in a clear and unambiguous manner to provide the operator with information relevant to the task. Icons and symbols are used consistently throughout the displays for all units, according to Eskom Operating Regulations for High Voltage Systems (ORHVS) 32-846. Symbols of plant in low level displays may be based on outline or physical structure of the plant device if ergonomically appropriate.

Colour codes used on mimics correspond to those listed in NRS 040 part 2. All voltages generated by the main generators are shown in black. A closed-circuit breaker is indicated as a solid red square and an open circuit breaker is indicated as a square outlined in green with no fill colour.

Screens should not only be developed for the new MV switchgear but should include all the sub-systems the SOR interfaces to, showing all statuses.

3.2.7.5 Remote Terminal Unit (RTU)

The *Contractor* designs and supplies RTU that acts as a termination interface and protocol conversion system to be able to interface to the IEC61850 network. The system accepts inputs and outputs from the plant.

All RTUs are IEC 61850 enabled and connected to the SAS Unit Level Switches with a redundant bus. The estimated quantities for RTUs will depend on the design of SAS as per Scope of Works.

The system will be fully redundant, the *Contractor* guarantees no less than 99.99 % availability. No single fault should stop the functionality of the RTU.

The *Contractor* propose, for *Employer's* acceptance, hardware alarms (e.g., Power supply fail, CPU failure, Communication module failure etc.) to be engineered into the system as well. This is required to allow total user supervision of the system.

All modules, logic cards, power units, control and monitoring units are standard interchangeable modules which can be inserted and / or replaced with minimal or no interruption of operation of the system.

3.2.7.6 Switching Devices

The *Contractor* ensures that 100 Mbps switched Ethernet network with a redundant bus architecture is used for the Board Level Architecture and 1 Gbps switched Ethernet network with a redundant bus architecture used for the Unit Level Architecture and the Station Level Architecture.

Substation hardened LAN/Ethernet equipment such as switches and routers are used in the substation environment. LAN equipment suitably specified for the substation environment is used. This refers mainly to the characteristics of the equipment, for example the electromagnetic interference specification, insulation levels, etc.

All communication equipment forming part of the SA system complies and is tested in compliance with the standard IEEE 1613™: Standard Environmental and Testing Requirements for Communications Networking Devices in Electric Power Substations. Ethernet switches used in substation automation applications comply with IEC 61850-3 standard for EMI (Electromagnetic Interference) immunity and environmental requirements to ensure reliable operation of networking equipment in substation environments.

Managed Ethernet switches are used, with features such as:

- IEEE 802.1p Priority Queuing, to allow frames to be tagged with different priority levels, in order to ensure that real-time critical traffic makes it through the network, even during high periods of congestion.
- IEEE 802.1Q VLAN (Virtual Local Area Network), to allow for the segregation and grouping of IEDs into virtual LANs in order to isolate real-time IEDs from data collection or less critical IEDs.
- IEEE 802.3x Full-Duplex operation on all ports
- IEEE 802.1w Rapid Spanning Tree Protocol
- IGMP (Internet Group Multicast Protocol) Snooping / Multicast Filtering that allows for multicast data frames, to be filtered and assigned only to those IEDs which request to listen to them.

The communication system performs error free data transmission. It is able to perform a "fail soft" recovery from various different conditions, for example communication link congestion. It is unnecessary to provide redundant communication services, but it is possible to support redundancy. It is also able to support complete redundancy, even though it is not required in all cases.

3.2.7.7 Communication Cables

The communication channel between different devices and systems are facilitated by fibre optic links. The *Contractor* provides this fibre optic cabling between the different SAS equipment. Multimode fibre optic cables are used for all the short distance communication requirements and the single-mode type are only considered for long distance communication. The *Contractor* provides the total cost for fibre optic cables as well as the price per metre costing. Costing takes into consideration the distance between the substations and as well as cable routing, using SAS Architecture Overview drawing 0.61-93928 as the basis. Estimated cable lengths and routing between substations is provided by the *Employer*, however the Contractor advises and designs for optimised alternative solutions for SAS network configuration.

The *Contractor* is responsible to ensure that cables installed outside the boards have adequate protection to minimise the possibility of physical damages. Environmental conditions are also taken into consideration while selecting such a cable.

The colour of the outer insulation (i.e. sheath or jacket) of all the fibre optic cables is GREY. The cables have Low Smoke and Fumes (LSF) sheath to ensure that the cables are not liable, like ordinary PVC cables, to produce corrosive halogens and copious smoke in the event of a fire.

The communication cables are designed such that there is minimal number of connections to limit the losses. The attenuation as well as the bandwidth of the communication link is optimised to allow for optimal data transfer.

The control cabling that will be hardwired to IEC 61850 compliant RTUs will be in accordance with GGS0386.

3.2.7.8 Time Synchronisation System

The *Contractor* is responsible to design the system in such a way that all devices connected to the SAS network are synchronised over the network using the Network Time Protocol (NTP). The internal clocks are time synchronised for time stamping with a resolution of 1ms. The time synchronised devices, such as the IEDs automatically recover, without any user intervention, should there be an interruption of the time synchronisation signal.

The C&I Global Positioning System (GPS) that currently exists at site is used to provide the time signal however, a module might be required to be added to provide the NTP time signal. In a case where it's required, this module is provided by Others. The routing/distribution of the time signal is also the responsibility of the *Contractor*.

In case NTP cannot be supported by the devices offered, the *Contractor* indicates and lists all GPS protocols that are compatible with the IEDs and the hardware requirements for the communication interface.

For general purposes, ±1 ms is sufficient accuracy, and for higher accuracy data such as analogue data sharing, 1 μs ± 0,5 μs.

3.2.8 Performance

Message types are subdivided into performance classes. There are two independent groups of performance classes, one for control and protection, another one for metering, monitoring and disturbance recording applications. The transmission time for the different message types complies with the performance requirements specified in IEC 61850-5 Clause 13.

The port-to-port transmission time of a protection command by making use of a GOOSE message as defined in IEC 61850 over the Ethernet LAN is less than 4ms. The delivery time of a message is the time allowed to transfer routinely updated data elements from a sending to a receiving IED and it must be less than the average update interval. It implies that peer-to-peer communication is a minimum requirement for a system that is expected to perform protection functions and communicate over the LAN network within the specified 4 ms time frame.

The communication system is, under maximum conditions, i.e., when all devices are communicating simultaneously; only operate at a maximum of 30% of capacity.

There are three categories of timing constraints for data transfer intervals and all three are provided for:

- high speed, less than 4 ms;
- medium speed, 4 ms < t < 15 ms, and

- slow speed t > 15 ms.

The following functional performance and timing criteria is also adhered to:

- time to send a control command/message (< 20 ms)
- time to send or receive a protection message (< 4 ms) (port to port time)
- time to send and receive an interlocking message (< 20 ms)
- time to display a state change (< 500 ms)
- time to display analogue input (< 500 ms)
- time to display alarm (< 500 ms)
- time to change HMI screen view (< 1000 ms)
- time to change control mode (e.g. from local to remote) (< 50 ms)
- automation function execution time (< 20 ms) (calculation of algorithm, excluding the field execution)
- boot up of the complete system and its respective components do not take longer than 30 seconds. The Contract supplies typical boot up times of other systems of similar size/complexity

The speed of operation/execution of any operation of any kind is not slower or worse than with a conventional protection, control and automation system implemented via hard wiring instead of Ethernet communications.

As a guideline from IEC 61850-5 Clause 15, during abnormal or emergency loads the substation bus is able to handle at least two times the loading of the normal load.

The overall substation automation communication system has an availability of at least 90% as well as the reliability of 95%. The Mean-Time-To-Failures (MTTF) or Mean-Time-Between-Failures (MTBF) (whichever one is relevant) of all components used to build the SAS is at least 50 years.

The basic philosophy is predisposed towards simplicity. Equipment that may reduce the reliability of the system is duplicated. This includes for example computer hard drives (if provided at all). Devices such as power supplies, communication links, computers (where applicable) and analogue inputs are also designed in such a way that the MTTF defined above may be adhered to.

The design life expectancy of all equipment and software forming part of the SAS is least 20 and 10 years, respectively.

As part of the detail design package to be compiled after Contract award, the total system structure as well as detailed calculations of bus loading, reliability and availability is provided to the Employer for Acceptance.

3.2.9 Security and Access Control

Access security in the substation communication domain is extremely important and is managed similarly to the office environment. It should be noted that the consequences of a security breach can be severe and could lead to an outage at a specific substation, but also to a network wide outage or blackout should individuals with criminal intent attempt and succeed to breach security of the substation automation and control communication network. This implies that the necessary security levels such as firewalls and virus protection are built into the design by the *Contractor*.

The *Contractor* installs approved Eskom Virus protection programs on all computers, preventing the substation automation network to be infected by viruses and other malicious software. The virus protection will be automatically updated daily through the Eskom LAN.

The EWS connects via a redundant firewall.

A suitable security access control process is implemented for the system. This access control system provides access to the substation bus. Each user is issued with a login name and password, which is user selectable after the first login. This ensures for example that only authorised users have the rights to operate switchgear and others are only able to perform monitoring functions.

The *Contractor* derives the suitable access categories for the SAS. The following defines the proposed categories of access and allowable actions per category:

Table 1: Definition of access categories for security purposes

Category 1:	Allow access for the purpose of viewing data, settings, disturbance records, etc. and getting access to the substation SCADA system/HMI excluding the ability to perform any controls. In this level the user is unable to make any changes. This level does not necessarily require a password attached to it, this may be the default view.
Category 2:	Allow the operator to have access to the substation HMI system for the purpose of controlling plant.
Category 3:	Allow the protection staff to have access to protection relay configuration and settings, disturbance records, CM equipment configuration, etc.
Category 4:	Allow communication bus maintenance to be executed (network administrator rights, full access).

It is made clear that the above categories do not reflect any ranking and are not mutually exclusive. For example: protection staff would be provided access to the system for category 1 and 3, operating staff only to category 2, etc. Also, category 1 is not higher than 4, and 4 is not higher than 1.

3.2.10 Specific Testing Requirements

The *Contractor* is responsible for ensuring that the terms and definitions for testing comply with those specified in IEC 61850-10 Clause 3.

The Contractor also ensures that the SAS undergoes conformance testing as laid out in IEC 61850-10 Clause 5 and 6. The SAS also undergoes performance testing, which includes communications latency, time synchronisation and accuracy testing as laid out in IEC 61850-10 Clause 7.

The required values of accuracy and allowable error are documented in IEC 61850-5 Clause 13.

For each bus interface type a protocol FAT should be done to prove that both devices concur to the protocol prior to installation and can be used on site.

3.2.11 List of Reference Procedures, Standards and Specifications

The *Contractor* complies with all standards, specifications, and regulations this Scope of Works:

Table 2: Standards, Specifications and Regulations

Number	Description
	Requirements for Control and Power Cables for Power Stations
NRS 024 Part 1	Diesel Alternator Sets Part 1: Diesel Alternator Sets for Fixed Installations
NRS 040 Part 2	High Voltage Operating Regulations – Part 2: Voltage Colour Coding for Diagrammatic Displays in Control Room – Colour Coding for Wall-Mounted Operating Diagrams and Electronic Displays Relating to the Generation, Transmission and Distribution of Electricity.
NRS 048	Electricity supply - Quality of supply
240-56355731	Environmental Conditions for Process Control Electronic Equipment used at Power Stations.
IEC 61000-6-5	Electromagnetic compatibility (EMC) - Part 6-5: Generic standards - Immunity for power station and substation environments.
IEC 61850	Communication networks and systems in substations.
IEC 61850-3	Communication networks and systems in substations Part 3: General requirements
IEC 61850-5	Communication networks and systems in substations Part 5: Communication requirements for functions and device models.
IEC 61850-10	Communication networks and systems in substations Part 10: Conformance testing
IEC 6087-5-101	Telecontrol equipment and systems – Part 5-101: Transmission protocols – Companion standard for basic telecontrol tasks
EED_GTD_C&I_006	Alarm Management System
IEEE 802	IEEE Standard for Local and Metropolitan Area Networks: Overview and Architecture
IEEE 1613	Standard Environmental and Testing Requirements for Communications Networking Devices in Electric Power Substations

3.2.12 List of Drawings

This is the list of drawings issued by the *Employer* at or before the Contract Date and which apply to this contract.

Note: Some drawings may contain both Scope of Works and Site Information. All of the drawings listed below, are for Kendal Power Station.

Drawing Number	Drawing Description
7982-18.4-002	EOD COROS Upgrade - Network Layout
8385-18.4-001	H1 and E490 Upgrade – Network Layout
0.64/12388 Sheet 1	Station and Unit MV and LV Single Line Electrical Diagram
0.64/12388 Sheet 2	Station and DC Single Line Electrical Diagram
0.64/12388 Sheet 3	CSY MV and LV Single Line Electrical Diagram

3.2.13 Control and monitoring logic

3.2.13.1 General requirements

The Control and Monitoring Logic (CML) functionality shall maximize on the data acquisition capability of the RTUs to provide for the coordinated real time control and monitoring of substation primary plant/equipment. The following CML functions are required at present:

- Monitoring of substation plant and equipment.
- Management of substation operation.
- Management of the integrity of substation supply.
- Ensuring the integrity of the SCS and related systems.

3.2.13.2 Monitoring of substation plant and equipment

The Gateway and Station RTU/IED shall have the capability of monitoring plant and equipment on a real-time basis. The Gateway shall ensure that all indications and analogues values shall by default originate from the protection Main1 system (M1), unless it is out of service or unavailable for whatever reason upon which the Main 2 system (M2) indications and analogues values shall become active. In addition, the Gateway and Station RTU/IED shall have the capability of interfacing to protection relaying schemes.

3.2.13.3 Monitoring description

The Gateway and Station RTU/IED shall provide online monitoring of the status and operation of substation plant and equipment. The data, which is captured by the Gateway and Station RTU/IEDs, shall be used to provide the basis for an online diagnostics and condition monitoring facility. The data captured shall also be packaged by the CML function for transmission to the SCADA master station/s. The Station RTU/IED shall provide a discrete/serial interface to some secondary plant equipment.

Monitoring requirements
The Gateway and Station RTU/IED shall perform inter alia, the following monitoring functions:

- Capture of status and measurand data.
- Sequence of event data from protection schemes.

Digital alarms

- Digital input 'alarms' shall be monitored and reported based on their individual or group priority.
- The individual alarm priorities shall be software defined at both the individual and group level.
- Each digital input shall be configurable to provide time stamping of status changes with an accuracy of 1 ms with respect to any other digital input in the same RTU.

The *Supplier* shall state the resolution of digital input time stamping in the offer.

Pseudo-variables

- The logical grouping of inputs shall be unrestricted.
- It shall be possible to assign some or all of these groups to logical pseudo-variables, which shall be processed as any other digital input.
- Pseudo-variables shall be derived by means of Boolean operations performed on discrete digital inputs to provide a single output quantity.

Analogue windows

- Software-configurable 'moving window' analogue monitoring techniques shall be applied to all analogue inputs and pseudo-analogue values. The 'moving window' concept implies that an analogue change shall not be reported or flagged as a change unless it exceeds a predefined 'window'.
- This 'window' consists of a configurable upper and lower limit around the current value of any analogue point.
- The 'window' shall remain static and shall only move to the new analogue value once the change has been reported.
- These thresholds shall be provided per individual analogue.

Analogue reporting. Analogue changes shall be reported under the following conditions:

- When the analogue input exceeds the 'window'.
- When the analogue input exceeds a predefined upper maximum limit or lower minimum limits. These limits are defined as high, high-high, low and low-low values.
- The reporting function shall feature hysteresis that inhibits repeated reporting of small changes around the thresholds. The high analogue value is reported when the HIGH threshold is exceeded, i.e. at H1. It is only reported again when the value falls below HIGH – hysteresis, i.e. at H2. The low analogue value is reported if the value falls below the LOW threshold, i.e. at L1. The analogue value is only reported again when it rises above the LOW + hysteresis threshold, i.e. at L2.
- It shall be possible to enable/disable the reporting of individual analogues.
- Preference will be given to equipment that allows analogues to be configured to report on a periodic basis.

Analogue time tagging

- Analogues, which have exceeded the upper maximum or lower minimum limit, shall be time tagged and logged into the Sequence of Events (SOE).
- Time tagging shall be a configurable function for all configured analogue inputs.

Monitoring physical implementation

- The Gateway shall collate all the data received from the IEDs/Station RTU/IEDs to provide a centralized substation database.
- The Station RTU/IED shall also collate all the data received from hardwired IEDs to provide this information to the Gateway.

- The Gateway and Station RTU/IED shall coordinate time tagging on a substation basis, so that time tagged information, which is passed to the SCADA master station, has a common reference within the context of the SCS.

3.2.14 Management of Substation Operation

The Gateway shall provide a data collation facility for remote master station(s). The Gateway shall also provide the SCADA master station with the ability to remotely control substation plant and equipment.

3.2.14.1 Substation Operation Description

- The Gateway shall have the capability of operating substation plant under remote control of the SCADA master station(s).
- The Gateway shall also operate substation plant under the direct control of the external HMIs in the context of the SCS.
- The Gateway shall ensure that all controls for the protection system shall by default be sent to the Main1 system (M1), unless it is out of service or unavailable for whatever reason upon which the Main 2 system (M2) controls shall be utilised.
- In addition, the Gateway shall provide a control path to the Station RTU/IED for the remote SCADA master stations.
- The Gateway shall provide the ability to collate data for transmission to a remote SCADA master station.

3.2.14.2 Substation Operation Requirements

Data Types/Reporting

- Prioritization and reporting of data shall be implemented with the view to optimizing system performance with respect to the available data communication rates.
- In addition, any mechanism provided, shall enable the implementation of flow control under system surge conditions.
- Real time CML data shall consist of: (a) Digital outputs. (b) Digital status points. (c) Accumulators. (d) Analogue measured. (e) Analogue set points.
- This data shall be captured according to the requirements defined in, 'Monitoring Requirements'.

Priority Queues

- All real-time CML data shall be provided within the concept of priority queues.
- On a master station demand basis, the contents of these queues shall be available for transmission.
- The Gateway and Station RTU/IED shall provide a priority queue mechanism that conforms to the requirements of IEC 60870-5-101 and IEC61850 protocols.
- The Gateway shall supply data to the queues on an exception basis. That is, only those items in the database that have changed since the last time the Gateway were polled.
- When transmitting data to the master station, the following information shall be provided:
    - The status of each queue.
    - The priority of the data which is being transmitted.

Resynchronization of Databases

- The SCADA master station shall issue a command to 'resynchronize databases'. This shall entail the Gateway transferring its entire state of database to the SCADA master station.
- The Gateway to Station RTU/IED interaction shall be identical to the interaction between the SCADA master station and the Gateway (as described above).

Time Synchronization – Gateway/Station RTU/IED Clock Accuracy

- The time source in the Gateway/Station RTU/IED shall have an inherent accuracy of better than 250 ms during any 24 h period. This means that time lost or gained during a 24 h period shall not be > 250 ms.
- The Gateway/Station RTU/IED shall be equipped with a battery backed-up Real-time Clock (RTC) with leap year support.
- It shall be possible to set the clock via the configuration software connected locally to within 1 ms of the Personal Computer's (PC's) clock, as well as via the Telecontrol protocol from the master station.
- The precision of the clock shall be 1 ms or better, i.e. CCYY/MM/DD hh:mm:ss.ttt.
- The RTC battery shall provide at least 50 days of total standby time.
- The battery should not need replacing more often than every 10 years under normal operating conditions.

Time Synchronization – Gateway to SCADA Master Synchronization

- Using IEC 60870-5-101 / IEC61850 it shall be possible to synchronize the time of the Gateway to the SCADA master station.
- The *Supplier* shall provide details of time synchronization accuracies that can be achieved.

Time Synchronization – Gateway to GPS Receiver Synchronization

- The interface between a substation master clock (GPS receiver) and the Gateway shall as per the requirements.
- The IRIG-B interface shall be designated as the primary/master time source interface, and any Gateway synchronization messages from other hosts shall be ignored.
- If there is communication port failure, the next designated time synchronisation host shall assume responsibility for the synchronization of the Gateway/Station RTU/IED.
- The Gateway synchronization shall be done to an accuracy of better than or equal to 1 ms when referenced to the GPS receiver. An accuracy of 1 ms means the following: (a) Any two simultaneous events on the Gateway shall not have a difference exceeding 1 ms (plus or minus). (b) The absolute time of an event that occurs simultaneously on the GPS and Gateway should not be > 1 ms from the GPS referenced absolute time.

Time Synchronization – Station RTU/IED or Bay IEDs to Gateway for Time Synchronization

- Using SNTP/NTP/PTP, it shall be possible to synchronize the time of any RTU/IEDs/Data Concentrators/Data Server to the Gateway to an accuracy of 1 ms.

Plant Control – Control of Plant shall be initiated in the following ways:

- From the remote SCADA master station to the Gateway. The Gateway in turn issues a control command to the Station RTU/IED/ or bay IED.
- From the external HMI Clients to the Gateway

Control sequence: Master station to Gateway. A control sequence from a Master station to the Gateway, shall be performed as follows (after all control handover and interlocking rules have been passed):

- Upon receipt of the 'Select and Execute' message, the Gateway shall select the appropriate control output relay. After checking that the correct relay has been selected, it shall execute the control by applying a voltage to the control output relay.
- Upon successful operation of the output relay, the Gateway shall send an 'Execute Confirm' message to the master, in addition to the change of state message from the controlled device.
- If the control operation failed, the Gateway shall send an 'Execute Fail' message to the SCADA master station, as applicable.

Substation Operation Physical Implementation

- Prioritization and reporting of data as described above shall be implemented at the Gateway.
- The control function shall be implemented at the Gateway as described above.

3.2.15 Gateway/Station RTU/IED Integrity

The Gateway/Station RTU/IED is to be used for the operation of plant and equipment in substations. It is essential that the integrity of the Gateway/Station RTU/IED be such that it shall at no time threaten human life or any plant and equipment.

3.2.15.1 Gateway/station remote terminal unit integrity description

The Gateway/Station RTU/IED integrity refers to the integrity of all software processes and hardware elements provided by the *Supplier*.

3.2.15.2 Gateway/station remote terminal unit integrity requirements

To enhance the functionality of the Gateway/Station RTU/IED the following criteria shall be provided for:

Watchdogs
The Gateway/Station RTU/IED shall provide hardware and software watchdogs that continuously monitor the hardware and software elements of these systems. These watchdogs shall ensure safe operation of the Gateway/Station RTU/IED at all times. If the Gateway/Station RTU/IED should fail, it should fail to a 'safe' condition.

Error Detection/Correction

- Adequate coding techniques for error detection shall be used to eliminate incorrect controls being carried out due to undetected errors in code/messages.
- Adequate coding techniques for error detection shall also be used to eliminate incorrect indications and alarms being presented due to undetected errors in code/messages.
- For remote control functions, it is required that the effectiveness of the coding system be such that the probability of an incorrect control command being performed is 10^{-10} or better.
- For remote indication purposes, it is required that the effectiveness of the coding system be such that the probability of an incorrect status indication of alarm being presented to the operator is 10^{-7} or better.
- The *Supplier* shall substantiate how these error rates are achieved, and shall clearly state the assumptions that have been made in determining compliance with the specified error rates.

Reliability/Availability

- The individual reliability of system components shall in no way cause the overall system availability at any one substation or site to drop below 99.98% per 1 000 h.
- The *Supplier* shall substantiate how the availability is to be achieved, and shall clearly state the assumptions that have been made in determining compliance with the specified availability.
- The *Supplier* shall clearly state the reliability of major system components in meeting the availability. These system components shall be described in the proposal at the time of tendering.
- It is a requirement that if 10% or more of the total number of each system component installed, fails during the warranty period, all such system components shall be replaced at the *Supplier's* expense and the warranty shall be extended for a further period under the same conditions.

3.2.15.3 Gateway/Station RTU/IED integrity physical implementation

The Gateway/Station RTU/IED shall both provide a relay contact, which is not part of the normal control output boards.

The relay contact shall be closed under normal operating conditions. When the Gateway/Station RTU/IED experiences a catastrophic failure, the Gateway/Station RTU/IED shall 'shut down' and the relay contact shall open. A catastrophic failure is defined as follows:

- Any failure of a major system component.
- Failure of system power supply.
- Corruption of the configuration database.
- Corruption of system or application software.
- Failure of one or more control outputs, if control sensing is active.

The failure of a digital input or analogue input card is not classified as a catastrophic failure.

This relay shall be under direct control of the microprocessor unit on the RTU.

'Shut down' is defined as follows: The Gateway/Station RTU/IED shall be provided with an automatic and orderly closing down of databases and processes on detection of a catastrophic failure.

The Gateway/Station RTU/IED shall have power-on sequencing, which shall occur automatically when power is restored to a unit after an outage.

This power-on sequencing shall include, inter alia, automatic resynchronization of Gateway/Station RTU/IED databases and a complete diagnostic check of both the Gateway/Station RTU/IED.

No data changes shall be reported to the master stations or the HMI Client/Server until the power-on sequence is complete.

3.3 PLANT INTERFACES

- The plant interface shall consist of the following:
  - Plant outputs.
  - Plant inputs.

- The inputs and outputs to the RTU shall be designed to withstand the surge withstand capability tests as defined in the IEEE Std C37.90.1-1989 without RTU damage, disoperation or data corruption.
- It shall not be possible to fit an I/O module in an I/O slot or position where so doing will cause any damage or disoperation whatsoever.
- It shall be possible to isolate/remove an I/O module for maintenance without having to power down the RTU or to take it offline.
- Failure of any one I/O module shall not affect the performance of any of the other modules.
- The RTU shall provide visible local diagnostic indications on all the modules.
- Visual status indication of the I/O on each I/O module is preferred.

3.3.1 Plant Outputs

Plant outputs are also termed control outputs. These outputs are essentially relay outputs, which are directly activated by the Gateway/Station RTU/IED. This is the primary method for controlling substation plant and equipment.

3.3.1.1 Plant Output Requirements

- The plant outputs shall consist of a normally open contact for each open or closed function. These contacts shall have a maximum switched voltage of VAC 250 V/VDC 50 V. The maximum switchable power of 100 V.A/60 W shall be required.
- Each digital control output shall provide a voltage free ('dry') contact with the following minimum rating: 1 A, VDC 110 V. The *Supplier* shall provide the ratings of the control relays on the modules that are offered.
- Control output modules providing pulse-width output functionality shall be available whereby a normally open contact will close for a configured period.
- The duration of the closing pulse per output relay shall be variable between 0,1 s and 10 s in 100 ms steps.
- Control output modules that support pulse-width functionality shall offer the option to prohibit the simultaneous operation of pulsed output relays on a per module basis. The *Supplier* shall state all related configuration parameters in the offer.
- Control output modules providing latching relay output functionality shall also be available.
- In this configuration, it shall be possible to have more than one output relay active at a time.
- The latched relay shall not be mechanically latched.
- Preference will be given to systems which allow control output relays on the same Digital Output (DO) module to be individually configured as either pulse-width outputs or latched outputs. The requirement is to have, for example, on the same DO module, outputs 1, 2 and 4 configured as pulsed outputs, while outputs 3 and 5 are configured as latched.
- All switching shall be carried out using a double pole switching method. This implies that a common relay shall switch the common supply rail at the same instant that a specific output relay is activated.
- The combined operation of the output relay and the control common relay shall take place in the following modes:
    - To switch through the VDC 50 V equipment derived voltage.
    - To switch an external voltage.
    - To provide a 'dry' contact to an external user.
- A VDC 48 V output switching voltage shall be provided by the RTU. It shall also be possible to provide this voltage from an external source.

- The 48 V switching supply shall be short-circuit protected.
- The short-circuit protection should be self-healing once the short circuit is removed. The *Supplier* shall provide details of the short-circuit protection mechanism.
- Control outputs shall use a local select-check back-execute principle. On receipt of a control select and execute request from the Remote Master Station, the remote unit shall select and confirm, internal to the module, selection of the appropriate control output relay. Power shall only then be applied to the output relay to operate it.
- Control outputs shall also support the direct operate principle.
- After initiation of the control sequence, the sequence shall be terminated either:
    - Automatically 10 s after commencing the sequence; or
    - After the successful execution of the sequence.
- In the event of any failure, no erroneous control shall be executed.
- Preference shall be given to an RTU system that checks control successes, and which can provide information on the source of control failures. The *Supplier* shall provide full details on such functionality if it is offered.

3.3.2 Plant Inputs

a) Plant inputs are the primary method of data acquisition for the Station RTU/IED
b) Plant inputs include digital inputs, analogue inputs and accumulator inputs.
c) Accumulator inputs are digital pulsed type inputs.

3.3.2.1 Plant Input Requirements

Digital Inputs

- Cables with lengths of up to 1 km are used for connecting digital inputs to the plant. It may be assumed that each 'potential free' contact in the plant is connected to a separate pair of wires. Regardless of any 'commoning' which results from the design of the digital input circuitry in a manufacturer's equipment, and with any combination of closed and open contacts (particularly all but one contact closed), it is required that an open contact be correctly detected as such. It may be assumed that the worst-case inter-core cable impedance is 1 MΩ.
- A closed contact shall be detected when a condition of 0 Ω to 200 Ω exists in parallel with up to 4,0 μF at the input. The hysteresis values shall be provided by the *Supplier*.
- The open contact shall be detected when a condition exists of 100 kΩ to 1 MΩ in parallel with up to 4,0 μF at the input. The hysteresis values shall be provided by the *Supplier*.
- All breaker status and alarm inputs shall be derived from potential-free inputs provided by the *Purchaser*. The RTU shall provide a suitable wetting voltage for reading these contacts. *Supplier* shall provide information on this wetting voltage and how it is sourced.
- All digital circuit inputs provided shall offer a noise immunity of *U*DC 5 V and 10 V root mean square (rms) at 50 Hz applied transversely, and 100 V rms at 50 Hz applied longitudinally to earth.
- Each input shall have a configurable contact closure delay, variable from 10 ms to 60 s.
- The digital inputs shall be configurable as single-bit inputs, double-bit inputs, accumulator (counter) inputs and Binary Coded Decimal (BCD) inputs for Transformer Tap Position indicators. Normal double-bit states (i.e. 01 and 10) shall be reported immediately, while abnormal double-bit states (i.e. 00 and 11) should only be reported after the abnormal state has been sustained for a configurable period. Similarly, only stable BCD values shall be reported, i.e. invalid intermediate

states should not be reported The *Supplier* shall state the related configuration parameters in the offer.

- The ability to configure a processing delay per digital input is sought. This delay should be settable in 1 s steps from 0 to 255.
- The status change should only be reported if the status change is sustained for the duration of the timer.
- Delayed status changes shall be time-stamped with the time at the start of the delay and not the end of the delay. The *Supplier* shall state all related configuration parameters in the offer.
- The Gateway/Station RTU/IED shall provide the ability to invert the logic status per digital input.
- The Gateway/Station RTU/IED shall provide the ability to disable and enable the reporting of digital inputs on a per input basis.
- Any digital input shall be configurable to enable the counting of digital status changes. Counter values shall be stored in non-volatile memory.
- The reporting of counter values shall be configurable, i.e. on the transgression of a configurable value, or on the basis of a configurable freeze period. The *Supplier* shall state all related configuration parameters in the offer.

Accumulator Inputs

- Each accumulator input value shall be represented by a minimum of a 16 bit binary word.
- All accumulator inputs shall accept input pulse rates of up to 20 pulses per second. Each accumulator shall be reset under three conditions: (a) Under remote control. (b) On a pre-set time. (c) After a given time period.

Analogue DC Inputs

- The accuracy of the Analogue to Digital (A/D) converter shall be sufficient to ensure that any specific analogue input shall have an accuracy ≤ 0,25% of the full-scale reading.
- All transducers may be regarded as linear over the range ± 7,5 mA, which can be regarded as the full-scale working range of all analogue inputs.
- The Analogue Input subsystem shall support the following input ranges: *V*AC DC ±1 V, ± 10 mA and 4 mA to 20 mA.
- The input circuitry shall not present more than 400 Ω load to the transducer.
- Analogue input circuits shall be balanced, floating and isolated. The flying capacitor technique (or equivalent) shall be implemented to achieve the required level of isolation.
- No potentiometers shall be used to scale any of the inputs. All input scaling shall be done via software configuration.
- With *V*AC DC 150 V or *V*AC 100 V rms (50 Hz to 300 Hz) applied common mode to the analogue inputs, the A/D converter count shall not change by more than approximately two counts.
- With *V*AC 1,5 V (50 Hz and 1 MHz) applied differentially to the analogue inputs, the A/D converter count shall not change by more than approximately two counts.
- Each analogue input shall be represented by a minimum of a 12 bit binary value.

Analogue AC Inputs

The requirements for interfacing to analogue AC inputs are as follows:

- Nominal input voltage *V*AC 115 V.
- Nominal input current 5 A.
- It is preferred that the analogue AC input modules provide the option for Digital Signal Processing (DSP) functionality.

3.4 Junction Box Requirements

The *Contractor* is to ensure that all junction boxes are to be rated at IP65 and IP67.

The *Contractor* is to ensure that manufacturing, mounting, earthing and labelling of the Junction Boxes is according to the standard *240-56355815 Field Instrument Installation Standard: Junction Boxes and Cable Termination.*

The *Contractor* is to ensure that internals of the Junctions Boxes will have a Perspex cover to restrict access to the wiring by unauthorized persons.

The Contractor is to ensure that all Junction Boxes are adequately corrosion protected as per the Eskom standard *240-75655504 Corrosion Protection Standard for new indoor and outdoor Eskom Equipment, Components, Materials and Structures manufactured from Steel Standard.*

3.5 Earthing and Lightning Protection Requirements

The *Contractor* is to ensure that all cable earthing and equipment earthing complies with Eskom *standard 240-56227443 Requirements for Control and Power Cables for Power Stations standard.*

The *Contractor* is to ensure that all equipment should have adequate lightning protection and is earthed as prescribed in the standard *240-56356396 Earthing and Lightning Protection standard.*

The *Contractor* is to ensure that the lightning protection shall have steel lighting rods, aluminium earthing and copper spikes connected to Kendal Power Station's earth mat.

The *Contractor* is to ensure that the instrumentation control system shall have a dedicated electronic earthing network and shall not be directly connected electrical or station earthing mat as indicated on Eskom earthing standard *240-56356396 Earthing and Lightning Protection standard.*

3.6 Control and Power Cabling Requirements

The *Contractor* is to ensure electrical power and control cables are to be installed as per standard *240-56227443 Requirements for Control and Power cables for Power Stations standard*

The Contractor is to ensure that all cables will be sized to allow a volt-drop of no greater than 5% of the voltage at the switchgear end or, as otherwise prescribed, in the standard *240-56227443 Requirements for Control and Power cables for Power Stations standard.*

The Contractor is to ensure that laying of cables underground cables is done in accordance with Eskom standard *240-56227443 Requirements for Control and Power cables for Power Stations standard.*

3.7 Low Voltage Switchgear Requirements

The Contractor is to ensure that the Low Voltage (LV) Switchgear shall comply with Eskom *Standard Specification: 240-56227516 Low-Voltage Switchgear and Control Gear Assemblies and Associated Equipment for Voltage up to and including 1000V and 1500V standard,* latest revision (arc compliance).

The *Contractor* is to ensure that all Miniature Circuit Breakers (MCB's) and earth leakage units are to be SANS approved.

3.8 Medium Voltage Switchgear Requirements

The Contractor to ensure that Medium Voltage shall comply with *Hawker Siddeley Switchgear Manual.*

3.9 Plant Coding and Labelling

Coding of the plant shall be based on the latest revision of 240-93576498 KKS Coding Standard and the Employer shall undertake the coding in line with its standards. The KKS coding shall be applied during the maintenance of the plant and cross referenced to all drawings, schematics, instructions and manuals. The Contractor shall be required to install missing KKS in plant.

The Employers KKS Standard shall be used to allocate codes to plant or system included in the Works. Plant Coding shall be undertaken by the employer as well as the following documentation to code:

Electrical

- Single line diagrams
- Electrical board general arrangements
- Cable schedule
- Cable block diagrams
- Logic diagrams

3.9.1 Plant Labelling

The Contractor shall also manufacture and install KKS labels to identified plant items as per list supplied by the Employer. Labels shall be manufactured and installed according to the Employer's KKS Plant Labelling and Equipment Descriptions Standard. The labelling standard shall be supplied as part of the enquiry documents.

3.10 Tender Evaluation Strategy

3.10.1 Technical Evaluation Threshold

Mandatory Technical Evaluation Criteria (gatekeepers) are 'must meet' criteria. These criteria shall not be weighted or point scored, but shall be assessed on a Yes/No basis as to whether or not the criteria are met unless set otherwise. An assessment of 'No' against any criterion shall technically disqualify the tenderer and shall not be further evaluated against Qualitative Criteria.

Qualitative Technical Evaluation Criteria are weighted evaluation criteria used to identify the highest technically ranked tenderer after determining that all the Mandatory Evaluation Criteria have been met. The Qualitative Evaluation Criteria are weighted to reflect the relevant importance of each criterion. The minimum weighted final score (threshold) required for a tender to be considered from a technical perspective is **80%**.

Evaluation will be done according to **Tender Engineering Evaluation Procedure *240-48929482***

4. Procedure for Submission and Acceptance of *Contractor*'s Design

4.1 Design Review Procedure

The *Contractor* is the Design Authority as defined in the Design Review Procedure (240-53113685). The *Contractor* is responsible for following this design procedure and conduct all the design reviews as specified in this procedure. The *Contractor* is responsible for conducting the following design reviews:

- Design Freeze Review
- Integrated Design Review
- Construction Completion Review
- Acceptance Testing Review

4.2 Engineering Change Procedure

The Contractor takes note of the Employer's Engineering Change Procedure (240-53114026).

Engineering changes includes any proposed change originating from engineering, contractors, project management or construction management.

The Engineering Change Procedure applies to the *Employer's* personnel or *Contractor's* performing engineering or engineering related work where the quality of the engineering work performed is the direct responsibility for the *Employer*

4.3 Process for Submission of Documents

The *Contractor* submits all documents according to the accepted VDSSs. The process for the submission of documents is described below:

- The *Contractor* submits the documents/drawings to the *Project Manager*.
- The *Employer's* Document Controller registers the documents.
- The *Employer's* Document Controller will supply the documents/drawings to all relevant parties within the *Employer's* project team.
- The *Employer's* project team reviews the documents/drawings and will submit all comments or inputs to the *Project Manager* and the *Project Manager* submits to the *Contractor* for consideration.
- If the *Employer* finds major deficiencies in the submitted documents/drawings, the *Contractor* revises the documents/drawings and resubmits to the *Project Manager*.
- The *Employer* reviews the documents/drawings and if no major deficiencies are found, the *Contractor* organises a Design Review session.
- The *Employer* and the *Contractor* conduct a Design Review.
- If any fundamental errors were found in the designs or further actions are required, the *Contractor* records all concerns raised and revises the designs.
- The *Contractor* organises a Design Review session once all designs were revised according to the concerns raised by the *Employer*.
- If no fundamental errors were found in the designs during the Design Review session, the *Contractor* compiles the Design Review minutes or report and submits it to the *Project Manager*.
- The *Employer's* Document Controller registers the report.
- The *Employer's* project team reviews the *Contractor's* report/minutes. If the report/minutes are not acceptable, the *Contractor* revises the report/minutes and resubmits to the *Project Manager*.
- The *Project Manager* will accept the *Contractor's* design once the report/minutes are accepted by the *Employer's* project team.

4.4 Time Required for Acceptance of Designs

Not later than one month after receipt, the Project Manager will return one copy of the drawing marked "Accepted"; "Accepted as Noted" or "Not Accepted", as may be appropriate. The notations "Accepted" and "Accepted as Noted" authorize the Contractor to proceed with the manufacture of the Plant covered by such drawings subject to the corrections, if any, indicated thereon. Where prints or drawings have been "Not Accepted" or "Accepted as Noted" the Contractor makes the necessary revisions on the drawings and submit further copies for acceptance in the same procedure as for the original submission of drawings. Every revision shows by number, date and subject in the revision block on the drawing.

4.5 Other Requirements of the *Contractor's* Design

4.5.1 Reliability and Availability

The *Contractor* performs RAM (Reliability, Availability and Maintainability) studies on the complete system in the *Works*, in accordance with the Employer's System RAM Analysis Guideline.

The *Contractor* submits as part of the detail design, the RAM study report of the full system to the *Project Manager* for acceptance.

The objectives of the studies are to achieve the following:

- An Availability factor of 99.9% per year for the complete SAS.
- A high Reliability factor of each subsystem of the complete SAS.
- Mitigation against known failures which could negatively impact the functionality and design objective of the SAS.
- Determining an Optimised Maintenance philosophy for the equipment making up the complete system.
- Performing redundancy studies on the systems.
- Using the above studies to optimise the system's spares holding.

4.5.1.1 FMEA (Failure Mode and Effect Analysis)

- The *Contractor* carries out formal Failure Mode and Effect Analysis (FMEA) studies on all systems in their supply and interfaces, to the respective systems in the *Works*. These studies are done in accordance with the requirements as defined in the Employer's FMEA Guideline.
- The *Contractor* submits as part of the detail design, the FMEA study report of the system to the *Project Manager and Engineer* for acceptance.
- The Contractor uses the FMEA study report to mitigate against failures which could negatively impact the functionality and design objective of the SAS.

4.5.1.2 Maintainability

- The *Contractor's* design provides redundancy so that the system can be maintained while online.

- The *Contractor's* design provides adequate space to allow for the respective maintenance regimes of the components or systems.
- The *Contractor's* design maximises the level of spare parts application, while minimising the spares inventory.
- The *Contractor's* design makes use of components that are readily available in South Africa.

4.5.1.3 Configuration Management

All documents supplied by the Contractor shall be subject to Eskom's approval. The language of all documentation shall be in English. All documentation shall be controlled and managed in accordance with Document and Records Management Procedure (32-6).

4.5.1.3.1 Document Identification

The Contractor is required to submit the Vendor Document Submission Schedule (VDSS) as per agreed dates to the delegated Eskom Representative. Eskom will pre-allocate document numbers on the VDSS and send back to the Contractor through the delegated Eskom Representative. The VDSS is revisable and changes must be discussed and agreed upon by all parties. Changes in the VDSS can be additional documentation to be submitted, changes in submission dates or corrections in documentation descriptions, document numbers, etc. The Contractor's VDSS shall indicate the format of documents to be submitted.

4.5.1.3.2 Document Submission

All project documents must be submitted to the delegated Eskom Representative with transmittal note according to Project / Plant Specific Technical Documents and Records Management Work Instruction (240-76992014). In order to portray a consistent image it is important that all documents used within the project follow the same standards of layout, style and formatting as described in the Work Instruction (240-76992014). The Contractor is required to submit documents as electronic and hard copies and both copies must be delivered to the Eskom Representative with a transmittal note.

In addition, the Contractor shall be provided with the following standards which must be adhered to:

- Project Plant Specific Technical Documents - Handover Works Instruction 240-124341168
- Project Documentation Deliverable Requirement Specification 240-65459834.
- Technical Documentation Classification and Designation Standard 240-54179170.
- Project/ Plant Specific Technical Documents and Records Management Work Instruction 240-76992014.

a. Electronic Submission (SharePoint Transmittal)

   Electronic submissions could be done using the SharePoint Transmittal Site functionality and route.

b. Bulk Submission

   For bulk document submission, the following link can be used https://zendto.eskom.co.za/

c. Emails and other submission methods

   Where applicable and contractually agreed, e-mail submissions can be used, as well as other submission methods employed in the relevant project e.g. Box; Norman Secure, etc.

4.5.1.3.3 Drawings Format and Layout

The creation, issuing and control of all Engineering Drawings will be in accordance to the latest revision of engineering drawing Standard 240-86973501. Drawings issued to Eskom will be a minimum of one hardcopy and an electronic copy that is editable. Contractor is required to natively draw and submit electronic drawings in Micro Station V8 (DGN) format, and scanned drawings in pdf format. No drawings in TIFF, AUTOCAD or any other electronic format will be accepted. Drawings issued to Eskom may not be "Right Protected" or encrypted. The Employer reserves the right to use these drawings to meet other contractual obligations. The Contractor shall include the Employer's drawing number in the drawing title block. Drawing numbers will be assigned by the Employer as drawings are developed.

4.5.2 As-built drawings, operating manuals and maintenance schedules

- The *Contractor* provides project documentation as per the *Employer's* VDSS (Refer to **Error! Reference source not found.**), to the *Project Manager* for acceptance. The VDSS details when the respective project documentation is required and in what format, for acceptance by the *Project Manager*.
- All project documentation, including reports, drawings and manuals, etc. are to be submitted in the English language.

4.5.2.1 Operating Manuals

- The *Contractor* provides operating manuals, developed by experienced *Contractor* personnel, for the operation of the designed system, in their supply of the *Works*. The operating manuals aim to assist the operators of the plant in the application and troubleshooting of the system.

4.5.2.2 Technical Manuals

- The *Contractor* provides technical manuals, developed by experienced *Contractor* engineering / technical personnel, for the operation of the designed system, in their supply of the *Works*.

  The technical manuals explain the details of the design and system, including detailed descriptions, AS BUILT drawings, diagrams, settings, parameters, logic diagrams and logic philosophies of the detail design. The technical manuals include troubleshooting guidelines.

4.5.2.3 Maintenance Manuals

- The *Contractor* provides a maintenance manual with respect to their supply of the *Works*, which documents the following: detailed maintenance plans, frequency of maintenance and replacement parts that are required during routine maintenance. The *Contractor* provides the life expectancy of the equipment and components and maintenance spares required, with respect to their supply of the *Works*.

4.5.2.4 Drawing requirements

- The *Contractor* develops and provides a drawing numbering system (drawing index) for the project, to the *Project Manager* for acceptance.
- The *Contractor* provides reproducible drawings in the required formats as per the Employer's VDSS (**Error! Reference source not found.**).
- The Contractor as a minimum provides the following dimensioned drawings, to the *Project Manager* for acceptance:

- General Arrangement Drawings
- Schematic drawings (showing the following as a minimum)
  - Detail Design
  - Device terminal numbers, terminal block numbers and terminal numbers.
  - All control and protection components
  - Power supply connections
  - Wiring numbers
- Single line diagrams

5. Safety Precautions

5.1 Health and Safety Plan (Construction Regulations)

Upon the award of the contract, successful *Contractor* must submit a Health and Safety Plan, filed in a Health and Safety File.

The Safety Officer employed by Kendal Power Station will audit these Health and Safety Plan to ensure compliance with the provisions of the Act. The approval of the health and safety plan can sometimes take 2 to 3 days to approve and ***NO WORK*** shall be conducted before the plan is approved. The *Contractor* has to consider this for their health and file costing.

a) The Contractor must work according to Kendal Power Station's site regulations and plant safety regulations.

b) The Contractor reports any unsafe conditions or practices to the Employer.

c) The Health and Safety Requirements to be met by contractors will be complied with at all times.

d) The **Life Saving Rules** will be applied to at all times:

- **Rule 1: Open, Isolate, Test, Earth, Bond and/or Insulate before Touch**
- **Rule 2: Hook up at heights**
- **Rule 3: Buckle up**
- **Rule 4: Be Sober**
- **Rule 5: Ensure that you have a Permit to Work**

6. Quality Assurance Requirements

The Contractor submits a quality control plans prior to commencing work. The quality control plans should cover inspections and test proposals for items or activities to be supplied in the contract. The quality control plan indicates the following:

a) The identification of the activity/operation

b) A list of sequence of operations including inspections and tests

c) The identification of the specification, drawing or procedure for each operation

d) The acceptance criteria with reference to the appropriate technical specification set out by the Contractor

e) The inspections and test the Contractor has nominated for hold and witness points

f) Provision for inspections and tests nominated by the Employer, and /or his representative

g) Inspection and test records which are generated by the Contractor

The *Contractor* is also responsible for the following:

a) The Contractor notifies the Employer of any changes to the quality system and obtains agreement prior to the implementation on the existing orders and contracts or sub orders and contracts.

b) Identifies any additional documents which are to be submitted to the Employer

c) Indicates the interface with the Contractor's quality system and applicable documents such as procedures and work instructions

d) In case a Sub-Contractor is employed, the Contractor indicates how they will be monitored.

The Contractor and/or Sub-Contractors give access to the Employer or his representative where appropriate to their premises and facilities at reasonable times to conduct quality assessments, audits, surveillances, and inspections to establish compliance with the contractual requirements

7. Environmental Requirements

Kendal Power Station is ISO 14001 compliant. The Contractor must comply with the requirements of this procedure titled: Environmental Management System Requirement for the Contractors number PG/240/008.

Kendal also has an SHEQ Policy PS/270/0083, to which every Contractor and employees must adhere. It is therefore the responsibility of the Contractor to ensure that the Contractor obtains copies of Kendal SHEQ Policy. The Contractor must identify all Environmental aspects and impacts related to his/her activities. The Contractor must have copy of the legal register related to the scope.

Kendal procedures applicable to the Contractor's area of responsibility to assist the Contractor and his/her employees to prevent pollution and comply with legislative requirements, and to familiarize themselves on such procedures, within 30 days from the date of commencement of work at Kendal. Copies of the above-mentioned documents shall be obtained from the Eskom Agent and/or Environmental Officer on the first day prior to commencement of work at Kendal.

The Contractor shall submit a proof to the Environmental Officer of Kendal that he and his employees has done all the necessary training on procedures and Policies supplied to them and that they do understand the contents of the procedures, registers and policies and will adhere to them at all times.

The non-adherence to the rules will result in a non-conformance, hence immediate termination of the contract.

Rules are as following:

a) Provide sufficient storage containers, labelled depicting general or hazardous waste and store in a designated storage area.

b) Ensure that all hazardous waste is disposed of at a licensed site. A copy of the hazardous waste disposal certificate must be submitted to the Employer Representative.

c) Ensure that all other general waste is disposed of at the licensed landfill site.

Ensure that your site does comply with the general good housekeeping practices

The contractor/Maintenance must comply with the following requirements.

a) Environmental Management System (ISO 14001:2015)

b) National Environmental Management Act (Act 107 of 1998)

c) Environmental Management Procedure for Contractors (*1018332)

d) Waste Management Procedure (*1024102)

e) Non-conformance, Corrective and Preventative Action (*1017357)

7.1 Refuse Disposal

The Contractor is responsible to keep the work area clean of any rubble.

All waste introduced and/or produced on the Employer's premises by the Contractor for this contract, is handled in accordance with the minimum requirements for the Handling and Disposal of Hazardous Waste in terms of Government Legislation as proclaimed by the latest National Environmental acts and regulations. The removal of any waste and hazardous waste is the responsibility of the Contractor.

8. Site Services and Facilities

8.1 Supply of Electricity

All points of supply requested by the *Contractor* are provided in terms of quantity and location at the discretion of the *Electrical Engineering Department*.

There is no energy charge for electricity used for construction purposes.

No connection is made to the permanent installation at the Power Station without the prior acceptance of the *Electrical Engineering Department*.

No guarantees of power supply quality are given and power supply breaks of some duration may occur without warning. Planned outages are also a possibility. The *Contractor* makes arrangements at his own expense to improve continuity and quality of power supply where necessary for any reason and no claim of any nature relating to power failures is considered.

8.2 Roads

Main access roads are surfaced and complete and may be used by the *Contractor* with the necessary care. The *Employer* maintains the Site roads, described above, to a fair condition. Any costs incurred by the *Project Manager* from damage caused to underground services, structures, etc. as a result of the *Contractor* not using the prescribed routes is recovered from the *Contractor*.

8.3 Evacuation, First Aid and Fire Fighting

The *Contractor* must have a trained First Aid and Fire Fighter, in case of emergencies.

8.4 Sanitary Facilities

The *Contractor* and personnel uses the *Employer's* sanitary facilities as directed by the *Project Manager*.

9. General

The Contractor shall ensure that there are at all times sufficient suitably qualified, experienced, and skilled staff available to carry out and supervise all the activities.

This contract and all information associated with its management is confidential and may not be divulged beyond the provisions stated within the contract. Should the Contractor violate this condition, the Employer may terminate this contract forthwith and nullifying any outstanding or further claims by the Contractor.

Neither the Contractor nor the key persons may have any interest, pecuniary, material or otherwise in any work arising from, impacting, or influencing the Contractor's ability to impartially fulfil the Scope of this contract, be it of a service or supply nature. The Contractor and the key persons are to declare any interest, pecuniary, material or otherwise, in any tender, offer or quotation to the Contracts Service Manager for any other work, supply or service, to the Employer's Agent at the time when such tender, offer or quotation is submitted. The Contracts Service Manager's interpretation of a situation shall apply where there is a conflict.

10. Authorisation

This document has been seen and accepted by:

Name & Surname	Designation
Msingathi Tose	Kendal Electrical Engineer
Remember Sigawuke	Kendal Electrical Engineering Manager
Ayanda Mahlobo	Kendal Electrical Engineer
Mooiman Phetla	Kendal Electrical Engineer
Philasande Zwane	Kendal Electrical Engineer
Mhlengi Phiri	Kendal Senior Technician (PTM)
Nonhlanhla Khumalo	Kendal Acting Engineering Manager
Thumeka Mbatha	Kendal Electrical Engineer
Dayalan Govender	Kendal Senior Electrical Engineer

11. Revisions

Date	Rev.	Compiler	Remarks
June 2022	0	N Mkhize	Technical Specification for SCADA Replacement

12. Development Team

The following people were involved in the development of this document:

- Nathi Mkhize

13. Acknowledgements

- N/A