Eskom	Specification	Technology

Title: **Duvha High Frequency Power Supply Roll-out to Units 4 and 6 Electrostatic Precipitators Technical Specification**	
Unique Identifier:	**382-ECM-AABZ28-D00017-11**
Alternative Reference Number:	**N/A**
Area of Applicability:	**Engineering**
Documentation Type:	**Technical Specification**
Revision	**2**
Total Pages	**59**
Next Review Date:	**N/A**
Disclosure Classification:	CONTROLLED DISCLOSURE

Compiled by	**Functional Responsibility**	**Authorised by**
Rishon Burger	**Riana Nieuwoudt**	**Sandile Peta**
EDWL: Boiler Auxiliary CoE	**Senior Engineer Particulates Control**	**Boiler Auxiliary Manager (Acting)**
Date: 15/10/2019	Date: 25/10/2019	Date: 25/10/2019

	Supported by	**Supported by**
	Saneshan Govender	**Dr Titus Mathe**
	General Manager – Plant Engineering (Acting)	**General Manager – Group Technology**
	Date: 25/10/2019	Date: 31/10/2019

CONTENTS

Page

TABLES

FIGURES

1 DESCRIPTION OF THE *WORKS*

1.1 EXECUTIVE OVERVIEW

A pilot project was initiated on the electrostatic precipitators (ESPs) on unit 5 at Duvha Power Station to test the effectiveness of high frequency power supply (HFPS) technology on the ESPs. The *Employer* has decided to roll out the technology to units 4 and 6.

Duvha Power Station is located near Emalahleni in Mpumalanga. Duvha Power Station is a 6x600 MW power station equipped with a 5 field, two casing Lurgi ESP design.

The Contractor is required to replace the first three (3) fields of conventional rectifier transformers (50 Hz) on each gas path of each of units 4 and 6 (total of 24 power supplies) with HFPSs that operates at 20000 Hz (20kHz) or above including the provision of HFPS controllers, new PPMS and PPMS interface to the unit control system. Refer to Figure 1 for the ESP plant configuration.

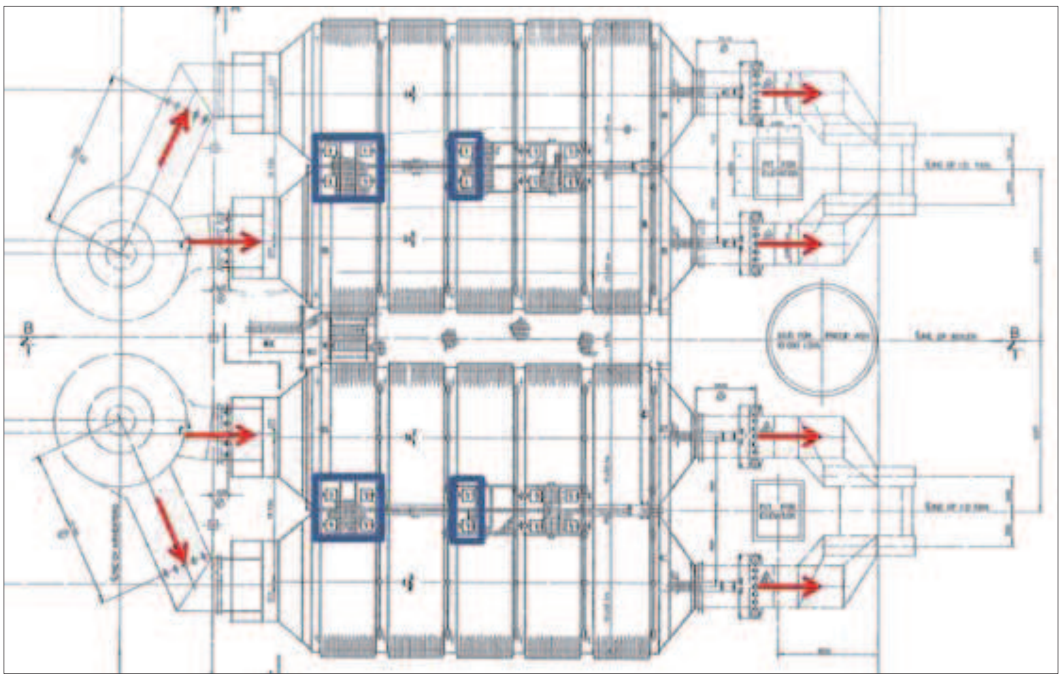

Figure 1: HFPS position layout

The *Contractor* interfaces with *Others* during outage scope of work. ESP internal maintenance will be performed by *Others* during the outage.

The *Contractor* carries out all activities and supplies everything necessary to provide the *Works* in accordance with the requirements of this specification. It is the responsibility of the *Contractor* throughout the execution of the different contract activities to bring to the attention of the *Employer* of any reasonably foreseen and known risks that could impact on the completion of the *Works* and recommend cost effective changes and obtain acceptance from the *Employer*.

The *Works* include the engineering, design, manufacturing, factory acceptance testing, site support, documentation, site delivery, installation, commissioning, optimisation and performance testing of HFPSs at Duvha Power Station as per the *Works*.

The *Contractor* optimises all 5 fields in each of the 4 gas paths within each of the ESPs units. As a minimum the optimisation includes:

- Electrical optimisation of the controllers,
- Optimisation of the rapping system (full power rapping, power-off rapping, reduce power rapping, clean system rapping, incremental rapping, automatic test rapping, start-up and shut down rapping),
- Optimisation using pulsing only and
- Optimised setting for when the SO_3 plant is out of service.

The *Contractor* ensures that the HFPS controllers are interfaced and integrated with the new Precipitator Plant Management System (PPMS) to enable control and operation from the PPMS. A new Precipitator Management System is provided as part of the *Works*. The Contractor also interfaces the new PPMS to the plant control system existing on units 6, 5 and 4.

The *Contractor* further performs all Civil and Structural work related to the installation.

1.2 *EMPLOYER'*S OBJECTIVES AND PURPOSE OF THE *WORKS*

The objective of this project is the roll out of HFPS technology to units 4 and 6 in order to ensure sustainable compliance with emissions legislation.

1.3 INTERPRETATION AND TERMINOLOGY

The following definitions are used in this document:

Description	Meaning
Available	It is the when a system, component or equipment is in the up state, i.e. able to perform as required.
Communication Network	Refers to the communication layers of the PPMS system; this being the control system equipment used for inter-controller communication, operator system communication, engineering system communication and communication between EPS fields. The communication network is inclusive of network switches, network cables, network infrastructure (patch panels, network trunking, splice boxes, etc.).
Engineering System	Refers to the engineering & diagnostic layer of the PPMS; this being the control system equipment via which engineers and technicians configure, maintain and troubleshoot the electrostatic system itself. The engineering system is inclusive of the

Description	Meaning
	engineering workstations, portions of the communication network and portions of the PPMS servers.
Engineering Software	It is the software through which engineers and technicians configure, maintain and troubleshoot the electrostatic system. It is inclusive of all diagnostic, maintenance, configuration and engineering software of the PPMS system. It includes the application engineering software, hardware engineering software, and any software used in the design of the PPMS system.
Engineering Workstation	It is the computer via which the engineering software is accessed. It is the primary interface of plant engineers and technicians.
Operator Software	It is the software through which the plant operator monitors and operates the precipitator plant. The term is used interchangeably with human machine interface (HMI). See also the definition of HMI.
Factory Acceptance Testing (FAT)	It is an activity that demonstrates that the HFPS controllers, PPMS system and their interfaces complies with its specification(s).
Failure	It is the loss of ability of a system, component or equipment to perform as required.
Mimic	It is a graphical representation of the precipitator plant. It contains dynamic and static elements that visually depict the configuration and status of equipment in the precipitator plant.

Table 1: Definitions

The following abbreviations are used in this document:

Abbreviation	Description
AIA	Appointed Inspection Authority
AKZ	Anlagenkennzeichnungs – system, Specification for labelling Power Station
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing Materials
C&I	Control and Instrumentation
CE	Collecting Electrode

Abbreviation	Description
COC	Certificate of Compliance
DC	Direct Current
DCS	Distributed Control System
DSP	Digital Signal Processing
DE	Discharge Electrode
DHP	Dust Handling Plant
ESP	Electrostatic Precipitator
FAT	Factory Acceptance Test
GO	General Overhaul
GTE	Group Technology Engineering
HF	High Frequency
HFPS	High Frequency Power Supply
HMI	Human Machine Interface
HV	High Voltage
Hz	Hertz
IEC	International Electro Technical Commission
IO	Input Output
IP	Ingress Protection
Ip	Primary Current
Is	Secondary Current
ITP	Inspection and Test Plan
kV	Kilo Volt
LOSS	Limits of Supply and Services
LV	Low Voltage
mA	milliampere
MCR	Maximum Continuous Rating
MCS II	Microcontroller Control System Version 2
MTBF	Mean time before failures
MTTD	Mean time to detection
MTTR	Mean time to repair
NCR	Non Conformance Report
NDE	Non Destructive Examination
NFPA	National Fire Protection Association

Abbreviation	Description
OEM	Original Equipment Manufacturer
O&M	Operating and Maintenance
OHS Act	Occupational Health and Safety Act
ONAF	Oil Natural Air Forced
OTDR	Optical Time Domain Reflectometer/f
P&ID	Process and Instrumentation Diagram
PLC	Programmable Logic Controller
PPM	Parts Per Million
PPMS	Precipitator Plant Management System
RT&D	Research, Testing and Development
TR	Transformer Rectifier
VDSS	Vendor Documents Submission Schedule
VI	Voltage Current
Vp	Primary Voltage
Vs	Secondary Voltage
WBS	Work Breakdown Structure

Table 2: Abbreviations

2 TRAINING

2.1 TRAINING WORKSHOPS AND TECHNOLOGY TRANSFER

The *Contractor* provides training to the *Employer* with regards to the operation; maintenance and engineering for the Works. On the job training takes place during installation and classroom training takes place after each unit is commissioned and optimised. The Contractor provides all required training material and training facilities. Training must be provided, by the *Contractor*, with regards to the following areas:

- Operating 8
- Engineering 12
- Maintenance 6

On the job training is available for the time the product is under guarantee.

The *Contractor* provides the training material for acceptance of the *Employer* before the training takes place.

3 ENGINEERING AND THE *CONTRACTOR'S* DESIGN

3.1 GENERAL

The *Works* include the replacement of 12 rectifier transformers with HFPSs in the first 3 fields of each of the ESPs on units 4 and 6 at Duvha Power Station. It also includes the provision of new PPMS and interfaces to power plant control system for unit 6, 5, and 4 as well as PPMS interface to ESP fields for unit 6, 5 and 4.

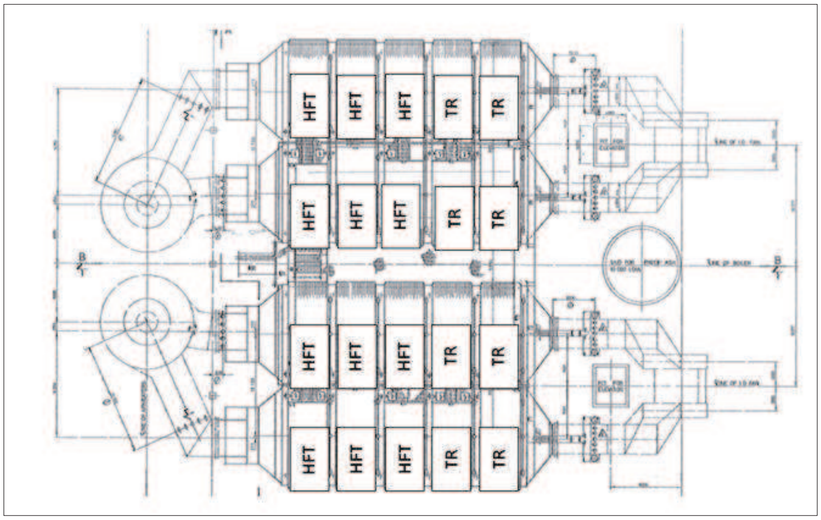

Figure 2: HFPS layout the ESP roof

The *Contractor* modifies the MSC II control panel under a permit system, to an HFPS ready state to enable on-load installation of HFPSs. This includes modifications to the MSC II control panels to install the 3rd phase drop-down bus-bar (of the same size as per the existing two operating phases) and provides additional terminals in the substation and installation of hard points on the ESP roof to provide for the new footprint of the second field if required.

As a tender returnable the *Contractor* brings to the attention of the *Employer* any other modifications required to enable an on-load installation.

The *Contractor* submits a detailed outage plan for acceptance to the *Employer as part of the tender returnable.*

The Contractor interfaces with *Others* performing work on the unit simultaneously as and when necessary.

The *Contractor* installs the HFPSs on-load and submits a detailed installation methodology, including removal of the old transformers, for acceptance to the *Employer.* During an on-load installation the boiler unit remains on load. Only the ESP field being worked on together with the fields up-stream of that are switched off and isolated electrically. This includes the use of a portable earth for possible static discharge from the HV supply rod. The *Contractor* starts with the last field that will be retrofitted and works to the front from there. This is to allow for safe commissioning of the completed section of the installation while the upstream fields are being retrofitted.

The *Contractor* disconnects and removes the existing transformers to a location on site identified by the *Employer*. The *Contractor* interfaces with the *Employer* to perform this task after the relevant field *is* isolated.

The *Contractor* uses a mobile crane or the existing crawl beams to lift and lower the existing transformers from the roof and lift the HFPSs to the roof. The crawl beams are assessed, load tested, and modified if required, by the *Contractor*.

The *Contractor* installs the HFPSs within the existing transformer footprint on the ESP roof as far as is reasonably practicable.

The *Contractor* supplies updated drawings of all modifications in as-designed as well as as-built format. This includes as a minimum all modifications to the switchgear, MCS II control panels, the HT ducting of the transformer, any new support structures, and the modifications to the existing crawl beams.

The *Contractor* provides technical support within 24 hours after a reported fault/failure within the defects period.

The *Contractor* indicates the frequency of scheduled maintenance on the HFPSs and their cooling systems and provides annual cost projections thereof. In addition the *Contractor* indicates the availability and lead times of all spares locally or foreign.

3.2 *EMPLOYER'S* DESIGN

3.2.1 Duvha Power Station ESP Operating and Current design data

The existing particulate emission control plants at Duvha Power Station units 4 to 6 are of the Lurgi design. They are located outside the boiler house. The ESP plant for each unit consists of 2 parallel casings, each having 2 gas passes without any division walls. Each pass has 5 electrical fields in series. CE rapping is done on 12 m level and DE rapping is done from the roofs of each casing. Per casing there is one CE rapping motor for two adjacent fields, and one DE rapping motor for two adjacent fields.

	Units	
Parallel casings	#	2
Plate height	m	13.75
Plate width	m	0.5
No. of Plates in a curtain	#	11
Plates curtain width	m	5.5
Gas passages per field	#	88
Pitch between gas passages in a field	mm	300
Fields in series per gas pass:	#	5
Plate area (total)	m^2	133100
Flow area (total)	m^2	726

Table 3: ESP design data

	Units	Guarantee	Worst Coal
Gas volume flow rate	m^3/s	995	1035
Gas temperature	°C	130	132
Dust burden	g/m^3	15.9	29.96

	Units	Guarantee	Worst Coal
Carbon in dust	%	2-3	2-3
Pressure drop	kPa	0.23	0.26
Temperature drop	°C	8	8
Treatment time	s	20.1	19.3
Migration velocity (Deutsch)	mm/s	39.0	40.4
Migration velocity (modified Deutsch, k=0.5)	mm/s	215.3	222.0
Gas velocity at electrodes	m/s	1.4	1.4

Table 4: Original design operating data at 97% MCR

	Unit	Worst
Gas volume flow rate (actual)	m^3/s	1363.02
Gas temperature	°C	158.5
Dust burden	g/m^3	30
Oxygen @STP	%	6
Moisture (min) @STP	%	7

Table 5: Existing operating conditions

Parameter	Units	Design Basis
GCV	MJ/kg AR	19.1
Ash	% MF	29.17
Volatiles	% MF	21.14
Sulphur	% MF	0.99
Nitrogen	% MF	1.77
Total Moisture	% AR	9
Inherent Moisture	% AD	3

Table 6: Expected coal qualities

The typical SO_3 injection rate is 51 kg/h or approximately 20.5 ppm.

3.2.2 ELECTRICAL

3.2.2.1 Electrical System Reticulation

The existing 11kV Unit Boards are manufactured by ABB and the model is called UNIGEAR SA. These boards are rated 32.06kA for 2seconds and the main busbars rating is currently 2000A with the main incomers also 2000A. The 11/0.4kV Precipitator Transformers A and B are currently being supplied from the 11kV Unit Board A and 11kV Unit Board B respectively.

The 400V Precipitator Board A and B are fed from the Precipitator Transformers (1250kVA) A and B respectively. The following switchgear schedules indicating the load list for U4 and U6 Precipitator Boards are as follows:

- 0.57/62878 : 380V Precipitator Board 4A
- 0.57/62876 : 380V Precipitator Board 4B
- 0.57/62908 : 380V Precipitator Board 6B
- 0.57/62906 : 380V Precipitator Board 6A

The electrical outside battery limits for Duvha HFPS retrofit project are as depicted in Figure 3 below.

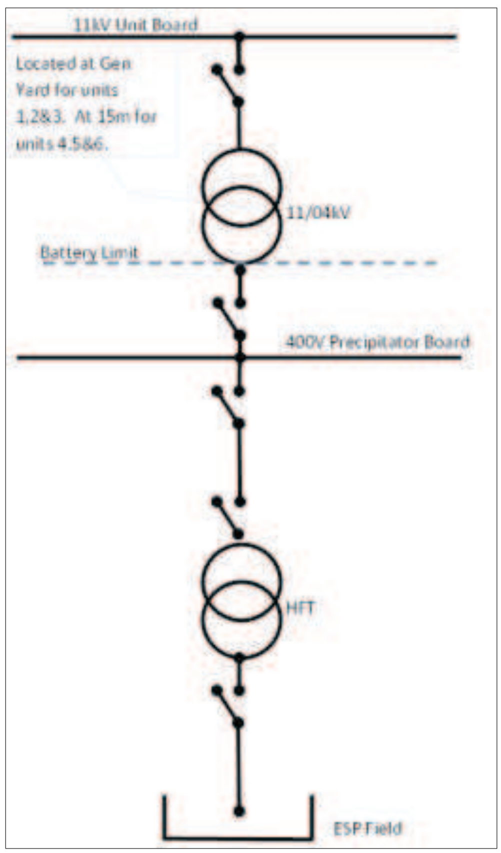

Figure 3: Electrical interface point

3.2.2.2 400V Precipitator Board modifications

The 400V Precipitator Board A & B for U6 and U4 are to be retrofitted to support the rollout for HFPS Project at Duvha Power Station. Retrofit is for the first 3 field circuits for the whole Precipitator. The operation of the conventional Transformer Rectifier (TR) uses only 2-phase primary power supply, hence 1-phase of the 3-phase circuit is currently not utilised. If not already done the *Employer* modifies Unit 4 & 6 first 3 Precipitator field feeder circuits powering the conventional Transformer Rectifier (TR) from the 400V Precipitator Boards A & B. The *Employer* modification scope of work on the 400V Precipitator Board A & B includes the following:

- Supply and install a drop-down flexible cable (of the same size as per the existing two operating phases i.e. 95 mm^2 x 2 connected in parallel) for the 3rd phase to be connected on the unused bus-bar.
- Drill adequately sized holes (similar to the holes on the existing two phase bus-bar) to connect the drop-down cables.
- Terminate the drop-down cables on the incoming terminals of the existing Moulded Case Circuit Breaker.
- Correct lug sizes shall be used on the cables with adequate crimping.
- Correct torque setting on the bolts shall be applied.
- Perform Ductor test on each phase of the bus-bars after termination of the drop-down cables.
- Colour coding and cable wiring to be addressed as per Eskom Standard.

An opportunity or readiness outage for the electrical work discussed above will be granted before the main installation in order to save time on the main installation.

The *Employer* provides schematic drawings of the modification done on the stated feeder circuits.

3.2.3 CONTROL & INSTRUMENTATION

The existing plant unit control system is the Siemens Teleperm C/Iskamatic B on units 5 and 4, and the Siemens T3000 on unit 6. The precipitator plant functions independent of the unit control system as it is equipped with a standalone Precipitator Plant Management System (PPMS) SCADA system for operation, monitoring, control, configuration, data storage and alarming purposes of the electrostatic precipitator plants. Refurbishment of units 5 and 4 to similar technology as unit 6 is planned and will be a separate project to the HFPS project.

The high level control architecture of the electrostatic precipitator plant control system of units 5 & 4 and unit 6 is depicted in figures 4 and 5 respectively below and consists primarily of the MCS II controllers (unit 5 also includes HFPS technology of controllers) and PPMS.

The PPMS provides for Human Machine Interface to the precipitator MCS II field controllers and allows for the remote engineering and configuration, operation, control, monitoring, alarming, data storage and historical trending of the precipitator plants. The PPMS is an Ethernet network consisting of the communication network layer comprised of APPLICOM Gateway and associated network infrastructure such as network switches and media converters, as well as the application system layer comprised of ClearSCADA SCADA system of Server and Client and provides for Engineering and Operator interface to the precipitator field controllers.

Unit 5 has been fitted with HFP's in the first three fields during which the communication gateway has been changed from APPLICOM gateway to the Sixnet IPM PLC. Furthermore the local display of the HFPS units have been removed from the ESP roof and mounted in the respective ESP field MCSII panel in the ESP substation. The communication protocol between the gateway and the SCADA server is Modbus TCP for all three units.

The PPMS SCADA consists of a single server located in the server room situated in the 2nd floor of the station admin building and the individual clients are located in the control room of each unit.

The SCADA system is based on object data base and as a result changes to symbols, mimics and other objects can be made online and into effect without the need for compiling and restarting. Five special functions are available from the PPMS SCADA system and include automatic start-up and shut-down, automatic programme selection, power off raping and high hopper level protection.

The MCS II controller is a microprocessor based controller that regulates the voltage and current supply of the rectifier transformer for optimal performance of the respective electrostatic precipitator fields. In addition to regulating power supply, the MCS II controller also performs rapper control of the respective electrostatic precipitator fields.

The MCS II controllers work on the CAN protocol and are integrated to form a network of CAN bus connected to the CANOpener which converts the CAN protocol to Modbus. The CANOpener then connects to the APPLICOM Gateway/IPM which serves as communication gateway between the PPMS server and the ESP controllers via Modbus.

Also forming part of the PPMS network is an S7 precipitator PLC, Ethernet remote IO modules, and SO3 plant PLC systems all connected via network switch. The S7 precipitator PLC acquires rapper motor current analogue signals and DHP binary level measurements on units 5 and 4. Whereas on unit 6 the precipitator PLC only acquires precipitator current and the hopper levels are acquired by the DCS and fed to the PPMS by the PPMS and DCS bus interface. The DHP binary level measurements have currently not been commissioned and shall form part of the scope of the project.

The remote IO modules are for acquiring the unit specific operating parameters for the special electrostatic precipitator plant operating functions. The remote IO modules have been decommissioned for unit 6 and the unit specific signals are acquired directly from the DCS. The connection to the SO3 PLC is to relay SO3 injection rates to the PPMS for optimum performance of the precipitator plant.

The S7 precipitator PLC, APPLICOM Gateway, media converters and network switch are all located in the PPMS PLC panel. The PPMS PLC panel together with the MCS II controller panels are all situated in the left hand precipitator substation of each of the three units.

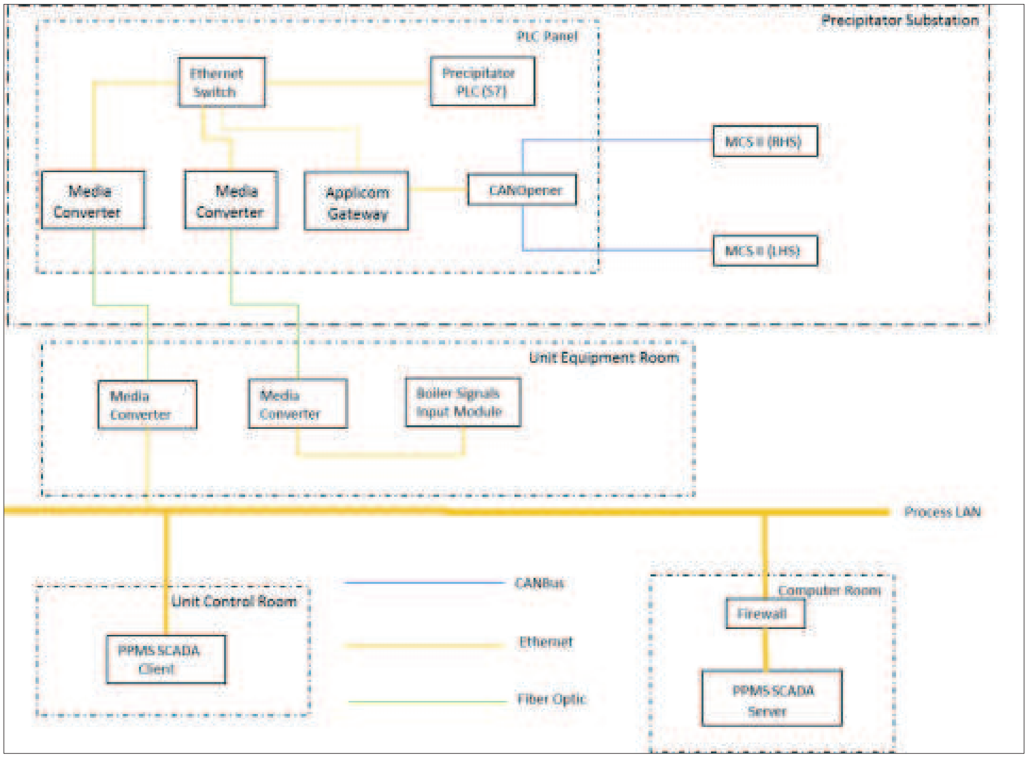

Figure 4: Depicting ESP control system architecture for unit 4 and 5

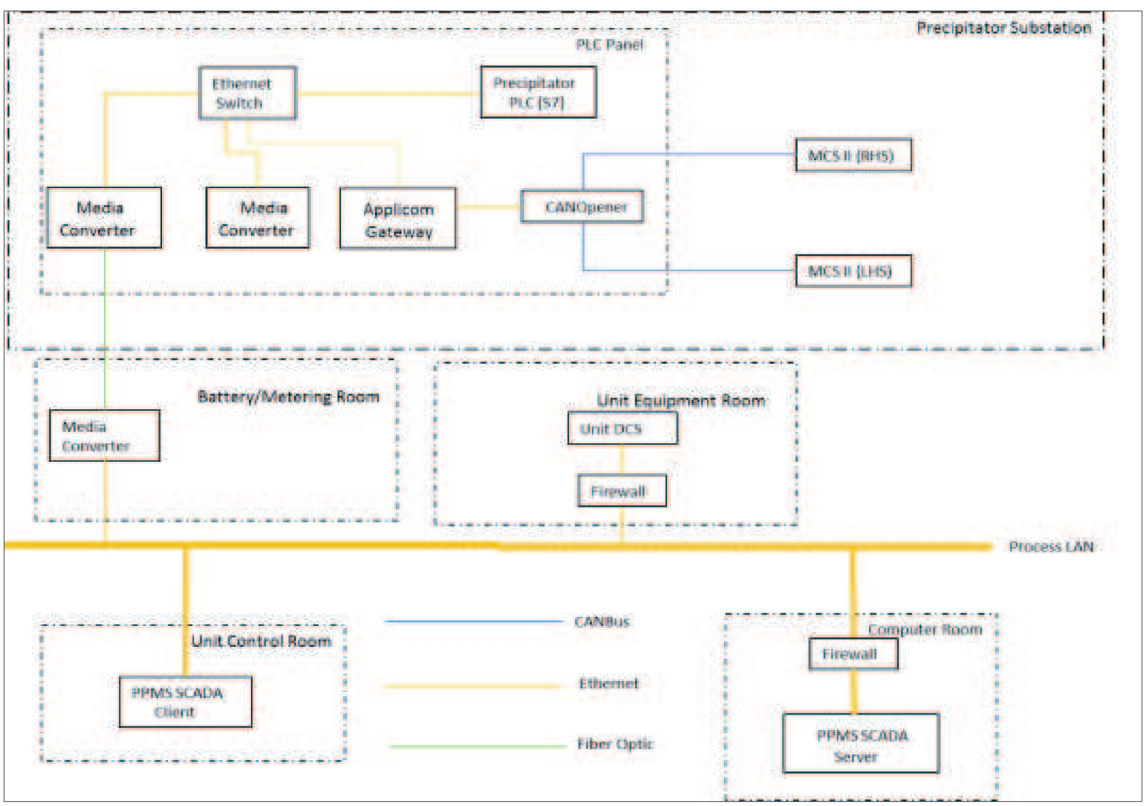

Figure 5: Depicting the ESP control architecture for unit 6

3.3 PARTS OF THE *WORKS* WHICH THE *CONTRACTOR* IS TO DESIGN

The *Contractor* provides the most suitable design for the intended HFPS installation. The aim is to get the ESP in a HFPS ready state during an outage to be able to do on-load installation/replacement of the existing transformers with HFPSs.

The *Contractor* designs and installs a new key interlock safety system to enable on-load isolation of a single transformer on all 5 fields per ESP.

The *Contractor* designs earth switches on the HV side of the transformer to be used during on-load isolation. The earth switches are installed on the first 3 fields where the HFPSs are installed. The earth switches interface with the new key interlocking system to allow for on-load transformer replacement.

The *Contractor's* design includes the complete engineering and design to enable on-load isolation and installation of HFPSs with associated equipment and control devices.

3.3.1 Responsibility for Design

1. The *Contractor* is the design authority.
2. The *Contractor* is responsible for the design of all temporary works required for the execution of the *works*.
3. All designs, design reports and construction drawings prepared by the *Contractor* are authorised by an ECSA professionally registered Technologist or Engineer as applicable.
4. The *Contractor* is mandated in terms of Construction Regulations 2014: Duties of Designer, 6(1) g to fulfil the duties described therein for the detailed designs done by the *Contractor*.
5. The *Contractor's* design is in accordance with all National Standards and Specifications as well as the *Employer's* Standards referenced in this Works Information.
6. The *Contractor* is responsible for construction monitoring at the level required to certify that the works have been constructed in accordance with the *Contractor's* design.

3.3.2 Deviations

Should the *Contractor* not comply with any section of this specification and an alternative is offered by the *Contractor*, the alternative shall be clearly stipulated in the Deviation Schedule provided. This is to form part of the tender returnables.

3.3.3 Mechanical design

The *Contractor* designs and supplies all modifications required to install the HFPSs and associated equipment within the existing transformer footprint on the ESP roof or as close as is possible. See Figure 66.

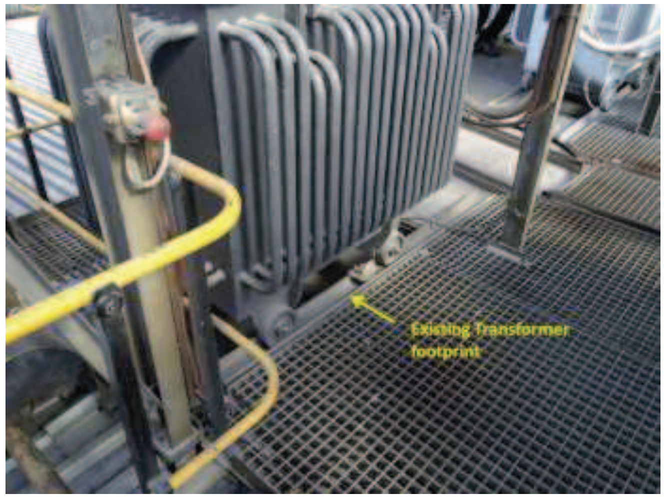

Figure 6: Existing transformer footprint

The *Contractor* installs a duct that connects to the HFPS earth switch and the HV flange on the ESP roof. See Figure 77.

The *Contractor* connects the earth switch to the station earth. The earth switch conforms to the *Employer's* earthing standard.

Figure 7: Existing HV ducting configuration

The *Contractor* verifies whether the flange on the roof, connecting to the HV ducting, has sufficient diameter to prevent arcing in this area. If the diameter is not sufficient the flange diameter is changed or a feedthrough insulator is installed by the *Contractor* in this area. Figure 8 below shows the approximate dimensions of the existing HV ducting. The *Contractor* verifies these dimensions.

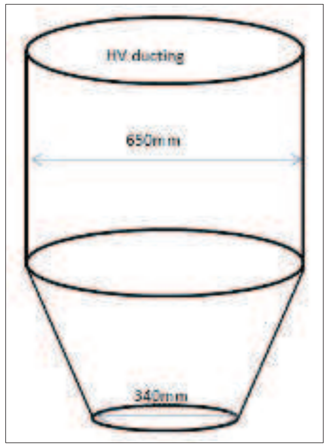

Figure 8: HV ducting dimensions

The employer will do electrical work on the LV panels to convert it to 3-phase. During this outage and before the main installation the *Contractor* inspects the plant in order to verify the sizing and integrity of the electrical connections between the TR sets and the discharge electrodes. This is to ensure that the eventual on-load installation of the HFPSs can be done without requiring access to the hot boxes below the roof for work on the said connections. No access for such work can be granted while the unit is on load. After this opportunity or readiness outage the unit is returned to service with the conventional TR sets still in operation.

The mechanical interfacing point for the HFPS installation is the flange on the ESP roof as indicated in Figure 7 and the existing transformer footprint shown in Figure 6. Field 2 HFPSs will have a new footprint on the opposite side of the existing location. Hard points need to be installed during the outage to accommodate the new platforms on field 2.

The HFPSs will be installed such that it can be moved to directly below the crawl beam for maintenance purposes. A spreader beam, lifting tackle, tracks or any other equipment necessary to move the HFPSs for lifting by the existing crawl beams, are supplied as part of this *Works.* A rigging procedure to remove the HFPS's down to ground level as well as to move the HFPS's from ground level to its final position using the crawl beam is provided by the *Contractor*.

The *Contractor* supplies the *Employer* with welding procedures and welding qualifications for any welding done while performing the *Works* as per the *Employers* welding standards.

Scheduled maintenance intervals coincide with and are not shorter than the *Employers* existing 18 months outage cycle. The Contractor submits the Life Cycle Costing for the individual HFPS components, consisting of all the related activities, and the intervals and costing thereof. This is to include the cooling system as well, if applicable, in accordance with the maintenance requirements.

The *Contractor* is aware of the discharge electrode rapping system shaft and take this into consideration for the transformer platform to clear these shafts sufficiently.

The transformer can withstand strong wind and extreme heat in summer times on the transformer. Weather protection canopies are installed over the HFPS units to protect against direct sunlight. It needs to be removable in the case where the HFPS unit needs to be removed from the roof.

The *Contractor* paints the HV ducting, both inside and outside, according to ISO 12944:1998.

The HFPS casing which houses power electronics and control instrumentation has a rating of IP65 or higher.

3.3.4 Electrical design requirements

The existing transformer specification is as follows:

Power Rating			
Secondary		Primary	
70kVP	1370mAM	380V	252A

Table 7: TR set rating

The existing transformers are rated to supply 270.4μA/m^2 to the field. It is the *Contractors* responsibility to design and provide a single adequately sized HFPS unit per field for the application at Duvha Power Station that has as a minimum the following secondary output rating:

kV	mA
80	1900

Table 8: Minimum requirements for HFPS

The minimum method of cooling employed is Oil Natural Air Natural (ONAN) taking site altitude and temperature rise into consideration. Based on the applicable ambient and environmental conditions ONWF (Oil Natural Water Forced) cooling is not preferred. High Frequency is defined as operating at 20 kHz or above on the secondary side.

The *Contractor* supplies a three-phase HFPS that shall result in the ESP efficiency improvement and yield an overall optimal output. The scope includes but is not limited to replacing the first 3 fields' conventional Transformer Rectifiers with the HFPSs on both casings per unit.

It is not the intent of this project to change the existing electrical power reticulation including the power supply configuration as much as possible.

- The expectation is that the 1250kVA Precipitator Transformer must be adequate for the installation of HFPS on the first 3 fields.
- The Contractor notifies the Employer by means of a power reticulation study whether the 1250kVA Precipitator Transformer is adequate to accommodate HFPS on the remaining fields to allow the Employer to make the necessary arrangements to accommodate HFPS's at a later stage on the remaining fields.
- The Contractor verifies the phase balancing on the remaining fields that are fitted with Rectifier Transformers after installation of the HFPS on the first 3 fields.

The new HFPS shall be adequately designed to operate optimally under the following abnormal conditions.

- Continuous primary voltage overloading at 110% of the transformer design
- Ambient temperatures of up to 50°C in full sun on top of precipitator roof
- Dusty environment > 1200 mg/m^2 per day

The Contractor ensures that the HFPS comply with IEC standards and the Employers relevant standards where applicable and are tested in accordance with the provisions of this specification.

The HFPSs shall have the capability to have the secondary side opened while being energized. The *Contractor* shall provide a procedure for this.

The *Contractor* shall supply the *Employer* with all the protection requirements for the HFPSs. These requirements shall comply with the *Employers* protection philosophy 240-56357424.

3.3.4.1 MCS II Control Panel requirements

The Contractor decommissions and retrofits the MCS II control panel on the first three fields of each ESP. The Contractor selects a correctly rated HFPS to optimise the ESP performance and selects, supplies and installs appropriately rated fuses at the MCS II control panel. The Contractor also installs additional required terminal for allowing the third phase termination. The Contractor is responsible for labelling the MCS II control panel accordingly.

The Contractor removes the thyristor bank set with all associated equipment (i.e. controller, relays, etc.) and retains the fuse carrier with new rated fuse only for the first 3 fields on all casings per unit. All aluminium bars are replaced with properly rated flexible conductors to the panel terminal strip. The MCS II control panels shall be in a serviced condition with doors lockable and panel earthed appropriately.

The Contractor shall be responsible to developing “As built” drawings depicting the plant (MCS II control panel, etc.) and this shall be as per the plant at any point of installation.

Figure 9: HV control panel

3.3.4.2 Interlocking earthing system requirements

The Contractor installs a new key interlocking system for safe isolation of all the fields on units 4 and 6. The Contractor shall design, submit for approval prior to installation and install an interlocking system which shall prevent access to all the HFPS panels while there is still power applied to the HFPS (e.g. switchgear bucket, surge arrestor panel, HFPS LV side/ panel, HFPS HV side and the HV room/ chamber). It is the responsibility of the Contractor to ensure that the design employed is fully compliant with the Employer's latest Operating Regulations for High Voltage Systems (ORHVS)

The Contractor shall ensure that all interlocking keys/ components used are as a minimum IP65 rated, where practically possible the Contractor shall ensure that the interlocking system keys are accessible easily without having to leave the ground or require ladders to access and operate safely.

3.3.4.3 Cables and cable racks requirements

The existing power cable from the 400V Precipitator Boards to the MCS II control panels is a 3 core, 185 mm^2, rated cable, but only 2 cores are connected. The Contractor shall utilise the unconnected core as the 3 phase supply for the MSC II control panel. The Contractor shall terminate the 3rd phase outgoing unconnected cables on the terminals of the 380V Precipitator Boards and the MCS II control panels.

The existing power cables from the MCS II control panels to the existing conventional transformers are 4 core, 185 mm^2, 300 A rated cables of which only 2 cores are utilised for power supply and one core for earthing. The 4th core is presently unused and available for use as a 3rd phase power supply. The existing cables are installed in racks and can be reused for this HFPS retrofit/installation.

To accommodate any cable length issues between the MCS II control panels and the HFPS, a junction box, with at least IP65 rating, is installed to link the HFPS and the 400V supply cable. The Contractor shall provide and terminate the power cables including cable racks to link the junction box and the HFPS. The cable entry to the HFPS shall be a bottom entry. This Isolator box shall be labelled by the Contractor according to the site KKS labelling requirement issued by the Employer.

The Contractor shall test the existing cables to verify if the conditions of the existing cables are in a good condition to supports the HFPS installation and shall further provide new cabling and racking designs for review and approval, if there is a need for additional scope accordingly. The Contractor shall further provide cost estimate for the cable rate per meter at tender.

The new cable rack and cables shall be designed in accordance with the Employer's standards (refer to Eskom document 240-56227443).

It is the responsibility of the Contractor to identify the existing damaged cables to be removed as per the project scope and present to the Employer for review and approval. Decommissioning of the damaged existing cables as approved by the Employer shall be performed by the Contractor.

3.3.4.4 Earthing and lightning protection requirements

The Contractor shall ensure all new equipment to be supplied as part of the works are properly bonded to the existing station earth mat. Contractor's designs shall be in compliance with the Earthing and lighting Standard (240-56356396). If pure copper is to be used it must be painted or copper clad steel.

The Contractor shall produce an earthing and lightning protection design for the HFPS and ESP system which interfaces with the existing Eskom substation plant earth mat.

The Contractor ensures that the scope of supply is compatible with the “As Built” precipitator earthing design system.

The Contractor submits at tender, the earthing and lightning concept designs drawings for the system in accordance with Eskom Standard Earthing and lighting Standard (240-56356396).

The Contractor ensures that the HFPS units are adequately earthed for optimal operation and protection. If a return earth is required the connection point needs to be installed during the readiness outage by the Contractor. Earth continuity tests shall be performed by the Contractor and provide certification for quality controls.

3.3.4.5 Surge Protection requirements

Each HSPS shall have surge protection installed on the LV side of the transformer from the switchgear. The surge arrestors shall be sized appropriately based on the worst case expected overvoltage conditions and surges which may also emanate from the ESP.

The Contractor shall ensure that the panel/junction box which shall be used for cable extension and housing of the surge arrestors shall be as a minimum IP65 compliant and shall have a point which shall allow for earthing to the ground grid. The surge arrestor panels shall have a local indication showing the status of each surge arrestor and the panel shall be labelled appropriately with a corresponding AKZ number.

The panels shall be lockable in such a manner as to prevent access to the surge arrestors unless the panel is de-energised. All locking mechanisms installed shall be IP65 rated and shall have dust prevention mechanisms over them. All panels shall be constructed from 3CR12 steel and shall be powder coated to SANS 1091 B32 (electric orange).

The Contractor shall ensure that the status of each surge arrestor from each transformer is made available to the PPMS.

3.3.4.6 Electrical general requirements

The *Contractor* supplies the *Employer* with all the protection requirements for the HFPS. These requirements must comply with the *Employers* protection standard if applicable. The *Contractor* ensures that the current interlocking system is retained otherwise any further design improvement proposals shall be submitted to the *Employer* for approval.

The *Contractor* is required to present a detailed test programme for the approval of the *Employer*

At tender, the Contractor submits the Type Test Certificate and the typical full FAT results of the same or above HFPS rating. The type test should have covered the following tests as the minimum:

- EMC Type test
- Temperature rise
- Short Circuit test
- Open Circuit

At tender, the Contractor submits a list of tests to be performed at FAT and SAT for the proposed HFPS in offer. The tests are to comply with IEC61378, IEC 60146 and related standards in case tests are evaluated using the different standards it should be listed in the deviation schedule and justified with the alternative tests clearly stated. These electrical tests will be done at various unit loadings (including at full load) and include, but are not limited to:

- EMC/EMI
- Insulation Resistance
- Withstand voltage test
- Temperature rise (oil & electronics)
- Efficiency
- Total Harmonic Distortion
- Power Factor
- Open Circuit Test
- Functional Test – performance test
- Power loss determination
- VI curves (manual and automatic)
- Spark & arc rate
- Sound level

The *Contractor* is responsible for compiling the following minimum documents with others document listed in this specification.

- Drawings (cable schedule, termination schedules, etc.)
- Schematic drawings
- Electrical design report (basis of design)
- Earthing drawings
- Performance specification for the HFPS
- EMI compliance Electrical test procedure and compliance standard

3.3.4.7 Decommissioning requirements

The conventional transformer sets of the first three fields will be decommissioned and moved to a location on site identified by the *Employer*. The Station will use these as spares.

The HFPS controller will replace the function of the existing MCS II controller. Thus the MCS II controllers will partially be decommissioned and kept as spares on site. The cut-out in the panel where the MCS II controller came out needs to be closed with a cover plate and the new HFPS controller display will be fitted in the panel. Refer to section 3.3.3.1 for retrofit scope of work on the MCS II control panel.

3.3.5 C&I design

3.3.5.1 General Scope of Work

The C&I scope of work includes but not limited to the following:

- Decommissioning and removal of the existing PPMS server and associated KVM equipment and network infrastructure.
- Decommissioning and removal of the existing PPMS clients located in the each of the three unit control rooms.
- Decommissioning and removal of the existing APPLICOM Gateway for unit 4 and 6.
- Storage of all de-commissioned equipment.
- The provision of new SCADA system of redundant server with KVM and Client workstations for operation, monitoring and engineering and configuration.
- Provision of HFPS DSP controller with local display screens.
- Field instruments, junction boxes, cabling and racking (where necessary) required for the entire HFPS system scope of work.
- Interface and integration of the unit 4 and 6 ESP fields to the new PPMS for monitoring, control, alarms, protection, configuration and data storage of unit 4 and 6 HFPS and MCS II related ESP fields.
- Interface and integration of the unit 5 ESP fields to the new PPMS for monitoring, control, alarms, protection, engineering, configuration and data storage of unit 5 HFPS and MCSII related ESP fields.
- Provision of bus interface for signal exchange between new PPMS and unit control system for units 6, 5 and 4.
- All communication network equipment and cabling required for the complete HFPS units including interface to PPMS, unit control systems and 3rd party PLC system.
- Develop new PPMS HMI mimics based on existing mimics including displaying inputs from control system, remote IO, Precipitator PLC and SO3 PLC (O2, SO3, emissions, hopper high levels and gas analyser signals).
- Configuration and implementation of existing rapping control philosophy into the HFPS controller.
- Provide for the seamless rapping and control between the HFPS and the MCS II control panel.
- Both HFPS and MCS II controllers configurable from the new PPMS.
- Earthing of all C&I equipment provided as part of the Works.
- Power supply requirements for all C&I associated equipment.
- Special tools, programming, software and licenses for the HFPS and PPMS system.
- Development of new design documentation including updating of existing documents and drawings for the entire HFPS system including interface to PPMS and Unit Control system.
- Training to be provided to Eskom on the HFPS design including design of new PPMS and interface to unit control system.
- Provision of control and operating philosophy for the HFPS including interface to the PPMS.
- A C&I maintenance strategy to be provided of the entire HFPS system.
- A recommended spares list to maintain the system.

The general scope of supply and services of the Contractor is documented in graphical format in the Duvha_LOSS_HFPS Diagram. The Contractor shall be responsible for identifying scope of supply and services that have not been captured in the above LOSS Diagram for a functional HFPS system.

3.3.5.2 Functional Requirements

3.3.5.2.1 Controllers and Field Design

The HFPS unit must be supplied as compact unit of transformer and controller and shall be provided with enclosure with minimum environmental protection of IP65 in accordance with SANS 60529.

The control and power circuit must be in two separate compartments and internal wiring shall comply with SANS 10142.

For optimum ESP performance, each ESP field must be supplied with its own controller so that no ESP field shares a controller.

Rapping will also be done by the controller according to the chosen rapping philosophy.

A local control keypad *shall* be provided and integrated with the HFPS controller and *shall* provide for local operation, configurations, monitoring, alarming and trending functionalities.

The local display keypads shall be relocated from the HFPS panels and mounted in the respective ESP field MCS II control panel in precipitator substation similar to configuration on unit 5.

An access control feature by means of password *shall* be employed on the keypad for operating and configuration functionalities only.

No access restrictions *shall* be required for monitoring of any section of the relevant ESP field from the local HMI keypad.

The HMI screen *shall* not freeze under any circumstances and *shall* not require a shutdown and start-up with any operator logout and login functionalities respectively

Field junction boxes shall be provided for grouping of the HFPS unit's field communication networks.

The design and allocation of junction boxes shall be with due regard of the mechanical plant configuration and shall be such that the LH and RH ESP fields are routed through separate field communication junction boxes.

Where necessary, the Contractor shall design, supply, install and commission field control and networking cabling.

FC type of fiber optic connectors shall not be acceptable.

The Contractor shall provide primary and secondary racking where necessary. All field junction boxes shall provide for minimum environmental protection of IP65.

3.3.5.2.2 Rapping

The following rapping philosophies are currently implemented on all five (5) electrostatic precipitator fields of unit 4 and 6 and must be configured and implemented with the HFPS controllers:

- Power off rapping
- Reduced power rapping
- Rapper queuing (Rapping one field at a time per casing)
- Master rapping (Rapping the same field of each casing at the same time)

The Contractor shall further make provision for an additional capacity for up to eight configurable rapping philosophies.

The HFPS controllers will be responsible for the control, protection and rapping of ESP fields 1-3 while the MCS II controllers will be responsible for the control, protection and rapping of ESP fields 4-5.

The complete rapping philosophies of all fields (i.e. HFPS and MCS II) must be synchronized, controlled and managed by the controllers in the field with all rapping status feedbacks being provided to the PPMS.

Furthermore rapping of all controllers including the MCS II must be configurable from the existing PPMS.

The operating and control philosophy of the HFPS's must include as a minimum over current protection, under voltage trip protection and limit conditions of the controller.

3.3.5.2.3 PPMS SCADA System

The existing ClearSCADA SCADA system *shall* be replaced with a computer based operator and engineering system.

The SCADA system *shall* be used for the remote operation, control, monitoring and alarming functionalities of the precipitator plant, as well as performing engineering and maintenance activities of the precipitator plant of units 6, 5 and 4.

The alarms generated by the SCADA system *shall* provide for both audible and visual indications in the respective unit control room.

The SCADA system *shall* be complete with server, operator clients, engineering station, and all network and communication equipment required for a fully functional system.

A redundant server shall be provided and located in the server cabinet situated in the server room in the 2nd floor of the power station administration building.

The server software running the server machine shall be Windows and shall be no lower than the 2019 version. The license shall be valid for lifetime for both development and operating functions.

The server and application software and licenses provided for the server machine shall be valid for lifetime for both development and operating functions.

Three (3) client workstations shall be provided and each workstation will be located in the control rooms of the individual units.

The client operating systems shall also be Windows and shall be no lower than the Windows 2010 version. The license shall be valid for lifetime.

The minimum size of both client and engineering screens is 24" and 19" respectively.

The client and engineering screen *shall* either be MVA, PVA or IPS LCD.

The engineering workstation *shall* further provide for the following characteristics:

- 19" rack mounted workstation
- Uses dedicated workstation hardware
- Rated for continuous use (24/7)
- Hard-drives are redundantly configured via a suitable RAID configuration
- Redundant power supplies
- Remote diagnostics, monitoring & alarming

The server provided as part of the *Works shall* be capable of performing the following functions:

- Carry-out and routing of the precipitator Plant operating data.
- Primary command data from the operator workstation to the MCS-II and HFPS controllers and feedbacks, as well as plant status information from the MCS-II and HFPS controllers to the operator workstations.
- Provide for the storage of the precipitator plant engineering database.
- The control system logic is created and modified via the engineering server and then downloaded to the relevant controllers.
- Provide for the long term storage (5 years) of the plant area's information.
- Provide for the centralized management and distribution of antivirus software and security patches updates on all workstations and servers on the precipitator plant network.
- Provide for viewing of the precipitator plant operations on clients machines on the Eskom LAN.

The above functions *shall* be hosted in a redundant hardware server. The server must have the following physical characteristics:

- Redundant connections to each communication gateway
- Redundant power supplies
- Use dedicated server hardware
- Hot swappable redundant hard drives via a suitable RAID configuration
- 19" Rack mounted in network cabinets

The Contractor shall be allowed to use its own HMI which must comply with the HMI Standard 240-7341351. The Employer currently employs HP screens and Dell Servers on the DCS system and for standardization purposes would be preferred in the Contractors design solution.

One HMI per unit shall be installed in each unit control room. The HMI shall be configured to have as a minimum the information currently available to the Operator of the existing PPMS including data from the plant control system. The HMI best practises: 240-7341351 are to be considered when developing displays.

All 5 fields will be integrated and configurable with the new HMI and shall include those of unit 5. The Operator will be able to seamlessly operate all 5 fields of units 6, 5, and 4 through the same HMI interface.

All rapping philosophies, listed in section 3.3.4.2.2 and all current functionality shall be available on the new HMI.

All computer hardware, software and networking equipment shall comply with Eskom document 240-73413511: Process Information Standard.

All signals generated from the controller will be available for display to the Operator and for storage on the new PPMS server. The *Contractor* designs the new SCADA HMI mimic to incorporate the new HFPS's including ESP fields of unit 5 and shall be in compliance the HMI Standard 240-7341351. The HMI shall be configured to have as a minimum the information currently available to the Operator including data from the unit control system.

The HFPS must comply with the following control parameters:

- Quench, spark set back
- Sparks and arcs per minute
- Primary Current limit
- Primary Current over current trip
- Secondary Current limit
- Secondary Voltage limit
- Secondary Under voltage trip limit
- Secondary Under voltage trip delay
- Maximum sparking limit
- Duty cycle limit
- Mode of operation
- Voltage limit

The control system of the HFPS must provide the following information to the HMI:

- Primary current
- Primary Voltage
- Secondary Current
- Secondary Voltage
- Sparking and Arcing rate

The control system of the HFPS must allow manual change from the HMI of the following parameters:

- Secondary current limit
- Secondary Voltage limit
- Secondary Under Voltage trip
- Secondary Under Voltage trip delay
- Spark and Arc rate limit

The system must be able to provide the option to do manual VI curves.

The Contractor must perform a synchronization exercise of the database of the old server machine onto the new server machine so that the existing database is retained and includes all historical trend data, journal and project data.

A comprehensive back-up and disaster recovery system shall be provided for all software programs provided as part of the Works and especially for the SCADA server machine. The Contractor further provides a back-up and restore which should clearly document steps for backing-up the existing server database and uploading it to the new redundant server. The procedure shall include pictures of the different windows and their configuration settings.

3.3.5.2.4 Networks

Ethernet communication shall be used between the Controllers, PPMS, remote IO modules and unit control system. Modbus TCP shall specifically be used between the SCADA server and the PPMS network communication gateway.

The Contractor shall provide, install and configure all the networking equipment and cabling required for connecting the HFPS system, interface to the new PPMS and Unit control system.

Networking equipment to be RAIL mount type and rated for industrial use.

Equipment with a high temperature rating (80°C) should be used where equipment is installed on the precipitator roof and precipitator substation.

All equipment shall be installed in enclosures with environmental protection of IP65 for equipment installed outside and suitable enclosures for equipment installed inside.

The communication gateway between SCADA server and the ESP field controllers is the obsolete APPLICOM gateway for unit 6 and 4 and shall be replaced by the Contractor as part of his HFPS system solution.

The communication gateway between the SCADA sever and ESP field controllers is the Sixnet PLC on unit 5. The Contractor must perform all required engineering activities to ensure the interface to the new PPMS system is commissioned successfully.

The Contractor provides a network architectural diagram of the complete HFPS system design solution depicting as a minimum all DSP's, controllers, media converters, network switches, servers, HMI's, bus communication equipment including the SCADA system and interfaces to the unit DCS and other existing 3rd party PLC systems. The communication protocol between major network systems shall also be shown within the architecture diagram.

The Contractor shall further provide a network functional specification which shall as a minimum describe the following:

- Description of the physical and logical network topology and structure.
- Descriptions of components that will be used for networks and their function.
- Open/proprietary communication protocols that will be used on the network.
- Primary/redundant network switching.
- Expected data flows on each network.

- Explanation of the features of the network management tool.

The network functional specification shall also provide and include equipment details (i.e. OEM brochures, technical specifications).

3.3.5.2.5 Power Supply Requirements

Network equipment in the field (i.e. ESP roof and Precipitator substation) shall utilize 24VDC and shall be specified for power supply type sourced from normal 380VAC supply.

Only the PPMS server and client workstation shall be specified for UPS power supply.

The source of the power shall be the scope of the Employer.

The Contractor shall however be responsible for the supply and installation of power cabling between the power source and the control system equipment.

The *Contractor shall* design the Field data communication panels to receive 230VAC and *shall* design the cabinet as a 24VDC system.

Power to all SCADA server equipment, network equipment and workstations *shall* be from a UPS source provided by the *Employer*. The *Contractor shall* be responsible for design, engineering, installation and commissioning of power cabling between source and destination.

3.3.5.2.6 Interfaces

The existing plant unit control system is the Siemens Teleperm C/Iskamatic B on units 5 and 4, and the Siemens T3000 on unit 6. Refurbishment of units 5 and 4 to similar technology as unit 6 is planned and will be a separate project to the HFPS project. The interface for the unit specific signals is acquired via the PPMS/DCS bus interface for unit 6 and via remote IO for unit 5&4. Also the DHP binary signals are acquired via the PPMS/DCS bus interface on unit 6 whereas on unit 5&4 they acquired via the precipitator plant PLC. Furthermore the precipitator plant rapper motor current signals are acquired via the precipitator plant PLC for all the three units.

The C&I solution provided as part of the HFPS project must cater for the both the unit 6 configuration as well the unit 5&4 configuration. Thus the Contractor is expected to provide a design interface solution that caters for both the existing unit 6 configuration as well as the unit 5&4 configurations during the tender stage. It is the Employers intention that the unit 5&4 will be refurbished with a similar technology as unit 6. Depending on the existing DCS technology on units 5&4 at the time of implementation of the HFPS project, the Contractor shall implement either the unit 6 interface configuration or the unit 5&4 interface configuration for unit 5 and 4. The actual implementation dates of the unit 5&4 DCS refurbishment and the likely interface solution to be implemented for the HFPS project will be revealed and further discussed with the Contractor during contract negotiations.

The integrated HFPS controllers as well as MCS controllers must be interfaced and integrated to the new PPMS SCADA system for all three units.

The new PPMS system shall be interfaced to the unit control system where the Contractor shall be responsible for all related configuration requirements on the PPMS and the Employer shall be responsible for all configuration requirements on the unit control system. The Contractor shall provide, install and configure all the networking equipment and cabling required for connecting the system to the unit control system. The Contractor shall provide and document all configuration settings for review and acceptance of Employer.

The ESP fields control functions shall function independent of the PPMS so that failure of the PPMS does not render any of the ESP fields none-functional. The control and rapping shall be performed by the HFPS controller and MCS II controllers i.e. the rapping and controlling on all 5 fields will be managed and controlled by the field controllers independent of the PPMS system. However the rapping and controlling functionalities shall be configurable from the PPMS.

This will require some form of synchronization between the MCSII field controller technology and HFPS field controller technology for rapping and queuing and the data from the PLC gateway will have to be integrated into the HFPS Server and Client. All programming, wiring, cabling, instruments and power requirements needed to achieve this will be the responsibility of the Contractor.

The preferred protocol to interface to the control system, gateway PLC and HFPS HMI is Modbus TCP IP. All alarms should be rationalised as per Eskom Standard 240-57859210 – Alarm System Performance of Digital Control Systems Applied in Fossil Plant Standard, and shall be audible and visible on the alarm display on the HMI.

The Contractor shall further interface the new PPMS systems to the unit 5 ESP field controllers and shall provide similar functionality as with unit 4 and 6.

3.3.5.2.7 General

The Contractor designs the system such that no single failure on one field affects any other part of the system. The Contractor will design the system such that no failure on one Unit affects another unit. Equipment that is common to more than one field or casing should be supplied from a source that is available when parts of the system are switched off (field/casing outages).

The Contractor shall install all C&I equipment in separate enclosures from Electrical equipment. The Contractor supplies and installs two fault finding devices per unit (4 in total) to be used to connect directly to controllers for Maintenance, configuration and fault finding purposes.

All cabling must be installed according to Eskom document 240-56227443: Requirements for Control and Power Cables for Power stations Standard. The contractor removes all de-commissioned equipment, cables, panels etc. that is replaced as part of the works. All equipment removed will be bubble rapped and stored in a location allocated by the Project Manager.

The contractor takes the following Standards into account when designing the networking, security, interfacing, configuration, installation and procurement for the works:

- 240-73413511: Process Information Standard
- 240-56355754: Field Instrument Installation Standard
- 240-56355815: Field Instrument Installation Standard Junction Boxes and Cable Termination
- 240-56227443: Requirements for Control and Power Cables for Power stations Standard
- 240-54937450: Fire Protection and Life Safety Design Standard
- 240-57859210: Alarm System Performance of Digital Control Systems Applied in Fossil Plant Standard

- 240-56355731: Environmental Conditions for Process Control Equipment Used at Power Stations Standard

3.3.5.2.8 Training documentation and drawings

The *Contractor* supplies documentation as per the VDSS included as an appendix to the Works Information. The *Contractor* provides the following:

- Full training on all equipment installed including installation, configuration and customization.
- A Customization document containing all custom configurations, settings, scripts etc.
- Copies of all Software and drivers installed
- All software licenses and license keys/codes
- Installation and disaster recovery procedures
- Updated and new drawings approved by ECSA registered person and done according to Eskom document 240-86973501: Engineering Drawing Standard - Common Requirements

3.3.5.2.9 License

The *Contractor shall* make provision of all licenses covering the equipment, standard software and application software supplied as part of the *Works*. The provided licenses *shall* be valid for the entire life of the plant and *shall* remain even for replaced equipment.

3.3.5.2.10 Security

The *Employer* will have full access to all configurable areas in the software. The system will have at least three fully configurable security environments to allow different access levels for Operating, Maintenance and Engineering. The *Contractor* will design his solution to meet the Security requirements in the Eskom document 240-55410927: Cyber Security Standard for Operational Technology revision 2.

3.3.5.2.11 Spares List

The Contractor will supply a list of critical and general required spares to maintain the complete system.

3.3.5.2.12 Project Execution Methodology

The systems development methodology to be followed after Contract Award for the HFPS C&I system is as follows:

1. Detailed Engineering: Detailed Engineering Design Freeze
2. Procurement, Fabrication & Manufacturing: FAT
3. Erection and Installation
4. SIT
5. Hot and Cold Commissioning
6. Optimization

7. As Built Documentation Compilation

3.3.5.2.12.1 Design Services for Preparation of Control and Instrumentation

The *Contractor shall* supply all relevant details and information of the plant control and instrumentation system design. The *Contractor shall* detail the field equipment design in the following specification documents:

- Appendix 1: Limits of Supply and Services

The LOSS diagrams indicate the scope of supply and services for individual items such as instrumentation and the supply and interfaces to automation system. The scope of supply and services of the *Contractor* is given in graphical format in the LOSS diagrams. During tender, basic and detail design phases, the *Contractor shall* liaise with the *Employer* and be responsible to identify scope of supply and services that are not indicated on the LOSS diagrams, and *shall* be required to update the LOSS Diagrams to ensure all high level scope items have been identified to ensure a functional control and instrumentation system.

- Appendix 2: Function IO Block Diagrams

The Functional IO Block Diagrams details the type and quantity of the inputs and outputs from control and instrumentation equipment. During tender, basic and detail design phase, the *Contractor shall* allocate Functional IO Block Diagrams to the control and instrumentation field measurement and actuation equipment in the instrument and drive/actuator schedule.

- Appendix 3: Instrument Schedule

The field instrumentation that *shall* be interfaced to the control and instrumentation system as analogue and/or digital input and output *shall* be populated in the Instrument Schedule. During tender, basic and detail design phase, the *Contractor shall* populate the instrument schedule with all equipment forming part of design and shall provide for the scope of supply and services as per the LOSS Diagrams referenced in the Instrument Schedule and the requirements of this Specification.

- Appendix 4: Drive & Actuator Schedule

The field drive and actuation equipment that *shall* be interfaced to the control and instrumentation shall be populated in the Instrument Schedule. The *Contractor shall* populate the drive and actuator schedule with all equipment forming part of design and shall provide for the scope of supply and services as per the LOSS Diagrams referenced in the Instrument Schedule and the requirements of this Specification

- Appendix 5: Virtual Signal List

The Virtual Signal List *shall* be used for all bus interfaces to the main automation system. The Virtual Signal List gives the detail information on the quantity and signal descriptions of the information that is transmitted over the bus.

- Appendix 6: Hardwired Signal List

The Hardwired Signal List indicates the stand alone systems that *shall* be interfaced to the plant control system.

- Appendix 7: Alarm and Limit Value List

The Alarm and Limit Value List *shall* list all the alarms for the system.

- Appendix 8: 220VAC Load Schedule

The Contractor *shall* document all power requirements for the complete system in the 220VAC load schedule.

3.3.5.2.12.2 Engineering and Design Activities

The *Contractor shall* perform all basic and detail design and engineering activities necessary for the development of the complete HFPS, PPMS, and PPMS interface to control system requirements for the complete precipitator plant. This includes the *Contractor*'s interfacing and participation with the *Employer* through clarification meetings in order to meet the control and instrumentation system design freeze for the Works.

The design and engineering activities *shall* include but not limited to the following:

- Preparation, review, clarification and final compilation of the Schedules listed under section 3.3.4.2.11.1 of this specification.
- Preparation, review, clarification and verification to ensure that the process plant P&ID, process flow diagrams, logic diagrams and operating philosophies are consistent.

The *Contractor shall* further be responsible for the development and engineering of control philosophies of the complete Works as well as submitting and maintaining documents as defined in the Vendor Documentation Submittal Schedule (VDSS).

The system engineering documentation *shall* conform to all the requirements of Section 3.3.4.2.11.3 and *shall* be in an adequate state of completeness to technically clarify the respective precipitator plant systems and subsystems as well as control and instrumentation system.

System engineering activities *shall* be executed by the *Contractor* in active co-operation with the *Employer*. The *Contractor shall* perform the function of technical leader and *shall* take full responsibility for all technical interfaces for the plant control and instrumentation system design.

Design freeze *shall* be the acceptance of all documentation as per VDSS for the basic and detail design phases. There *shall* thus be a basic design freeze as well as detail design freeze.

3.3.5.2.12.3 Requirements Related to Technical Documentation

The basis for the completion of all engineering activities *shall* be acceptance of documentation as defined in Vendor Document Submittal Schedule.

The *Contractor shall* comply with the requirements of VGB-R 171e *Provision of Technical Documentation (Technical Plant Data, Documents) for Power Plants*.

All technical documentation *shall* be numbered and classified according to IEC 61355 and VGB B 103.

The documentation requirements *shall* cover all stages of the *Works,* from the engineering stages; through installation and commissioning; and operating, maintenance and training stages of the project.

3.3.5.2.12.4 Factory Acceptance Testing

Factory acceptance testing *shall* be conducted for the HFPS and PPMS provided as part of the *Works*. The factory acceptance testing *shall* test the following as a fully connected and integrated system:

- System hardware equipment, functionality and performance
- System application software functionality
- System performance
- HMI equipment and performance

The complete HFPS system, PPMS control system equipment *shall* be factory tested prior to shipment to Duvha site.

The minimum FAT testing and inspection requirements are defined in the standard IEC 62381 1st edition (2006-11). The *Employer* will determine if any further testing is required in addition to that specified, such as that of any new technologies being used.

The *Contractor shall* prepare a detailed test procedure in preparation for FAT. The proposed test procedure *shall* be prepared by the Contractor and submitted to the *Employer* for approval during the detail design stage. The final test procedure *shall* be prepared by the *Contractor* and submitted to the *Employer* for approval at least 28 days prior to the scheduled test date.

As a minimum, the proposed FAT procedure identifies the following:

- Major test activities
- Comprehensive list and description of the individual tests to be performed
- How the tests are to be prepared and conducted
- Test dates and durations
- Checklists - how the test results will be documented
- Acceptance criteria
- How the identified discrepancies will be processed
- Re-testing requirements

A Final FAT report *shall* be prepared by the *Contractor* that includes the following as a minimum:

- Test procedures used during FAT
- Detailed test results
- Discrepancies identified during the tests
- Resolution of the discrepancies
- Re-tests conducted and results thereof
- FAT certificate

The *Contractor shall* submit the Final FAT Report to the *Employer* for approval. FAT Completion *shall* be achieved upon approval of the Final FAT Report by the *Employer*.

3.3.5.2.12.5 Erection and Installation

This stage *shall* consist of the procurement, installation, and on-site inspection and testing of all supplied items forming part of the Works.

The *Employer* will specify hold and witness points during the installation and testing stages of the project.

The *Contractor shall* issue preliminary notification of such hold and witness points by giving not less than 28 days advance notice to the *Employer*, and confirms such hold and witness points at least 7 days prior to the test activity.

3.3.5.2.12.6 Site Integration Testing (SIT)

Site Integration Testing (SIT) *shall* take place at the Duvha Power Station site after the equipment is delivered to site and has been installed and an erection completion signed-off by the *Employer*.

SIT *shall* be carried out to ensure the correct performance of the control equipment, to ensure safety of plant and personnel, and to ensure compliance of the control and instrumentation system with the Specification before commissioning of the plant commences.

As a minimum, the SIT testing and inspection activities *shall* be provided by the *Contractor* for the *Works* consists of the site integration and site acceptance activities defined in the standard, IEC 62381 1st edition (2006-11).

The *Contractor shall* prepare a detailed test procedure in preparation for SIT. The proposed test procedure, together with test dates, shall be prepared by the *Contractor* and submitted to the *Employer* for approval during the detail design engineering stage. The final test procedure *shall* be prepared by the *Contractor* and submitted to the *Employer* for approval at least 28 days prior to the scheduled test date. A Final SIT Report shall be prepared by the *Contractor* inclusive of the following as a minimum:

- Test procedures used during SIT
- Detailed test results
- Discrepancies identified during the tests
- Resolution of the discrepancies
- Retests conducted and results thereof
- SIT certificate

3.3.5.2.12.7 Commissioning

Commissioning is defined as bringing into service all items of the *Works*, and meeting the functional requirements and performance criteria of the Specification. This includes all necessary testing and verification of the stated performance criteria. The *Contractor shall* commission all interfaces to control precipitator plant

The *Contractor shall* provide all the test equipment required for the commissioning of the individual modules, the sub-assemblies and the functional groups.

This stage consists of all field equipment checks, loop checks, drive interface checks, and testing system functionality up to but excluding providing actuation power and process medium in the plant, energy whether electrical, hydraulic or pneumatic.

The *Contractor shall* submit the Cold Commissioning test results to the *Employer* at the conclusion of cold commissioning and request the commencement of hot commissioning.

Hot commissioning is where the plant processes are placed into operation in conjunction with the control and instrumentation system. The *Contractor shall* be responsible for the commissioning of the complete control and instrumentation system including the final control elements, bus interfaces and their protocols, as well as the HMI, station plant control system. The commissioning activities *shall* be carried out in conjunction with the *Employer*.

The *Contractor shall* be responsible for the hot commissioning of all the equipment forming part of the *Works* and the interfaces to satisfy the requirements of the Specification.

In cases where various components are connected to form an integrated system, the *Contractor*, at the time of commissioning, *shall* carry the responsibility for the correct functioning of the whole of the system.

If a defect is identified in the equipment interfacing or external to the *Contractor's* scope the *Contractor shall* request the *Employer* to rectify the defects.

3.3.5.2.12.8 Operational Acceptance Testing (OAT)

Commissioning *shall* be concluded with the Operational Acceptance Test (OAT). The *Contractor shall* request commencement of operational acceptance test from the *Employer*.

The OAT *shall* include the checking of all interlocks and protections, sequence controls and analogue controls.

The *Contractor shall* produce a detailed OAT test procedure 28 days in advance for approval by the *Employer*. The OAT procedure includes as a minimum, the loop tuning procedures and acceptance criteria for the individual loops.

A Final OAT Report *shall* prepared by the *Contractor*. The *Contractor* submits the Final OAT Report to the *Employer* for approval. Commissioning completion is achieved upon approval of the OAT Report by the *Employer.*

3.3.5.2.12.9 AS Built Documentation Package

'As Built' documentation, as listed in Vendor Documentation Submittal Schedule (VDSS) *shall* be supplied by the *Contractor* to the *Employer* upon completion of capability testing.

Acceptance of the 'As Built' documentation is a pre-requisite for the Sectional Completion of the Plant Area concerned.

The documents *shall* be reviewed by the *Employer* for correctness and conformance to the accepted design.

3.3.5.3 Cable racking and routing

The routes for cabling between the various equipment such as; interface junction boxes, unit control room, precipitator substation and precipitator roof will follow the cable routes of the Electrical system according to the 240-56227443 standard: Requirements for control and power cables for Power Station. All field equipment to be integrated to the PPMS via junction boxes. The *Contractor* ensures that all cabling is in conduits and racks.

Fiber optic cable provided as part of the works must be tested for their integrity after delivery, installation and commissioning. The Contractor must certify his fiber optic installation system using the OTDR tool which shall also be provide by the Contractor including certification of the installation. The Contractor must further provide a fiber optic cable installation procedure which shall comprehensively describe the railing, pulling, connection, termination and testing methodology.

3.3.5.4 C&I system and equipment requirements

The following requirements must be read in conjunction with the table in Section 6: Codes and Standards.

3.3.5.4.1 Redundancies

All hardware, software and control network redundancy with regard to the control system and power supplies will be configured to match the redundancies of the various mechanical process areas. The C&I system redundancies will be consistent with the mechanical plant and electrical power redundancy and distribution configuration to minimise the effects of equipment failure on the overall unit. Through functional distribution of equipment, the C&I system will be designed and configured for the following reliability:

A. Safety

No individual C&I fault or no two concurrent faults endanger the safety of the people, plant or jeopardise the integrity of the major plant.

B. Unit trip/Load Loss

No individual C&I fault causes the unit load to drop below 45% MCR, or causes a forced outage or unit trip.

C. Multi-Unit Trip

No individual C&I fault or two concurrent faults cause a multi-unit trip.

D. Operator Interface

No individual C&I fault causes loss of operator work station or control and operator information.

3.3.5.4.2 Field equipment

All field equipment to be installed according to the Field Installation Standard listed below:

- 240-56355754 - Field Instrument Installation Standard.
- 240-56355815 - Junction Boxes and Cable Termination Standard.
- 240-56355843 - Pressure Measurement Systems Installation Standard.
- 240-56355888 - Temperature Measurement Systems Installation Standard.
- 240-56239129 - High Pressure Pipe Work for Fossil Fired Power Stations
- 240-56356396 - Earthing and Lightning Standard
- 240-56227443 - Requirements for Control and Power Cables for Power Stations
- 240-43156827 - Introduction to the Welding Rulebook
- 240-56355729 - Plant Control Modes Guideline

3.3.5.4.3 System expandability

The design of the complete HFPS, PPMS SCADA system and interface to the unit control system *shall* provide for later expansion such that future changes and enhancements can be readily incorporated. The following spare capacity *shall* be provided for in the design:

- 10% spare installed IO of each HFPS control panel shall be spatially distributed throughout the panel throughout the IO modules.
- 20% reserve physical space in all panel racks (I/O, signal conditioning etc.).
- 10% spare installed terminals per panel.
- 20% spare installed capacity in all multi-core cables (rounded up)

The *Contractor shall* demonstrate the above requirements at design freeze and *shall* be without the necessity of having to reconfigure the design.

The *Contractor shall* further provide for the following at Completion without reconfiguring the design:

- The utilisation of the CPU *shall* not exceed 45% loading during normal operation
- The *Contractor* must cater for full expandability range for bus loading
- 30% spare memory capacity for software expansions.
- 20% spare capacity for expandability on licensing of tags.

3.3.5.5 Spares

The *Contractor* supplies a spares list for the complete system. This includes critical spares, descriptions on why a spare part is critical, possible lead times and quantity to be kept. A list of suggested minimal non-critical spares is also supplied.

3.3.6 Civil & Structural Design

The *Contractor* is the design authority with regards to the existing structure for the loads induced by the HFPS and its support structure as well as any modifications carried out to the structure.

The *Contractor* takes full professional accountability and liability for the *works* and provides the following for review and acceptance:

- Consolidated detailed design report signed by a Professional Civil Engineer/Technologist in accordance with Eskom document 240-56364545: Structural Design and Engineering Standard including but not limited to:
    - Survey drawings, design criteria/parameters, specifications and standards that were used, loadings, assumptions, calculations and results including detailed design calculations, design models, sources of information and any record of other information associated with the completed works. All calculation files and analysis/design models are also submitted in native electronic format together with the design report.
- Detailed drawings for construction. All drawings are required to be submitted in CAD formats. All submitted drawings to be signed by a Professional Civil Engineer/Technologist with ECSA registration number stated on drawing.
- Construction Specifications for the *Works*.

Any discrepancy or ambiguity between the *Employer's* Specifications or requirements is immediately brought to the attention of the *Project Manager* for clarification, by the *Contractor*.

All Civil and Structural designs are in accordance with the following *Employer's* Design Standards:

- 240-56364545: Structural Design and Engineering Standard
- 240-107981296: Constructability Assessment Guideline
- 240-56364535: Architectural Design and Green Building Compliance Manual

Currently, the power supplies are located on the roof of the ESP structure. Each ESP casing is served by 10 electrical power supplies. The 10 power supplies are positioned on structural steel platforms which are supported by the main roof beams of the ESP structure. Drawing 0.57/19833 provides a plan view of the existing steel platforms indicated in Figure 10 below.

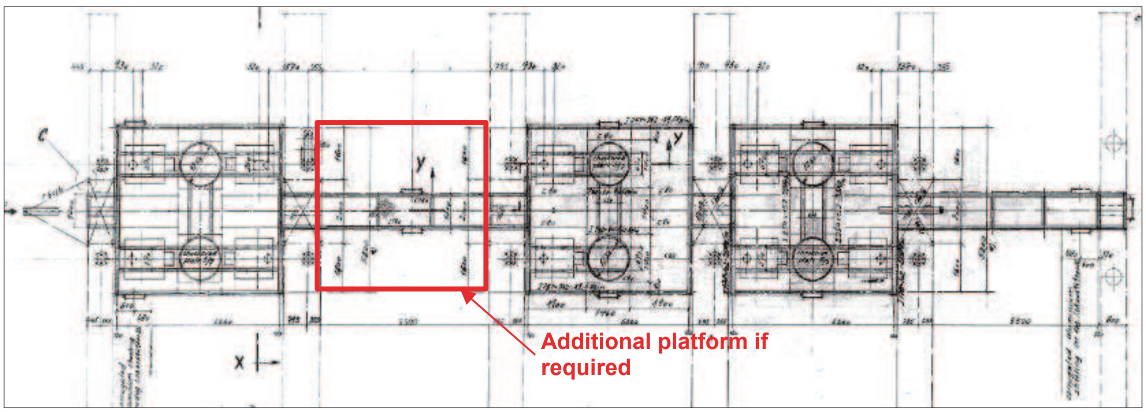

Figure 10: Plan of platforms on a casing

The steel platform is equipped with rails which allow the existing power supplies to be moved into position from the centre of the casing. A hoisting system (i.e. crawl beam) is located at the centre of the casing.

Based on the recent installation of HFPS's installed on the roof of Unit 5, it is expected that the existing platforms will not be able to accommodate the new HFPS's. An additional platform may therefore be required, similar to the platform constructed for Unit 5 as indicated in Figure 10.

1. The *Contractor* confirms the available space for the new HFPS's and performs a structural analysis and design on the existing support platform for its reuse in the supporting of the proposed HFPSs to be installed.
2. The *Contractor* is responsible for the design and construction of a new support platform if required including any required modifications on the existing support platform or any other existing structures to accommodate the new HFPS's.
3. The *Contractor* takes the removal of the HFPS in future for maintenance or replacement purposes into account in the design of the platform.
4. The *Contractor* includes a detailed methodology for the future removal of the HFPS in the detailed design report and provides the detailed design of any temporary support

structures required to move the HFPS in the lifting area of the crawl beam if required for the removal.

5. The *Contractor* analyses the existing roof supporting structure of the ESP as well as its supporting columns for any increase in loading or change in loading arrangement due to the installation of the HFPS or modifications made to the existing structure. The *Contractor* is responsible for the designs and execution of all modifications required.
6. The *Contractor* verifies if the existing crawl beam is able to support the new HFPSs and lift the HFPS's to ground level for maintenance purposes. If the crawl beam is found to be unusable, then designs and modifications are required to ensure that the crawl beam can support the new HFPSs. Designs and modifications to the crawl beams and its support structure are executed by the *Contractor.* The *Contractor* thereafter conducts a load test and provides a load test certificate for the crawl beams before it is used.
7. The *Contractor* is required to produce any as-built information of the ESP structure required for the analysis which includes tests on steel samples to determine the material properties of the structural steel used in the construction of the ESP structure to complete his design.
8. The *Contractor* is responsible for the surveying and production of any as-built information of the existing ESP required for the design.
9. The *Contractor* is responsible for the complete surveying and setting out of the works including establishment of any benchmarks, within Duvha Power Station, which is required to complete the *Works*.
10. If survey information on existing benchmarks within Duvha Power Station is unavailable, the *Contractor* is required to consult the Surveyor-General's office to obtain information on available registered beacons near Duvha Power Station which can be used to establish any required benchmarks close to the *Works*.
11. The new platform is required to be equipped with removable hand-railings and access steel ladders.
12. The *Contractor* is required to ensure the structural integrity of all structural modifications and takes full accountability for any modifications made to the existing structure.
13. The *Contractor* is responsible to reinstate (to the original design) all affected finishes during the construction which includes ensuring the structure is waterproof and gas tight, and the repair of all insulation and cladding damaged during the *works*.

3.4 PROCEDURE FOR SUBMISSION AND ACCEPTANCE OF CONTRACTOR'S DESIGN

1. The *Contractor* submits all designs to the *Project Manager*. The designs submitted are complete packages with all elements (drawings, datasheets, calculations etc.) included.
2. The *Employer* reserves the right to review any design in the detail that is deemed necessary. The *Employer* accepts no accountability and liability due to the review of any designs or if any acceptance is given.

3. The *Contractor* is the Design Authority as defined in Eskom document 240-53113685: Design Review Procedure for the *works*. The *Contractor* is responsible for following this design procedure and conducts all the design reviews as specified in this procedure. The *Contractor* is responsible for conducting the following reviews:

   - Design Freeze Review
   - System Integrated Design Review
   - Pre-commissioning Review
   - Acceptance Testing Review
   - Handover Review

   The *Contractor* takes into account this review process in the schedule.

   The *Contractor* supplies the *Employer* with a complete multidisciplinary integrated design to install the HFPSs. This includes the submission of the following design deliverables for review and acceptance:

Mechanical

- Design drawings for HV ducting and connections
- Earth switch drawings
- Transformer removal and HFPS installation procedure

Electrical

- Updated schematic drawings
- Cable schedules and cable termination schedules
- General Arrangement drawings
- Component list specifications
- Electrical design showing details of changes (red line drawings)
- Earthing drawing/ design
- Performance specification of the HFPS
- EMI Compliance standards
- Predicted harmonics spectrum
- Surge protection
- List of Test equipment to be used to validated electrical performance
- Electrical test procedure and compliance standards
- Fault finding equipment

C&I

- Functional logic diagrams
- Loop diagrams
- Panel layout drawings
- Cable schedule
- Detailed operating, protection philosophies and descriptions
- Equipment list
- Cable block diagrams
- Network architecture diagram (up to including interface to control system)

- OEM Manuals (PPMS and HFPS)
- Functional specification (covering details of equipment making up the system architecture)

Civil and Structural

- Design report of supporting structures and assessment of existing structures including crawl beam designs and modifications
- Construction, fabrication and as-built drawings including specifications for the construction.

3.5 OTHER REQUIREMENTS OF THE CONTRACTOR AND THE DESIGN

The HFPSs are easily removable for maintenance purposes if necessary. The *Contractor* provides a procedure and schedule for on-load and off-load HFPS replacement and maintenance. The replacement of HFPSs must be according to the *Employer's* safety regulations.

The *Contractor* provides maintenance manuals as well as the required training to maintain and operate the HFPSs.

The HFPSs must be able to operate in dusty conditions. This is especially true for the cooling system filtration, if any is used. The *Contractor* ensures that the HFPSs installed are able to operate under the above conditions. It is a requirement that the cooling system be operational in a dusty environment with maintenance frequencies that coincide with and are not shorter than the existing maintenance cycles for Duvha Power Station, i.e. 18 month intervals. See section 3.3.3.

The contractor provides drawings and component lists showing new and existing components prior to installation. All new components relevant to the design will be coded by the employer in accordance with the AKZ numbering system used at Duvha Power Station. The Contractor is responsible for installing the required labels as per paragraph 3.5.2.

3.5.1 Documentation Management and Identification

All documents supplied by the *Contractor* are subject to the *Employer's* acceptance. The language of all documentation is in English.

The *Contractor* includes the *Employer*'s drawing number in the drawing title block. This requirement only applies to design drawings developed by the *Contractor* and his *Subcontractors*. Drawing numbers are assigned by the *Employer* as drawings are developed.

The *Contractor* is required to submit the Vendor Document Submission Schedule (VDSS) as per agreed dates to the delegated *Employer's* Representative. The *Employer* pre-allocates document numbers on the VDSS and sends back to the *Contractor* through the delegated *Employer's* Representative. The VDSS is revisable and changes must be discussed and agreed upon by all parties. The *Contractor*'s VDSS indicates the format of documents to be submitted. Eskom is responsible for managing the schedule i.e. track submission progress of documentation by the Contractor as per the committed dates on the VDSS.

3.5.1.1 Document Submission

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. Electronic submissions could be done using the SharePoint Transmittal Site functionality or by means of a flash drive. CDs are not acceptable.

The *Contractor* is provided with and adheres to Eskom document 240-76992014: Technical Documents and Records Management Work Instruction. For bulk document submission, the following link can be used https://zendto.eskom.co.za/. Proper communication on the use of this link is essential because uploaded documents expire after 14 days.

3.5.1.2 Transmittal

The *Contractor* lists all project documents (soft copies and hard copies) for submittal on the transmittal with the following metadata fields:

- Title of the document
- Document Unique Identification number
- Revision number
- Name of Discipline
- Reason for issuing/submission
- Sender's detail
- Sent date
- Recipient's Details
- Date received
- Quantity of documentation referenced on the transmittal
- Number of copies
- Format/medium submitted (eg: paper, DVD, etc)
- Sender signature
- Recipient signature, once submitted, to acknowledge receipt

3.5.1.3 Identification of the Documentation

The *Contractor* ensures that document has the following as a minimum attributes on the cover page:

- Title of the document
- Document Unique Identification number (Eskom number)
- Contractor Document number, if applicable
- Document status
- Revision number
- Document Type
- Document security level
- Document revision table/history
- Page number on the footer

- Document Author/Authoriser/
- Document Originator Contractor

3.5.1.4 Format and Layout of Documents

For consistency it is important that all documents used within a specific domain follow the same layout, style and formatting standard.

3.5.1.5 Layout and Typography

Every document should comply with the following font specifications:

- Font Colour: Black
- Main Headings Font Type: Arial, Bold, Capital Letters
- Main Heading Font Size: 12pt
- Sub Headings Font Type: Arial, Bold, Title Case
- Sub Headings Font Size: 11pt
- Body Font Type: Arial, Sentence Case i.e., only the first letter of the first word is a capital letter.
- Body Text Font size: 11pt
- Line Spacing: 1.5 line spacing
- Margins: standard
- Alignment: full justification to be used
- Paragraphing: one line skip between paragraphs
- Pagination: centred page numbers (about 0.5 inches from bottom)
- Indentations: standard tab for all paragraphs (about 0.4 to 0.5 inches)

3.5.1.6 Document Headers

The header should include the project name, document title, document number, revision number and page number.

3.5.1.7 Naming of files

The *Contractor* will comply with the Eskom standard for naming documentation files. The standard is as follows:

For documents that have approval date and signature

(*YYYYMMDD_DocType_DocumentTitle_UniqueIdentifier_Revision.FileExtention)*

For documents that do not necessarily require the ‘Approved Date’ and ‘Revision & Versioning’, use the date of update

(*YYYYMMDD_DocType_DocumentTitle_UniqueIdentifier_Revision.FileExtention)*

3.5.1.8 Drawings Format and Layout

1. The creation, issuing and control of all Engineering Drawings is in accordance to the latest revision of 240-86973501 - Engineering drawing Standard.
2. Drawings issued will be a minimum of one hardcopy and an electronic copy.
3. Drawings issued may not be “Right Protected” or encrypted.

3.5.2 Plant Labelling

It is the responsibility of the *Contractor* to manufacture and install labels according to station based labelling standard on all areas of plant that are affected by the Works. Eskom is to provide the labelling standard.

The Coding practitioner shall facilitate base-lining of all equipment lists from the contractor, and only baseline equipment lists shall be used as a basis for the production of labels.

The Abbreviation Standard for Labelling of Plant at Power Stations (240-109607332) shall be provided to the *Contractor* as a reference for the creation of equipment lists.

3.5.3 Warranty Period and Site Assistance

Take-over by the *Project Manager* is dependent on successful completion of the works, commissioning and testing, plant labelling and all required documentation handed over and accepted including all known defects corrected.

A warranty period of 52 weeks shall apply from the date of take-over. During this period the *Contractor* is responsible for rectifying defects that arise, and a 24h response period after a defect is raised is also guaranteed. The support for this response function is locally based in South Africa.

3.6 EQUIPMENT REQUIRED TO BE INCLUDED IN THE WORKS

All equipment required to execute the *Works* is the responsibility of the *Contractor*.

The ESP roof is equipped with 3 x 220 volt, 16 amp power supply points. The *Contractor* uses his own distribution box, if required, in accordance with SANS specifications.

3.7 AS-BUILT DRAWINGS, OPERATING MANUALS AND MAINTENANCE SCHEDULES

The *Contractor* supplies the *Employer* with all the as built drawings, operating and maintenance manuals required to operate and maintain the HFPSs.

The *Contractor* provides the *Employer* with a maintenance schedule.

Documentation is required in hard and soft copy, preferably on flash drives. 3 hard copies per document are required. The drawings must be as per the *Employers* drawing standard (240 – 86973501).

PERFORMANCE GUARANTEE DESIGN BASE CONDITIONS

The Contractor guarantees maximum emission levels of 40 mg/Nm^3 at 10% O_2 on a dry basis. A baseline emissions performance test is done as specified in paragraph 3.8 below.

The electrical performance guarantee will be measured against the increase in maximum power input to the field evaluated on a per field basis. It will be calculated using the following formula:

$\frac{kV \times mA}{1000} = kW$,where kV and mA are secondary input conditions.

Before the HFPS installation the Contractor performs a baseline performance test at full load with the existing transformers still in use. After the HFPS installation and optimisation, another performance test will be performed at full load and used to evaluate the increase in maximum power input. The minimum increase is 20% in maximum power input from the baseline to the HFPS installation.

If major internal defects are suspected on a specific field the *Employer* and *Contractor* may mutually agree to exclude the specific field.

3.8 PERFORMANCE TESTS BEFORE AND AFTER INSTALLATION

The *Contractor* provides full ESP efficiency test results before and after the HFPS installation. The efficiency test before the HFPS installation is done after an outage, if possible, when the internal condition of the ESP is as good as possible. The measurements shall include as a minimum:

- Gas volume flow – ESP inlet and outlet
- ESP flue gas inlet temperature
- Moisture in flue gas
- Inlet and Outlet dust burden (dry gas and 10% O_2)
- Oxygen at ESP inlet and outlet
- Coal proximate and ultimate analyses
- Coal ash composition

All efficiency measurements shall comply with the requirements of EN 13284-1.

In the case where the unit is on an unexpected outage before the main installation and there is ample opportunity to install the HFPSs during such outage this will take preference. In this case the baseline test falls away and for that reason the baseline test should be costed as a take-out option.

The test done before the HFPS installation shall serve as a baseline performance to the *Employer*. The performance tests after the HFPS installation must be conducted within the proving period of 3 months after commissioning.

The *Contractor* must comply with the Quality Assurance standard EN14181 and ISO 9096.

Particulate emission measurements must be carried out employing procedures and equipment which comply with the requirements of United States Environmental Protection Agency (USEPA, Method 17: Determination of particulate matter emissions from stationary sources.).

The *Contractor* supplies the *Employer* with a formal performance test report after the completion of the performance test.

4 CONSTRUCTION

4.1 GENERAL

The *Contractor* is required to:

1. Adhere to the South African Environment Protection Act, the waste management code of practice and the South African Occupational Health and Safety Act No. 85 of 1993, the regulations promulgated thereunder and Eskom Safety, Health, Environment and Quality (SHEQ) Policy 32-727 for all *works*.
2. Submit a comprehensive method statement of the entire *works* to the *Project Manager* for acceptance prior to the start of the *works*
3. Submit a project specific safety file to the *Employer* for comments / acceptance.
4. Submit a detailed level 4 schedule for the *works* to the *Project Manager* for acceptance after contract award.
5. Take all necessary precautions to ensure that none of the existing plant that is not in the scope of *works* is damaged during completion of the *works*.
6. The *Contractor* disposes of all rubble at a waste disposal site to be accepted by the *Project Manager*. The waste disposal site is selected to suit the classification of the materials to be disposed of. Certificates of disposal are required to be submitted to the *Employer,* by the *Contractor*.
7. Store salvaged components, like TR sets and controllers (MCS II) elevated off the ground to protect from ingress of dust and rainwater, etc.
8. Continuously monitor the condition in demolition areas and surrounding areas for any hazardous substances and in such case, the *Contractor* is required to take necessary precautionary measures.
9. Manage access to the working areas and the Site.
10. Manage activities on Site to ensure that no interference takes place between his work and that of others.
11. Complete "Contract Activities Daily Reports".
12. Liaise with the *Supervisor* regarding utilities and telephone facilities required for his Site establishment.
13. Liaise with the *Supervisor* regarding the location of waste disposal sites and rubbish dumps,
14. Maintains and promotes labour harmony on the Site and in the working environment.
15. Immediately report any potential labour disharmony to the *Supervisor*.
16. Not recruit or employ any personnel from the *Employer* and Others, without prior acceptance of the *Project Manager*.

4.2 CONSTRUCTION AND ERECTION

1. The *Contractor* is responsible for the construction of the *works* and all associated services in accordance with the *Contractor's* detailed design and specifications.
2. The *Contractor* disposes of all demolition waste at a licenced waste disposal site to be accepted by the *Project Manager*. The waste disposal site is selected to suit the

classification of the materials to be disposed of. Certificates of disposal are required to be submitted to the *Employer*.

4.3 QUALITY MANAGEMENT

1. The *Contractor* submits a fully detailed Quality Control Plan (QCP) for acceptance within four weeks of the Contract Date.
2. The *Contractor* submits a schedule of unpriced orders to be placed and this is updated regularly.
3. The *Contractor* is responsible for defining the level of QA/QC (intervention Points) or inspection to be imposed on his *Subcontractors* and suppliers of material in the Quality Control Plans (QCPs). This level is based on the criticality of equipment and be submitted to the *Project Manager* for acceptance.
4. The *Contractor* submits on a monthly basis, the following QA returns:
    - A register of Defects with those older than 30 days being flagged and an explanation attached
    - Register of accepted Defects
    - A register of Non Conformance Report
    - Monthly Project Quality Report
    - Monthly updated Site and pre-site programmes
    - Inspection dates
    - Site Acceptance Tests
    - Inspections completed / outstanding
5. All quality control documentation is submitted to the *Project Manager* within 7 days of Contract date.

4.4 HANDOVER

The *Contractor* compiles data books progressively for all manufacturing and construction/erection inspection, operating manuals and test records and documents for every piece of plant worked on. The *Contractor* submits data books to the *Supervisor* and *Project Manager* for their review for all equipment and works undertaken with the applicable requirements and specifications.

Apart from any statutory data packages required, the *Contractor* also compiles and signs off a data package of the relevant drawings, test certificates etc. to the *Project Manager* for acceptance. These include, but are not limited to:

- Surveys
- Approved ITP's, QCP's;
- Method statements and specifications adhered to;
- Rigging studies;
- Risk assessments;
- Approved Drawings;
- Design Calculation Reports
- Fabrication Drawings;
- Material Certificates;
- Weld Map;

- Weld Matrix Sheet;
- Weld Sequence;
- Welding Consumables Certificates;
- Welding Procedure Specifications;
- Welders' Qualifications;
- ESKOM approved NDT Contractor;
- Approved NDT procedure;
- NDT Technician Qualifications;
- NDT Reports/ Results;
- Weld test certificates
- Certificate of Manufacture;
- Inspection Reports;
- Corrosion Protection Consumables Certificates;
- Calibration Certificates;
- Notifications;
- Modifications;
- Concessions;
- Technical Queries, Engineering Responses and communications with *Project Manager/ Employer*
- Non-conformance reports;
- Internal Release Notes;
- Transport notifications;
- Calculations for any temporary works that may be required for the safe execution of the works;
- Material certificates;
- As-built data and drawings of the completed *works* signed by a Professional Engineer/Technologist. As-built drawings are submitted in PDF and native CAD formats (.DGN / .DWG).
- Completion Certificates signed by Professional Engineer/Technologist confirming that *works* have been constructed in accordance with the design as stipulated in the National Building Regulations.

5 PLANT AND MATERIALS STANDARDS AND WORKMANSHIP

The *Contractor* is required to adhere to the latest editions of, and the normative references within, the following SANS standards, codes of practice, regulations & standards for the design, execution and commissioning of the *works.* They are read in conjunction with the technical requirements.

Number	Title
240-56364545	Structural Design and Engineering Standard
240-107981296	Constructability Assessment Guideline
240-56364535	Architectural Design and Green Building Compliance Manual
SANS 10064	The preparation of steel surfaces for coating
SANS 2001-CS1	Construction works Part CS1: Structural steelwork
SANS 50025 series	Hot rolled products of structural steels Parts 1-6

Number	Title
SANS 10400	The Application of the National Building Regulations
SANS 121	Hot dip galvanized coatings on fabricated iron and steel articles - Specifications and test methods
240-56737448	Fire Detection and Life Safety Design Standard
240-54937439	Fire Protection - Detection Assessment Standard
240-54937450	Fire Protection and Life Safety Design Standard
240-56737448	Fire Detection and Life Safety Design
240-109607332	Abbreviation Standard for Labelling of Plant at Power Stations
240-56242363	Emissions Monitoring and Reporting Standard
240-105658000	Supplier Quality Management Specification
240-56227443	Requirements for Control and Power Cables for Power Stations Standard
SANS 10108	Classification of Hazardous Location
OHS Act	Occupational Health and Safety Act No 85 1993
240-86973501	Engineering Drawing Standard Common Requirements
240-128353314	Drawing Number System Standard
240-66920003	Documentation Management Review and Handover Procedure for Gx Coal Projects
240-76992014	Project / Plant Specific Technical Documents and Records Management Work Instruction
240-56356396	Earthing and Lightning Protection Standard
240-75655504	Corrosion Protection Standard for New Indoor and Outdoor Eskom Equipment, Components, Materials and Structures Manufactured from Steel Standard
240-106628253	Standard for Welding Requirements on Eskom Plant
240-56357424	MV and LV Switchgear Protection Standard
240-56227589	List of Approved Electronic Devices to be used on Eskom Power Stations
240-55714363	Coal Fired Power Stations Lighting and Small Power Installation Standard
240-56356396	Earthing and Lightning Protection Standard
240-56227516	Specification for LV Switchgear and Control Gear Assemblies and Associated Equipment for Voltages up to and including 1000 V AC and 1500 V DC
240-56241933	Control of Welding during Construction, Repair and Maintenance Activities Standard
240-56355815	Junction Boxes and Cable Termination
240-56355888	Temperature Measurement Installation
240-56355754	Field Instrument Installation
240-56355535	Process calibration Equipment
240-56355466	Alarm Management System

Number	Title
240-56241933	Control of Welding during Construction, Repair and Maintenance Activities Standard
240-56246601	Qualification, Certification and Accreditation Requirements for Personnel and Entities Performing Welding Related Work on Eskom Plant Standard
EN 13284-1	Stationary source emissions. Determination of low range mass concentration of dust. Manual gravimetric method
CISPR 16	Radio interference levels from ISM equipment
	Duvha Plant Safety Regulations rev. 4
	Duvha Environmental Management Procedure

Table 9: Eskom and International Standards

5.1 ADDITIONAL REQUIREMENTS

5.1.1 General

- The *Contractor* is required to confirm all site dimensions, levels and cast-in items positions on site prior to any fabrication of steel.
- The *Contractor* is required to submit a comprehensive method statement for the *works* to the *Project Manager* for acceptance prior to the start of the *works*
- The *Contractor* is responsible for the design, erection, maintenance and removal of all temporary bracing or propping required for the execution of the *works.*
- The *Contractor* takes full professional accountability and liability for all temporary items required for the execution of the *works*.

5.1.2 Steelwork

- All work is required to be in accordance with the latest edition of SANS 2001-CS1
- The Contractor is responsible for the stability of the entire structure and all structural elements during all the erection stages.
- All dimensions are required to be verified on site by the Contractor before any fabrication of steelwork commences.
- All welding is required to be conducted by coded welders. Supporting documentation is also required to be submitted to the Project Manager for acceptance. All welding is required to comply with AWS D1.1.
- All welds are required to be inspected using visual aids
- The Contractor is required to supply all bolts, washers, nuts etc. for the structural steelwork.
- Welded connections are required to be welded all around with a minimum of 6 mm fillet welds or the appropriately designed fillet weld size. Butt welds are required to be full penetration welds
- Grade 8.8 or higher bolts are to be used throughout
- Minimum thickness of gusset plates is to be 10 mm.

The table below indicates particular specifications pertaining to SANS 2001-CS1 and must be read in conjunction with the code.

Clause	Particular Specification
4.1	**Materials**
4.1.1	Add the following: • All structural steelwork is required to be grade S355JR in accordance with SANS 50025
4.1.4.1	• Electrodes for electric welding are required to be E7018.
4.1.5.1	• Ordinary bolts to be grade 8.8 with class 8 nuts, as a minimum
5.3	**Non-destructive testing of welds**
5.3.3	• Fillet welds are required to undergo magnetic particle inspection (20 % of welds)
5.3.4	• All butt welds and full penetration welds are required to undergo Ultrasonic or X-ray non-destructive testing (100 % of welds)

Table 10: Specifications pertaining to SANS 2001-CS1

6 LIST OF DRAWINGS

This is a list of drawings issued by the *Employer* at or before the Contract Date and which applies to this contract. It is the responsibility of the *Contractor* to verify the correctness of the drawings and dimensions.

Note: Some drawings may contain both Works Information and Site Information.

Drawing number	Revision	Title	Status
0-57/19543	2	UNITS 4-6 PRECIPITATOR CASING ARRANGEMENT AND DETAILS	For Information
0-57/17087	8	UNITS 4-6 PRECIPITATORS GAS CLEANING PLAN GENERAL LAYOUT	For Information
0-57/33530-1	0	UNITS_4-6_PRECIPITATOR SUBSTATION ELECTRICAL EQUIPMENT LAYOUT	For Information
0-57/33530-2	0	UNITS_4-6_PRECIPITATOR SUBSTATION ELECTRICAL EQUIPMENT LAYOUT	For Information
0-57/33530-3	0	UNITS_4-6_PRECIPITATOR SUBSTATION ELECTRICAL EQUIPMENT LAYOUT	For Information
0-57/33530-4	0	UNITS_4-6_PRECIPITATOR SUBSTATION ELECTRICAL EQUIPMENT LAYOUT	For Information

Table 11: List of drawings to be issued by Employer

7. BASELINE APPROVAL

This Technical Specification has been seen and accepted by:

Name and Surname	Designation
David Kunene	Electrical LDE
Niloshen Moodley	Civil and Structural LDE
Sibusiso Nhlapo	C&I LDE
Virginia Mbe	System Engineer
Moloko Radipabe	System Engineer
Takalani Mashamba	System Design

8. REVISIONS

Date	Rev.	Compiler	Remarks
August 2019	1	R Burger	Final Draft
October 2019	2	R Burger	Section 3.2.3: Figure 5 amended to include a firewall Section 3.3.2: Deviation Schedule section was added to the document Section 3.3.3: Maintenance intervals for Duvha amended from 3 years to 18 months Section 3.3.4: The method of cooling which is preferred is stated, along which is not preferred Section 3.5: Required maintenance intervals amended to match that of section 3.3.3 Section 3.3.4: The mentioned ambient dust conditions is amended, both the value and the unit of measurement Section 3.3.4.6: Type test certificates, FATs and SATs are amended Section 3.3.5.2.3: The server software shall be Windows no lower than 2019 version. Also, the client software shall be Windows no lower than 2010 version. Section 3.3.5.2.4: Amended Section 3.3.5.2.6: Amended

9. DEVELOPMENT TEAM

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

- Rishon Burger
- Riana Nieuwoudt
- David Kunene
- Sibusiso Nhlapo
- Niloshen Moodley
- Moloko Radipabe
- Virginia Nama Mbe

10. ACKNOWLEDGEMENTS

N/A

11. APPENDIX A – EXISTING OPERATOR MIMIC AND CONTROL PHILOSOPHY

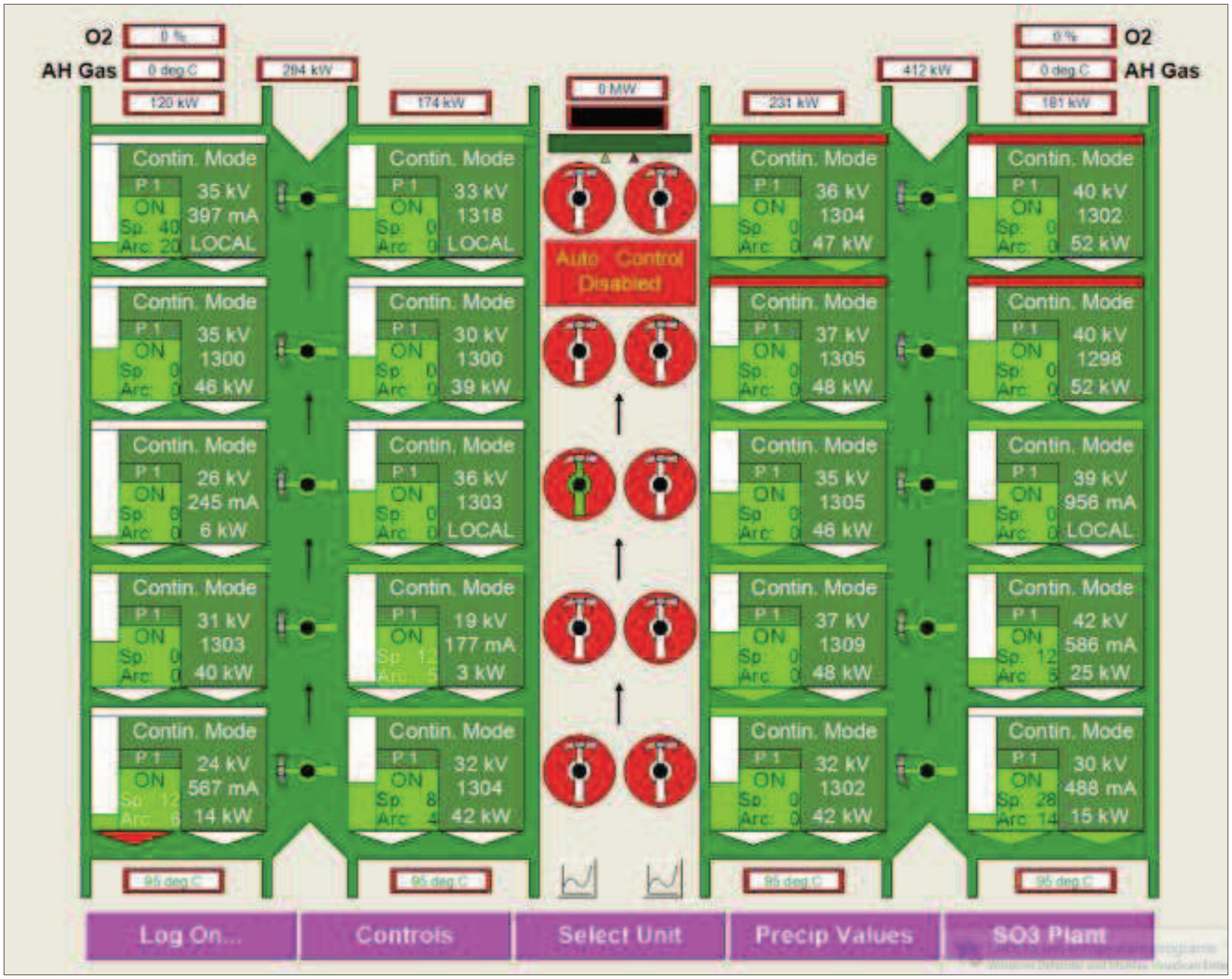

Figure 11: Main mimic of the PPMS

The HFPS installation must be compatible with the PPMS in order to do the following:

- **Auto Program Change** program 1 for full load conditions a routine that change programs according to Generator Load or Emission value set-points.
- **Auto Program Change** program 2 for low load conditions a routine that change programs according to Generator Load or Emission value set-points.
- **Auto Plate Cleaning** program 3 a routines, enabling de-energized or power off rapping according to pre-selected time set-points or Generator Load values.
- **Auto Startup / Shut down** program 4 a routine follow the Shutdown and Startup depending flue gas temperature and number of mills in operation and prescribed time

delays between field starts are taken into account when starting the fields after a shutdown / startup.

- **Auto High Hopper Level Protection** program 6 changes the programs of all fields' controllers that are affected by high hopper levels. A program is set up to protect the electrical fields from mechanical damage when the level is high.

- **Auto Collector Rapper queuing** a routine enabling that no collector rapper rap at the same time, this is to avoid un necessary rapper spike and protect the DHP from flooding and mechanical damage to chain conveyors.

The following rapping philosophy is presently applied and must be available on all five fields (including HFPSs) using the existing PPMS:

- Power off rapping or Reduced power rapping
- Rapper queuing (Rapping one field at a time per casing)

Interface (controls, indications, alarm and trips on PPMS)

Remote controls in the unit control room (as a minimum)

- Rapping
- Secondary current limit
- Secondary Voltage limit
- Secondary Under Voltage trip
- Secondary Under Voltage trip delay
- Sparking rate

Remote indications in the unit control room (as a minimum)

- Primary current
- Primary Voltage
- Secondary Current
- Secondary Voltage
- Sparking rate and accumulated Arcing

Remote alarms in the unit control room (visible as a minimum)

- Over current protection (unbalanced power trip)
- Under voltage trip protection
- Limit conditions of the controller
- HFPS controller fault
- Communications error

Trips (as a minimum)

- Over current protection (unbalanced power trip)
- Under voltage trip protection

12. APPENDIX B: ELECTRICAL LIMIT OF SUPPLY AND SERVICES