Eskom	Technical Specification	Medupi Power Station

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1. **INTRODUCTION**

The excitation system forms part of the export system of the power station unit and is a critical component to the working mechanism of the generator. Medupi Power Station has six 940 MVA synchronous generators which are connected to the national grid. The purpose of the excitation system is to control the stator voltage of a generator.

The present excitation system is of the static type, which means that the main winding output of the generator is used to supply voltage to the excitation system. This is then rectified and supplied to the rotor windings via the brushgear. The AVR automatically adapts the excitation to meet the requirements of the generator. It varies the field current to meet the demand which allows the generator to be adequately controlled and operated anywhere within the generator capability diagram as shown in Figure 1. Failure of the excitation system will result in a Unit trip.

Medupi Power Station is fitted with an excitation system at each of its six Units originally manufactured by ALSTOM, now GE. The life expectancy of these systems are 15 years. Although the life expectancy of these systems has not been reached, some of the internal components have become obsolete, making spares a big challenge for the station. Also, recent failures on the excitation system indicates that the system is unreliable and requires an immediate replacement to keep the Unit in operation. Replacement of this system will ensure better reliability of the export system thus reducing UCLF.

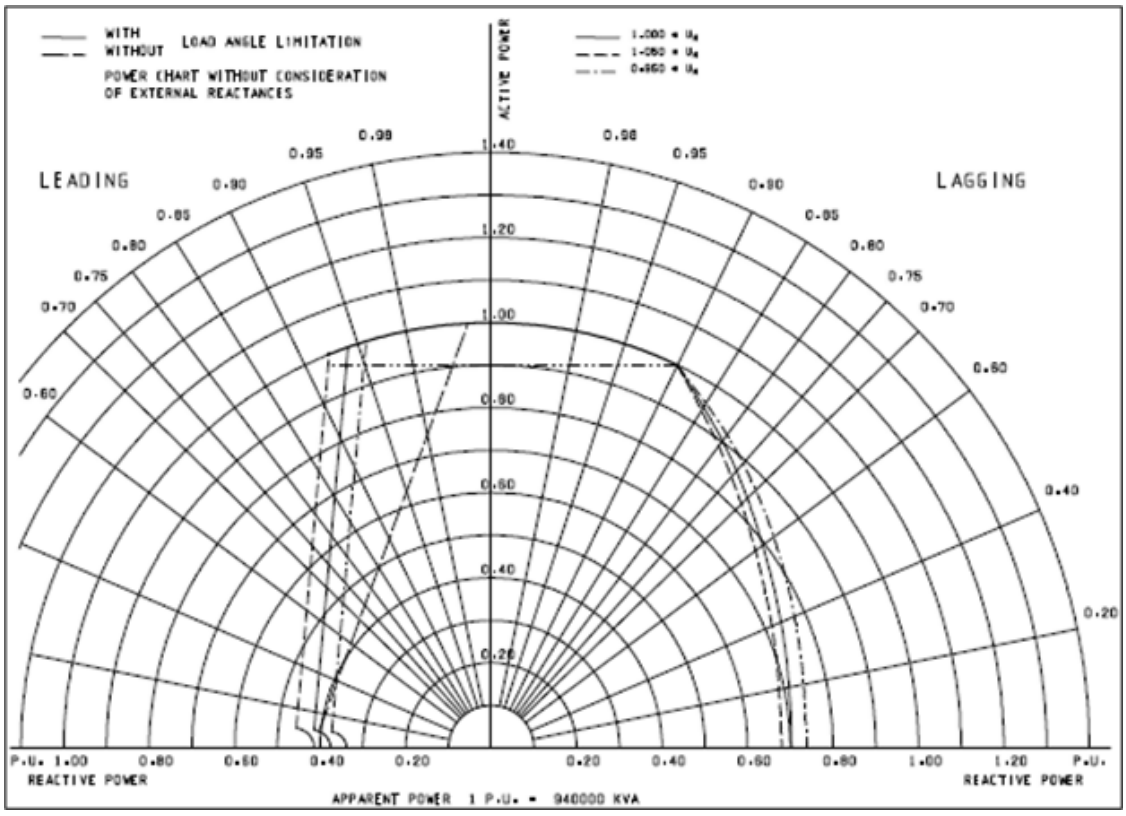

Figure 1: Medupi Generator Capability Diagram

2. SUPPORTING CLAUSES

2.1 SCOPE

The scope of the document is the engineering technical design for the Medupi Power Station Excitation System replacement project.

2.1.1 Purpose

The purpose of this technical specification to define the technical specifications required, meet the ROC requirements for this project and addressing the existing problems experienced on the Medupi power station excitation system.

2.1.2 Applicability

This document applies to Medupi Power Station

2.2 NORMATIVE/INFORMATIVE REFERENCES

2.2.1 Normative

The works shall conform to the documents and drawings listed, as well as other documents forming part of the reference documents.

The applicable revisions and amendments of the reference documents shall be the latest versions in force at the time of the Contract award.

[1] ISO 9001 Quality Management Systems.

[2] QM-58 Supplier Contract Quality Requirements Specification

[3] Construction Regulations, 2014

[4] 32-727 - Eskom Safety, Health, Environment and Quality (SHEQ) Policy

[5] Occupational Health and Safety Act No. 85 of 1993,

[6] 240-4332798: Engineering Policy

[7] 240-56356566: Generation stand-alone disturbance and fault recorder.

[8] 240-56227443: Requirements for Control and Power cables for power station standard

[9] 240 56227589: List of Approved Electronic Devices to be Used on Eskom Power Stations Standard

[10] 240-56356401: Eskom generator protection philosophy for large Fossil Fuel Power Stations with Generator Circuit Breaker Standard

[11] 240- 56357419: Generator Synchronising and network synchronism standard

[12] 240- 56356566: Management of fault recorders standard

[13] IEC 60034-16: Rotating Electrical Machines – Excitation Systems for Synchronous Machines

[14] 240-57859210: Alarm system Performance of Digital Control Systems for Fossil Plant Standard

[15] 240-56355466: Alarm Management System Guideline

[16] 240-56355728: Human Machine Interface Design Requirement Standard

[17] 240-56355731: Environmental Conditions for Process Control Equipment Used at Power Stations Standard

[18] 240-55410927: Cyber Security Standard for Operational Technology

[19] 240-64685228: Generic Specification for Protective Intelligent Electronic Devices

[20] 240-66920003: Project Handover Documentation Management Procedure

[21] 240-76992014: Project/Plant Specific Technical Documents and Records Management Work Instruction

[22] BS 4579: Standard for Performance of Mechanical and Compression Joints in Electric Cable and Wire Connectors

[23] BS 88: Low Voltage Fuses

[24] SANS 60794: Optical fibre cables

2.2.2 Informative

[25] IEC 60255: Measuring relays and protection equipment – whole part

[26] IEC 61850: Design of electrical substation automation

[27] SANS 61850: Communication Networks and Systems for Power Utility Automation Fuses SANS ISO 9001 Quality

2.3 DEFINITIONS

2.3.1 DISCLOSURE CLASSIFICATION

Controlled Disclosure: controlled disclosure to external parties (either enforced by law, or discretionary).

2.4 ABBREVIATIONS

Abbreviation	Description
AC	Alternating Current
AVR	Automatic Voltage Regulator
C&I	Control and Instrumentation
CoE	Centre of Excellence
CT	Current Transformer
DC	Direct Current
DCS	Distributed Control System
ECN	Engineering Change Notification
ECS	Excitation Control System
EDWL	Engineering Design Work Lead
FAT	Factory Acceptance Test
FCR	Field Current Regulator
GCB	Generator Circuit Breaker

Abbreviation	Description
HMI	Human Machine Interface
HVAC	Heating Ventilation and Air Conditioning
HVCB	High Voltage Circuit Breaker
IEC	International Electro technical Commission
IED	Intelligent Electronic Device
LCD	Liquid Crystal Display
LDE	Lead Discipline Engineer
LED	Light Emitting Diode
LPS	Low Pressure Services
NTP	Network Time Protocol
OEM	Original Equipment Manufacturer
OHS	Occupational Health and Safety
PI	Proportional-Integral
PID	Proportional-Integral-Derivative
PSS	Power System Stabiliser
QCP	Quality Control Plan
ROC	Required Operational Capability
SANS	South African National Standards
SAT	Site Acceptance Tests
SCADA	Supervisory Control and Data Acquisition
SHEQ	Safety, Health, Environment, Quality
SNTP	Simple Network Time Protocol
SRD	Stakeholders Requirement Definition
SSME	Support Subject Matter Expert
VDSS	Vendor Document Submittal Schedule
VT	Voltage Transformer

2.5 ROLES AND RESPONSIBILITIES

This document will be used to guide the Requirements Engineering Practitioners and Engineering Design Work Leads in the definition of design related requirements.

Technology Principal: The Technology Principal role is foremost a Governance role responsible and accountable for the work under SCOT and is functionally responsible for the standards in the excitation system. The TP role requires a well-recognised Subject Matter Expert for the excitation system. The role determines the competency requirements in MEA as well as the training and tools required for the technology area.

Engineering Design Work Lead (EDWL): This role is primarily accountable for the integrity of the overall engineering design solution during asset creation and/or modification. This role is the custodian of the

requirements specification (as an integrated set) and co-ordinates the design work provided by the LDE and DE roles and oversees the integration of this work into a final integrated design solution.

a. Accountable to the individual delegated by this Work Instruction to perform Engineering Design and Project Engineering Work.
b. Accountable for the development of the EMAP
c. Is responsible for the integrity of the engineering solution.
d. Accountable for the overall management of interfaces across design disciplines/systems or domains to deliver an integrated solution
e. Accountable for design change management
f. Deliver final and integrated design report related to the project or asset creation scope assigned to him/her.
g. Ensure design is of the desired integrity and meets the agreed requirements
h. Custodian of the requirements-set and the interface register between disciplines/ systems and domains
i. Accountable for the maintenance of the design baseline (Operating and Maintenance)
j. Provides technical input at early upfront planning stages to enable the development of a detail schedule and cost estimates
k. Ensure technical delivery achieved to baseline scope, schedule, and cost
l. Provide feedback on design progress
m. Interface with Eskom business partners on Technical Requirements

Lead Discipline Engineer (LDE): This role manages the technical integrity of designs during asset creation and modification for their specific engineering discipline/system and is accountable for the management of all interfaces and boundary conditions thereof. If appointed individual is not registered, a professionally registered individual must supervise.

a. Accountable to the individual delegated by this Work Instruction to perform Engineering Design and Project Engineering Work or the discipline/system manager further delegated by the former.
b. Supervise the delivery of technically feasible and cost-effective designs within discipline/system
c. Avail the right tools and artefacts to design engineers working under his direction
d. Ensure that governance and due process are followed
e. Co-ordinate and facilitate Engineering Design Reviews
f. Manages the requirements of the specific discipline/systems
g. Manages the boundary conditions of the designs within the specific discipline/system
h. Manage the interfaces between the various design engineers within specific discipline/system
i. Consolidate designs into one integrated design for his/her respective discipline or system
j. Ensure design is compatible with designs from other disciplines or systems

2.6 PROCESS FOR MONITORING

This document shall be monitored through internal and multidisciplinary reviews. Any changes in the requirements are to be managed through the Project Engineering Change Management Procedure (240-53114002).

2.7 RELATED/SUPPORTING DOCUMENTS

1. 241-2022519 - Medupi Power Station Replacement of Excitation System Required Operational Capability

2.8 CODES AND STANDARDS

2.8.1 Electrical

1. South African National Grid Network Code: Version 10.1
2. 240-56356566: Generation stand-alone disturbance and fault recorder.
3. 240-56227443: Requirements for Control and Power cables for power station standard
4. 240 56227589: List of Approved Electronic Devices to be Used on Eskom Power Stations Standard
5. 240- 56356401: Eskom Generator Protection Philosophy for Large Fossil Fuel Power Stations with Generator Circuit Breaker Standard
6. 240- 56357419: Generator Synchronising and network synchronism standard
7. 240- 56356566: Management of fault recorders standard
8. IEC 61869: General requirements for instrument transformers
9. IEC 1218-1: Tensile force heat cycling, resistance and temperature measurement for power lugs
10. SANS 10142-1: Wiring Premises
11. 240-56356396: Earthing and Lightning protection.
12. SANS 60794: Optical fibre cables

2.8.2 C&I

1. 240-57859210 Alarm system Performance of Digital Control Systems for Fossil Plant Standard
2. 240-56355466 Alarm Management System Guideline
3. 240-56355728 Human Machine Interface Design Requirement Standard
4. 240-56355731 Environmental Conditions for Process Control Equipment Used at Power Stations Standard
5. 240-55410927 Cyber Security Standard for Operational Technology
6. SANS 61850 Communication network and Systems for Power Utility Automation
7. SANS 60794 Optical Fibre Cables

2.8.3 Civil & Structural

Parties using this document shall apply the most recent edition of the documents listed below:

1. 240-56364545 - Structural Design and Engineering Standard
2. 240-56364535 - Architectural Design and Green Building Compliance Manual
3. SANS 10400 - The Application of the National Building Regulations
4. Construction Regulations, 2014
5. 240-99527377: Inspection manual for civil works at Eskom's power stations, March 2019.
6. 40-86232481: Medupi Power Station Buildings Roads and Structures Maintenance Strategy
7. 144332407: Guideline for Eskom Power Station Concrete Remedial Works

2.8.4 HVAC

1. 240-102547991 General Specifications for HVAC Systems Standard
2. 240-70164623 Eskom Heating Ventilation and Air Conditioning (HVAC) Design Guideline
3. 240-53114248 Thyristor and Switch Mode Chargers, AC/DC to DC/AC Converters and Inverter / Uninterruptible Power Supplies Standard

2.8.5 Configuration Management

1. ISO 9001 Quality Management Systems.
2. 240-93576498 KKS Coding Standard
3. 240-109607332 Eskom Plant Labelling Abbreviation Standard
4. 240-71432150 Plant Labelling Standard
5. 240-53113685 Design Review Procedure
6. 240-86973501 Engineering drawing Standard

3. ENGINEERING AND THE CONTRACTOR'S DESIGN

3.1 DESCRIPTION OF THE PROJECT

3.1.1 Existing System

Each of the six Medupi Units have an identical static excitation system installed. The whole excitation system consists of the Generator brushgear, the excitation transformer, the DC and AC busbar and ducting and the excitation cubicle. In the static excitation system installed, the power for providing field excitation is supplied from the generator output terminals. The excitation transformer is connected to the output terminals of the generator to step down the voltage to the excitation panel. At the present situation the focus will be on the replacement of the excitation cubicle with all its components. All other equipment will be replaced if interfacing with the new cubicle is not possible.

The currently installed excitation cubicle is an Alstom EM5 cubicle. The system consists of two identical digital voltage regulators, Channel 1 and Channel 2, both with an integrated FCR (Field Current Regulator). Each regulator has its own power supply and its own digital thyristor-firing module. A failure of the active

regulator causes the system to change over to the standby regulator. The cubical have an interface with the DCS for monitoring and control purposes. The excitation cubicle has the following specifications:

Table 1: Excitation Cubicle Specifications

Cubicle Type	EM5
Regulation structure	2/2
Bridge type	KSDK220F125E24-I
Number of rectifier bridges	5
Rated field current	6090 A
No load field current	1942 A
Maximum field current during normal excitation	6699 A
Field current during ceiling excitation (10 sec.)	9744 A
Rated excitation voltage	657 V
Protection index of switch gear and rectifier compartments	IP 31
Protection index of regulator compartment	IP 31

The Excitation cubicle for all the Units is housed in an independent access-controlled excitation room situated on the 0m level of the Unit. The room have a dedicated HVAC system currently installed. Appendix A shows the general arrangement of the excitation panel and Appendix B shows the arrangement of the excitation room.

3.1.2 System Upgrade Overview

The upgraded system would need to ensure that the primary purpose of the excitation control system, which is to provide the varying field current to the generator rotor and control the generator terminal voltage and reactive power to meet the demand of the transmission grid. The upgrade will include:

1. A reliable, redundant and up to date ECS system to allow for:
    a. Ease of maintenance and operating.
    b. Availability of spares and technical knowledge
    c. Ensure that there is no risk of long-term plant outages due to parts, spares or skills shortages.
2. A fault recording system to capture data during fault events.
3. A full redundancy on the communication of the thyristor bridges.

3.2 EMPLOYER'S DESIGN REQUIREMENTS

3.2.1 Employer's design

1. The Employer will make existing plant interface information available to the Contractor. The Employer supplies KKS codes to the Contractor for completion of the interfacing and IO lists.

3.2.2 Parts of the works that the Contractor designs

1. The Contractor provides all the design services for the works, including design of plant, materials layout, all interfaces, additional cabling requirements and any modification required for the HVAC system. These will include but is not limited to general arrangement, single lines, ac and dc key diagrams, cabling terminations, cable block diagrams, cable schedules and input-output (I/O) lists.

2. The Contractors' design interfaces with the Generator Protection panels and the unit DCS. There is also an interface with the HVAC control system.
3. The Contractor provides and designs the communication network for the works, including the HMI, switches and fibre optic cables.

3.2.3 Detail Design Phase

The detail design will be required from the Contractor. The detailed design package consists of:

1. The final drawings (electrical and mechanical) of the complete excitation system to be submitted
2. General layout drawing of the panels,
3. Single line diagram of the solution,
4. Block diagram of the system,
5. Panel internal wiring drawing,
6. Termination and cable schedules,
7. Manuals
8. Software program and the necessary software to review the program, this should include all licence required for the full use of the software.
9. PSS Study Report (Design Report)
10. Transfer functions of the system in the time and frequency domain
11. All specifications of the proposed equipment to be used
12. A complete factory acceptance testing procedure
13. A complete on-site inspection check list
14. An erection check list
15. A complete cold commissioning procedure
16. A complete site acceptance testing procedure
17. A complete hot commissioning testing procedure
18. Maintenance Plan must be in line with station maintenance and outage strategy.
19. A complete recommended spares list

3.2.4 Design procedure and submission for acceptance

1. The Detail Design should be submitted in a soft copy format. Drawings to be submitted in Bentley Microstation format and text documentation to be at least in PDF but the latest version of Microsoft Word is the preferred format for ease of review and commenting.
2. The Detail design is presented to the Project Manager for acceptance prior to factory acceptance testing.

3.2.5 Use of the Contractor's Design

1. The Employer may use the Contractor's design for any purpose in relation to excitation control systems at the Employer's installations.

3.3 FUNCTIONAL REQUIREMENTS FOR THE WORKS

The functional requirements of the excitation system should comply with the latest approved revision of 240-155615284 Generation Excitation System Standard. The section to follow will present the Medupi specific requirements and interfaces of the current installed excitation system.

3.3.1 Functional requirements

The following are descriptions of devices that are to be built into the works or that the works is capable of doing:

1. The control system needs to be digital. This includes sampling of analogue values up to the generation of firing pulses.
2. All settings need to be digital. Analog to digital conversion of potentiometers as setting adjusters shall not be allowed.
3. The control system must not introduce voltage oscillations and the machine terminal voltage is to remain within the limits.
4. The voltage regulator must be continuously acting with adjustments for all gains and time constants, with no dead-band or zone of insensitivity.
5. The regulator must be easily operated, maintained and repaired; ensuring continuous operation of the unit by means of redundancy.
6. Regulator redundancy is provided in the form of two identical automatic voltage-regulating channels, Channel 1 and Channel 2. Both these channels need to be able to act as master while the other follows. This includes the converters if a 1+1 or N-1 configuration is chosen.
7. To minimise the risk of common mode failure, the two channels must not share any power supplies or input or output cards.
8. The voltage control system shall consist of at least a lag-lead-lead-lag controller (similar to a PID controller). The frequency response characteristic shall be adjustable. The variable parameters shall be considered as settings applied to the AVR.
9. Both channels shall include a field current regulator of the proportional plus integral type and constantly following their respective voltage-regulating channels.
10. Each channel shall make provision for a test function, where control of the field current can be done manually without being reliant on any feedback signal from the control system.
    a. This mode shall be available for test purposes only, software interlocking shall be required to activate this function.
    b. The control system must prevent the test mode from being engaged by the operator under normal operating conditions.
    c. The test mode allows for open circuit and short circuit tests to be carried out on the synchronous generator as well as feed-back loop checks of the excitation control system prior to engaging any of the regulation loops.
11. Voltage sensing circuits in the voltage-regulating mode shall respond to the three-phase line-to-line machine terminal voltage. Sensing of only one line-to-line or a line-to-neutral voltage is not acceptable.
12. The machines shall be capable of operating in parallel with stable reactive power. Cross-connection of ECS circuits between machines shall not be acceptable.

13. The regulator must ensure that there are no oscillatory operations before synchronising, on load and after load rejection.
14. All control and communication cables are the responsibility of the Contractor. The Contractor shall provide detailed cable requirements to interface with all other systems as required. Correct terminations on both panel and plant side thereof are done by the Contractor and witnessed by the Employer to ensure correct terminations are done.
15. The system shall have a built-in sequence of events recorder with all logged data time stamped at the source when data originates within the excitation system. All binary inputs originating from external sources are time stamped when the inputs on the I/O cards are activated.
16. An excitation-on interlock must be provided by the unit control system to prevent excitation from being switched on either from remote or local.
17. A field flashing circuit is part of the works to allow reliable excitation build-up upon initial excitation. The field flashing current is supplied from a 400 VAC supply. The field flashing must be able to handle three consecutive field flashing attempts based on the longest field flashing time. The Contractor provides options for both and states the source requirements thereof. The final field flashing arrangement will be finalised during the design phases of the project.
18. Bi-stable relays are used for any status/signal used within the excitation control system that are used for critical plant conditions (e.g. interlocking). Upon loss of auxiliary supply to the relay, the status/signal (i.e., field breaker status, etc.) value may not change except when so intended (i.e. DC fail indication)
19. The excitation control shall start up in Auto mode (Voltage regulator Mode) and preferably to Channel 1 when the power is recycled, provided all the signal that may cause a transfer is healthy. It is therefore important that the boot sequence is set-up correctly to allow proper settling of disturbance signals before the channel and modes selection are applied.

3.3.2 Interface requirements

3.3.2.1 General

1. The Contractor allows enough time to achieve proper interfacing between all the Employer's Engineers and the Contractor. The Contractor is involved in clarifications and technical queries regarding interfacing and be actively involved during interfacing sessions.
2. The following systems will be affected:
    a. Generator Protection
    b. Excitation transformer protection and monitoring
    c. Synchroniser
    d. Generator parameters
    e. Generator CT's and VT's
    f. Excitation transformer AC converter supply
    g. Station and unit AC/DC supplies
    h. Local plant HMI
    i. Floor plans, cable entries and dimensions
    j. KKS requirements
    k. Control room DCS

l. Control room operating desk
m. Grid Code requirements
n. Excitation room HVAC
o. Earth switch

3.3.2.2 Interface details

1. All alarms, events and analogues generated from the ECS must be available for display locally as well as relayed for display to the station DCS system. The interface must provide data in the form of a value and time and that replicates the exact attributes and values from the generated source.
2. The Contractor shall provide all networking components and cabling for all internal network requirements. This includes network switches, network interface cards, device driver software and software licenses.
3. The Contractor provides any fibre optic cables, connections, splices, splice boxes and fibre optic fly leads between the control system, recording equipment and DCS system where required.
4. The following communications setup requirements must be met:
   a. No single point of failure for internal control communication for the Excitation System
5. Interface principle between the ECS and external plant is:
   a. All control signals are hardwired. The ECS has high impedance opto-couplers to interface with these signals. “Wetting voltage” (24VDC) is form the Unit Control System. No control is done via the communication link.
   b. All trip signals are hardwired. No tripping is done via the communication link.
   c. All alarm signals are via communication link to the DCS system, except the alarms that have been strategically selected to be hardwired.
   d. Status information is hardwired only for a few selected signals. All other status information is sent via communication link to the DCS system.
   e. Analog quantities are hardwired 4-20mA for only a few selected analog quantities. The rest are published via communication link to the DCS system.
   f. All I/O interfaces are wired two wires per signal. If needed, bridging is only allowed on the terminal rails and not on the I/O cards or devices themselves.
   g. All hardwired ECS binary inputs are wetted by its own wetting supply. All external plant binary I/O supply’s dry contacts only.

3.3.3 Control and Monitoring Requirements

1. The control circuit shall be of a digital system to allow versatility thereby minimising hardware configuration when changes are required. It shall have extended ability for self-diagnosis, testing and fault finding.
2. The Supplier shall provide a reliable, easy-to-use data input facility which will facilitate local operation in terms of controlling, testing, displaying as well as resetting of alarms. This shall be in the form of a local control panel or industrial PC permanently installed at the excitation control panel.
3. The supplier shall provide three notebook computers with the appropriate operating system as an easy to use data input facility which will also facilitate local operation in terms of controlling, testing,

commissioning, displaying as well as resetting of alarms. It shall also be used for configuration changes and download of configuration for back-ups as well as data logger and any oscillography data for further analysis.

4. The following input signals from the external plant are required as digital inputs to the excitations system. All external binary signals are dry contacts.

Table 2: AVR Binary inputs

Signal to Excitation	Comments
Excitation ON	FCB closes and excitation switches on. Field flashing will also be initiated by the excitation from this command if field flashing is required.
Excitation OFF	Excitation system switch pulses off while FCB stays closed. This command cannot be executed by the excitation while the machine is online/ synchronised to the network.
Excitation ON permissive	A permissive signal from the DCS to allow excitation to be switched on. This shall, as a minimum, include speed>95% *typ)
Excitation Trip Main1	Conditions Main 1 trip. The FCB is also directly tripped from M1.
Excitation Trip Main2	Conditions Main 2 trip. The FCB is also directly tripped from M2.
Excitation OFF Main1	Only switches off excitation, FCB remains closed (FCB may open depending on plant philosophy)
Excitation OFF Main2	Only switches off excitation, FCB remains closed (FCB may open depending on plant philosophy)
Set-point raise block	Gen protection blocks set point raise when V/Hz is detected.
Excitation Active Mode set point raise and lower	Raise and lower signal from control desk/HMI via C&I Unit control system to change the set point of the active mode that is selected.
Force Channel Changeover	Forces a channel changeover in the event of sustained field over current
Channel 1 ON	Selects regulation channel 1
Channel 2 ON	Selects regulation channel 2
PSS ON	Selects PSS to ON
PSS OFF	Selects PSS to OFF
Alarm acknowledge	Acknowledges excitation system alarms and reset alarm if alarm condition has cleared
AVR Mode ON	Ensure regulation is selected to AVR mode when doing any run-up (project specific requirement)
Voltage set-point raise	Set-point raise pulses from Unit Control or Synchroniser
Voltage set-point lower	Set-point lower pulses from Unit Control or Synchroniser
HV yard Breaker closed	HV yard breaker status for excitation off interlocking and superimposed regulator and FCR.
HV yard Breaker open	HV yard breaker status for excitation off interlocking and superimposed regulator and FCR.
Gen Breaker closed	Gen breaker status where applicable.

Signal to Excitation	Comments
Gen Breaker open	Gen breaker status where applicable.
Generator Protection	Generator Protection trip
Alarm acknowledge	Alarm acknowledge from the control room
Reference value AVR Decrease	Reference value decrease from the control room
Reference value AVR Increase	Reference value increase from the control room
PSS Inhibition	
Q annulment	
Voltage Control	
Tan Phi (power factor) regulator	
Q regulator selector	
Note: All signals are preliminary and will be finalised during the detail design phase	

5. The following remote hardwired digital outputs from the excitation are required. All outputs are dry contacts:

Table 3: Binary output signals from the ES per channel

Signal from Excitation	Comments
Excitation is ON	Confirms that excitation is ON
Excitation is OFF	Confirms that excitation is OFF
AVR mode ready	AVR mode selected and no auto fault
AVR mode active	Excitation is on and AVR mode active
Set-point Max AVR	Local and remote indication of AVR Set-point at maximum position
Set-point Min AVR	Local and remote indication of AVR Set-point at minimum position
FCB is open	FCB is open
FCB is open	Fields switch drop out philosophy, hardwired from FCB auxiliary contact
FCB is closed	FCB is closed
Excitation ready	All local conditions are ready to switch on excitation: Not in local, AVR mode selected, all doors closed, field flashing supply healthy, etc.
Channel 1 is ON	Regulation channel 1 selected
Channel 2 is ON	Regulation channel 2 selected
Excitation system tripped	Excitation has tripped, status indication to DCS and other systems.
Excitation system tripped to Main 1	Excitation System trip command to Main 1 Gen Protection (2 x N/O contacts per channel)
Excitation system tripped to Main 2	Excitation System trip command to Main 2 Gen Protection (2 x N/O contacts per channel)

Common alarm	Hardwired alarm; most other alarms may be communicated via communication bus.
Over-excitation alarm	Hardwired alarm, to enable unit operator to act on plant condition
Under-excitation alarm	Hardwired alarm, to enable unit operator to act on plant condition
Gen breaker closed	Hardwired command to close generator breaker
Note: All signals are preliminary and will be finalised during the detail design phase	

6. The following shows analogue signal parameters from the EC to the Unit Control System along with the typical signal requirements. All EC installations must make provision for any additional spare capacity.

Table 4: Typical Analogue signals from the ES to the Unit Control System

Signal from Excitation	Signal
Generator field current	4-20mA
Generator field voltage	4-20mA
Rotor temperature	4-20mA
Converter cubicle temperature	4-20mA
Spare	4-20mA
Spare	4-20mA
Spare	4-20mA

7. Local controls include:
    a. Channel changeover/select from Channel 1 to Channel 2 and vice versa.
    b. Regulation mode selection. (AVR/FCR)
    c. Field breaker close/open commands
    d. Excitation ON/OFF.
    e. Set-point raise and lower of the active channel.
    f. Local alarm acknowledge.
    g. Local alarm resetting.
    h. Power System Stabiliser (PSS) ON/OFF (the default position of the PSS is on).
    i. Local/remote selection via HMI shall be password protected or via external key switch

3.3.4 Alarm and status indications

1. Alarms that have been initiated by the ECS while in service are not to reset automatically when the alarm condition clears. These alarms shall only be cleared by accepting or resetting the system.
2. All alarms and statuses which are sent to the plant DCS shall also be available on the local HMI.
3. As a minimum, the following alarms are made available on the Employer's DCS via communication link:
    a. AVR Manuel ON

b. PSU failure Ch1
c. PSU failure Ch2
d. AVR AC Supply fail
e. AVR DC Supply fail
f. AVR Channel 1 fault
g. AVR Channel 2 fault
h. Converter Bridge x fault: (temp high, pulse loss, fan fail, fuse fail, tripped, etc.)
i. Over excitation limiter active
j. Under excitation limiter active
k. Excitation transformer temperature high alarm (per phase)
l. Excitation transformer temperature very high alarm (per phase)
m. Rotor temperature high alarm
n. Excitation Transformer status (healthy/trip)

4. As a minimum, the following statuses are made available to the Employer's DCS via communication link:
   a. AVR Channel 1 selected.
   b. AVR Channel 2 selected.
   c. Field Breaker open
   d. Field Breaker closed
   e. PSS ON
   f. PSS OFF
   g. Set point minimum reached
   h. Set point maximum reached

5. As a minimum, the following local alarms are made available on the ECS HMI:
   a. Channel 1 AVR not ready
   b. Channel 2 AVR not ready
   c. Channel 1 AC/DC power supply faulty
   d. Channel 2 AC/DC power supply faulty
   e. Channel 1 24 VDC supply faulty
   f. Channel 2 24 VDC supply faulty
   g. Channel 1 synchronising voltage failure
   h. Channel 2 synchronising voltage failure
   i. Converter Bridge * temp high alarm
   j. Converter Bridge * temp high trip

k. Converter Bridge * air flow low alarm
l. Over excitation limiter active
m. Under excitation limiter active
n. field over voltage
o. Rotor temperature alarm level 1 and 2
p. Emergency change over initiated
q. Conduction monitoring alarm and trip condition indicating which bridge/bridges and element are faulty

6. As a minimum, the following local statuses are made available on the AVR HMI:
   a. Active channel in operation (Channel 1 or Channel 2)
   b. Active mode in operation (Auto/Manual)
   c. Excitation OFF
   d. Excitation ON
   e. Field breaker is closed
   f. Field breaker is open
   g. PSS ON
   h. PSS OFF
   i. Local operation selected
   j. Remote operation selected

7. Additional alarms/statuses of the plant that the Contractor deems necessary are to be provided and will be reviewed by the design team. The Contractor will be responsible for any upgrades to the DCS and the necessary wiring due to the additional alarm/statuses.

3.3.5 Local analogue indication requirements

1. Permanent indication of all machine quantities is required.
2. The following panel mounted indicating instruments are provided:
   a. Generator stator voltage
   b. Generator stator current
   c. Generator active power
   d. Generator Power factor
   e. Generator reactive power
   f. Generator field current
   g. Generator field voltage
3. All the indicating instruments are analog instruments with sizes, accuracy, full-scale deflection angle etc. If a LCD panel with analog instruments is provided, its time response emulates that of true analog indications. Bar graph type displays are not allowed.

4. Instrument displays are consistent, i.e. all instruments have the same face size, similar scale markings and the same full-scale deflection angle.
5. Transducers/isolating amplifiers for all quantities are provided by the Contractor.
6. Requirements for the transducers to be specified by the Employer and Contractor.
7. Requirements for the indicating instruments to be specified by the Employer and the Contractor.

3.3.6 Engineering and Special tools

1. Notebook PCs are generally not regarded as special tools but the Contractor has to provide at least three such devices and these are available during FAT. Notebook PCs are dedicated to the ECS and due to driver compatibility issues and rigorous testing by the Contractors to choose the right hardware, they are regarded as special tools for this project. Notebooks are to be supplied with licensed operating system software and disks. The Contractor provides a fully functional engineering tool to commission and modify all intelligent electronic devices supplied as part of the Works. The engineering tool includes the necessary software and hardware required to access the intelligent electronic devices.
2. There are a minimum of two special tools for all other special tools supplied to this project.

3.3.7 Field flashing

1. Field flashing is a requirement and attention to the breaking capacity of the field flashing contactor is given especially if the supply voltage is higher than the rated field voltage for open circuit conditions. This is to prevent over excitation that can lead to over voltages on the machine.
2. Protection with the aid of a timer is used to stop the field flashing should the machine not self-excite within a predetermined time.
3. The Contractor indicates exactly the application of field flashing and proves that it can withstand all the requirements in the proposed arrangement. Options for both AC and DC field flashing to be provided.
4. The existing field flashing supply comes from the 400V AC supply.

3.3.8 Power supplies

1. The main source of auxiliary power is supplied by the excitation transformer and dry type auxiliary transformers. This is to allow the excitation system to be as autonomous as possible.
2. The power supply transformers are adequately sized to allow the primary source of control power to be derived from this source.
3. Suitable filtering is installed so that the connected power supply modules are not affected by any commutation interference from the power electronics.
4. The Employer provides protection in the form of fuses/circuit breakers for all station supplies at the supply points.
5. The dual outlet wall socket supply in the ECS panels has earth leakage protection as required by SANS10142-1 and complies with the 16A, 250V South African socket outlet requirements.
6. The secondary source of power for internal power supplies comes from one 220VDC supplies from the Essential DC board. VA requirement of the supply is provided by the Contractor. This supply needs to be moved to a clean DC supply.
7. This 220VDC supply is also used as a tripping supply.

8. Two independent power supplies per channel supply the control system's "Channel 1" and "Channel 2" as a primary source of power.
9. Please note that power can only be diode decoupled after galvanic isolation of the primary sources i.e. only the secondary side of the power supplies. Diode decoupling on the primary side is completely unacceptable.
10. The following supplies are currently available for the ECS panel:
    a. 400V 4 wire AC supply
    b. 220V AC supply from non-essential boards
    c. 200V DC Unit supplies

3.3.9 LV Control Transformers

1. All new transformers supplied are of the dry type.
2. The use of toxic insulation materials is not allowed.
3. The leakage flux produced by any magnetic component is kept as low as possible to avoid heating of its mountings and surrounding components.

3.3.10 Converter Bridges

1. The converter bridges shall have a N-1 redundancy.
2. Each rectifier element is permanently marked with its make, rating and manufacturer's type number.
3. The plant and material are rated to achieve continuous maximum field forcing excitation even under N-1 configuration.
4. The Contractor ensures that all Plant and Material is rated to withstand the highest possible surge current and surge over-voltage.
5. The surge calculations are submitted to the Project Manager for acceptance.
6. The converters are rated to be installed and operated with forced air cooling in an environment with an ambient temperature of 40°C.
7. Air is taken in from the bottom of the panel and exhausted at the top.
8. When the panel have fans for cooling of the bridges quick and easy maintenance is required to minimise system downtime as well as to improve the quality of the work. The Contractor shall propose a replacement system; the feasibility of this shall be reviewed and approved by the Employer.
9. The contractor shall furthermore display the type of monitoring and control used for the cooling mechanism.
10. Proper filtering with easily removable filter elements for cleaning is provided. It is known that the filters get clogged up quite frequently due to PF and dust, filter design caters for these environmental conditions. Quick replacement is required to minimise contaminants to enter the cubicles while filter changes take place.
11. The cooling fan motor assembly shall be readily available in South Africa.
12. Each converter has fan redundancy in the design. To ensure that all fans are operative, fans selection/change-over is performed and monitored immediately after initial excitation to give the assurance that the redundant fans are operational/serviceable. This automated check is a

prerequisite for the excitation system ready signal to the control system to allow the synchroniser to be switched on.

13. The cooling fans have separate internal supply transformers for the “main” fans and the “back-up fans”. Each fan set also have an external test supply input and can be selected to either main supply or test supply.
14. The panels fit the existing floor space occupied by the existing excitation panels. Should more floor space be required, the Contractor ensures that load carrying ability of the floor is not exceeded. The height, width and total length of the installed panels are designed to fit the available space. Any additional space requirements are clarified with the Employer during the basic design phase.
15. The Contractor provides the dimensions on the drawings and confirms the position indicated as acceptable.
16. The panels are exposed to high and low temperatures, high and low humidity and therefore be rated as IP54CH in terms of SANS IEC60529.
17. No water-cooled converter stacks are allowed.
18. If any part of the cooling systems fails, an alarm is activated both locally and remotely.
19. Temperature monitoring of the converters are supplied as well as air flow sensors.
20. Each cubicle door for the cubicles installed has a lockable handle to open and close the door.
21. The locking mechanism for the handle is external to the handle to accept padlocks.
22. Each excitation cubicle door is equipped with a high quality limit switch. These switches are required as an interlock for all doors to be closed before excitation can be switched on and generates an alarm in the event list. Post excitation on, these switches only generates an alarm in the event list and does not trip the excitation system.
23. The polarity on the slip rings needs to be swapped around about every 18 to 36 months. The converter or field breaker cubicles make provision for short pieces of bus bars to be used as polarity change links. It is possible to make these changes without dismantling any part of the cubicle or other parts of the bus bar or field breaker. These links are also easily accessible within the panel.
24. A new shunt for field current measurement is fitted to the DC bus bars in the converter/field breaker cubicles.
25. Studs or bolts that are part of insulators used to support bus bar or shunts do not form part of any conduction path bolted joint. Insulators only support the conductors for mechanical rigidity and insulation purposes.
26. All bus bar support insulators are rigid enough to withstand the electro-mechanical forces of the bus bar and or cabling under short circuit conditions. Design calculation of any cable or bus bar supports are provided to the Project Manager for approval.
27. All cubicles are adequately earthed to the station earth. The station earthing point is provided by the Employer. The Contractor supplies the earth connection material and connects the panels to the supplied earthing point.
28. A converter test supply during outages related maintenance is required inside the panel. This can be in parallel with the flashing circuit supply. Feedback from this supply needs to go to the controllers. Any connection to a test must also isolate the normal supply to prevent back energising of the excitation transformer.
29. Any communication breakdown to the bridges should not limit the performance of the other bridges and the control should indicate the position of the communication breakdown.

3.3.11 Protection device requirements

1. All protective relays/IEDs and circuits comply with 32-333 and 240-64685228.
2. The relays/IEDs do not malfunction should the DC auxiliary supplies be switched on and off permanently or repeatedly at a random rate.
3. Refer to specification 32-333/240-64685228 for the required apparatus performance under electrical disturbances.

3.3.12 Spares and Equipment List

3.3.12.1 Recommended Spares List

1. The Contractor submits a recommended spares list with prices at tender stage.
2. A critical list of spares is issued by the Contractor. Such list features a minimum of one of each of the major components.
3. The final list is agreed in consultation with the Customer. The Contractor guarantees the supply of spares for a period of minimum fifteen years.

3.3.12.2 Spares

1. The Employer intends to keep as little spares as possible and is to negotiate a spares management system with the Contractor.
2. The Contractor guarantees the availability of spares for a minimum period of fifteen years from the date of last delivery.
3. When the Contractor intends to discontinue the manufacture of spares, during the fifteen-year period, the Contractor is to give written notice to the Employer of such intention three years before production ceases.
4. The Employer is to have the right within six months of receiving notice, to order at reasonable prices, the quantities of spares required.
5. Also, the Contractor must demonstrate an upgrade path philosophy for the newly installed equipment (new relay platform development will be compatible with the newly installed equipment, including software and firmware upgrades).
6. A proper and adequate service agreement with the Contractor is going to be entered into by the Customer in order to ensure spares and technical support availability for the equipment replaced.

3.3.12.3 Spares Availability during Project implementation

1. In order to ensure seamless project implementation and to avoid possible costly delays during equipment replacement time window (possible extension of duration of an outage or postponement of the replacement), it is required that the Contractor secures the availability of one complete set of spares for one complete AVR unit and its associated equipment at all times for the duration of the project implementation.
2. This is to deal with possible failures and to ensure that project goalposts are not impacted during execution.
3. The spares are made available before the completion of the first unit.

3.3.12.4 Wiring and Wiring Identification

1. All current and voltage transformer circuits are wired with colour coded multi-strand 2,5mm² PVC wire.
2. The control and voltage transformer circuits are wired such that the voltage drop does not exceed 1,5% under any conditions.
3. The AC circuits are wired with multi-strand 2,5mm² black PVC wire and DC panel wiring and bus wiring are wired with 1.5mm² grey multi-strand PVC wire.
4. For easy wiring code identification wire colours are as follows:
    a. Black for AC circuits
    b. Grey for DC circuits
    c. CT and VT wiring are coloured as per the phase - red, white, blue and black (neutral).
5. Bus wiring is terminated on one side of the terminals only. This leaves one side of the terminals free for individual panel use only. If more than two wires are required to be connected on the bus wiring side of the terminal, an extra set of terminals is placed next to the first two, with bridge pieces (note: multi-strand wire bridge piece with lugs) to provide connection points.
6. Alphanumeric ferrule codes are to be provided on all wires. All panel wiring is marked with Grafoplast wiring markers or equivalent (subject to Project Manager acceptance).
7. Wires are marked on both ends with the same number. A wire adopting its termination point in a terminal rail as its wire number is not acceptable. When one wire has to move from one terminal to another the complete philosophy fails.
8. Alphanumeric ferrule codes are provided on all wire ends shown on the standard current transformer and voltage transformer circuits and on all bus wires.
9. Ferrules with wire identification numbers read from left to right (the right way up) on vertical terminal strips and from top to bottom in all other cases. Ferruling will be of the type that can be removed or changed without disconnecting or cutting wires.
10. Stripping of insulation is done in such a way that conductors are not damaged. The stripping tool is of the type that permits the length of the strip to be pre-set.
11. The crimping tool does not release the termination during normal operating until the crimp is correctly formed. The crimping tool is regularly inspected for correctly forming the crimp and the pressure of the release mechanism. The crimping tool must not damage the wiring and lug insulation. Note: No “pin” crimping allowed.
12. All wire ends are terminated using crimp type lugs. Not more than two conductors are connected to any single side of a terminal.
13. For control wiring each wire tail is of sufficient length to reach the allocated equipment plus an additional length of 50mm to facilitate changes in wiring. The slack appears as close as possible to the component in the form of a loop.
14. Wiring presents a neat appearance and is braced and placed in PVC trunking to prevent vibration and the possibility of forces being exerted on termination arrangements. Where only a few wires have to be braced (excluding panel doors) “wash line” supports are used, no stick-on plastic bracing supports is allowed.
15. Wires to plant and material on swing doors are so arranged as to give a twisting motion and not a bending motion to wires.

16. Wires passing through holes in compartments are protected by means of neoprene grommets. Bevelling of sheet steel is not acceptable as a substitute.
17. No panel wiring must be joined other than via a terminal.
18. Dielectric (insulation withstand) test of all wiring is conducted using 1kV to earth for 60 seconds with all electronic equipment's disconnected.

3.3.12.5 Terminals

3.3.12.5.1 Materials and Construction

1. Moulding materials are self-extinguishing, or resistant to flame propagation, substantially non-hygroscopic, and do not carbonise when tested for tracking.
2. The mouldings are dimensionally stable and have high impact strength.
3. The materials used are to be of the flexible type to avoid cracking of terminals.
4. Mouldings are mechanically robust, of flexible material and withstand the maximum possible torque that may be applied to the terminal screws.
5. Terminals where pressure is applied to the moulding when tightening the terminal screw or nut are not acceptable.
6. Steel parts, other than stainless steel, are plated and passivated.
7. Current carrying parts are non-ferrous and plated. All plating is compatible with other parts of terminations and lugs.
8. Screws into steel are steel, stainless steel or phosphor bronze. Steel screws are plated and passivated.
9. All plating complies with the standards BS 1706 and BS 1182 parts 1, 2 and 5.
10. Tapped holes have not less than 1 full thread.
11. Separate terminals are provided on each unit for incoming and outgoing connections and their contact pressure is independent of each other.
12. Terminal covers or shrouds and barriers, are of insulation material, self-extinguishing or resistant to flame propagation, mechanically robust and preferably clip into the moulding.

3.3.12.5.2 Mounting

1. The terminals are spring retained on the assembly rail complying with DIN EN 50045 and when mounted and wired in service is close fitting to avoid the accumulation of foreign matter between adjacent terminals.
2. End barriers or shields are provided for open sided patterns.
3. It is possible to replace any terminal in an assembly without dismantling adjacent units; it is permissible, however, to loosen any clamping device.
4. Screw retention of any component from the rear of the mounting rail is not acceptable.
5. All terminal blocks are readily accessible.

3.3.12.5.3 Power Terminals

1. Terminals for external power cables up to and including 16 mm² are of the screw clamp insertion type or stud type complete with bolts, nuts, washers and locking devices.
2. Terminals for external power cables above 16 mm² are of the stud type complete with bolts, nuts, washers and locking devices.
3. Drilled solid copper bars are provided for terminating all external power cables 35 mm² and above also where three or more cables in parallel are specified.
4. The arrangement is suitable for accepting cable lugs on conductors up to 630mm² and is complete with bolts, nuts, washers and locking devices.

3.3.12.5.4 Control Terminals

1. The terminals are of the rail mounted screw clamp spring loaded insertion type where terminations or lugs are compressed between two plates by means of terminal screws.
2. Terminals are spring loaded such that the action of the springs is independent of the action of the terminal screws.
3. Terminal screws are captive within the mouldings and their heads do not project above the mouldings when fully released.
4. Each terminal accepts up to two hooked blade type lugs.
5. Terminal entries are shrouded such that no current carrying metal is exposed when hooked blade lugs are fitted.
6. Springs are aged and withstand corrosion that might affect performance during their working life. Springs do not carry current (i.e. Springs on each side of terminal is not connected to one another).
7. Cross connection facilities are provided for connecting two or more adjacent terminal ways without interfering with the terminal openings.
8. Where used in current transformer circuits, the terminals are capable of accepting hooked blade lugs (4mm wide) on 2.5 and 4mm² wire.
9. The terminals are sized to provide for pre-insulated lugs to fit after being crimped with the ‘flat’ crimp lying parallel with the rail.
10. The insulation impulse level and isolation requirements between individual terminals are to be guaranteed.

3.3.12.5.5 Stud Type

1. Two terminal studs are provided for each “way” and are of sufficient length to accommodate two ring tongue terminations in addition to a full nut and a locking device.
2. Loose links, where provided, are secured by a nut and washers, and are of tin-plated copper or brass.
3. Barriers are provided between terminal “ways”.
4. These barriers project at least 1 mm above the studs.

3.3.12.5.6 Screw Clamp Insertion Type

1. The terminals are rail mounted and comply with the requirements as laid down for the control terminals with the exception that they are not spring loaded.

3.3.12.5.7 Component Terminals

1. All types of commonly used terminals are permitted according to ESI Standard 12-1 or agreed by the Employer.
2. However the type of terminal in which the screw bears directly onto the termination or the conductor (i.e. “pinches the conductor”) is not acceptable.

3.3.12.5.8 Unit DCS Interface Terminals

1. Screw type corrosion protected disconnect test terminals (blade type) are used for the protection and control interface to the DCS system.
2. The terminals are suitable to accommodate 0.5 mm ² UVG type cables.
3. The terminals are separately mounted in the panels and are not mixed with other voltages and terminals.

3.3.12.5.9 Control Lugs

1. All Control lugs are of the compression type.
2. Cable lugs and ferrules are in compliance with NRS 028:1991.

3.3.12.6 Power Lugs

1. Crimping of power lugs is in accordance with BS 4579 Part 1.
2. Crimping tools are re-calibrated according to their manufacturer specifications.
3. The crimped area is equal to the conductor square area.
4. Documented proof of conformance to IEC 1218-1 specification requirements for tensile force heat cycling, resistance and temperature measurement may be requested by the Employer.

3.3.12.7 Hardware

1. The equipment does not mal-operate if the DC auxiliary supplies are switched on or off permanently or repeatedly at a random rate for periods of no longer than 500ms.

3.3.12.8 Operating Indicators

1. Operation indicators, e.g. alarm and trip annunciation, operate immediately when the protection functions operate.
2. Indicating lamps are of the LED type and are easily replaceable from the front of the panel without the use of special tools.
3. The voltage of the lamps is as per the circuit served.
4. The mounting of the lamp and resistor facilitates adequate ventilation.
5. Visual indication of alarms might also be served via scrollable LCD display or other type of visual display.

3.3.12.9 Test Facilities

1. The Contractor is responsible for factory and routine testing in conjunction with the Employer’s representative.

2. Commissioning is carried out by means of microprocessor protection relay test equipment, accessing the incoming current and voltage quantities to the relays via associated current test blocks and voltage test blocks.
3. Test blocks are provided for all current and voltage quantities.
4. Testing and interrogation of the protection equipment is done via means of communication ports in the front of the panels.

3.3.12.10 Instrument Transformers

1. **Voltage transformers**
   a. The Employer's standard VT secondary voltages are 110 V phase-to-phase and 63.5 V phase to neutral.
2. **Current transformers**
   a. The Employer's standard CT secondary currents are 1 amp.
   b. Main and interposing CT ratios will be shown in drawings provided by the Employer.

3.3.12.11 Fuse links and carriers

1. Fuses are of the BS 88 or equivalent industrial high breaking capacity type.
2. Fuse links and fuse bases for bolted connections are used for power fuse applications.
3. Fuse links and fuse bases with blade contacts are not acceptable for this application.
4. All other fuses for DC and AC supply and VT fuses and fuse holders are of the type NFS or equivalent.
5. No screw type fuse holders are permitted.

3.3.12.12 Earthing requirements

1. The apparatus is adequately earthed.
2. All non-current carrying conductive parts including the entire panel frame, all removable covers, relays, meters, gland plates, etc., are effectively connected to the earthing conductor by means of their mounting arrangement on the panel or by a separate earthing conductor.
3. This is done in such a way that the touch potential at any point on the panel due to a full phase to phase or phase to earth fault is limited to earth potential.
4. The earthing conductor is connected to the station earth mat at the designated earthing point of the panel.
5. The earthing conductor is pre-drilled to allow for connection to the station earth mat.
6. Should additional earthing conductor be required to meet the above requirements and specifications, the Contractor provides and installs such material.

3.3.13 C&I

3.3.13.1 Existing System Description:

The Contractor shall review and maintain the existing alarm signals during concept, detail design, supply and installation of new excitation system. All alarm signals are via communication link to the DCS system,

except the alarms that have been strategically selected to be hardwired. The performance standards and technical requirements for the DCS are set out below:

1. 240-57859210 Alarm system Performance of Digital Control Systems for Fossil Plant Standard
2. 240-56355466 Alarm Management System Guideline
3. 240-56355728 Human Machine Interface Design Requirement Standard
4. 240-56355731 Environmental Conditions for Process Control Equipment Used at Power Stations Standard
5. 240-55410927 Cyber Security Standard for Operational Technology
6. SANS 61850 Communication network and Systems for Power Utility Automation
7. SANS 60794 Optical Fibre Cables

The Contractor shall study these standards and procedures to understand the requirements and constraints pertaining the interfacing of excitation system to the DCS. Where applicability of these standards and procedures is not clear the Contractor shall query such with Engineer before undertaking Works.

The Contractor shall submit the following documentation for approval by the Engineer:

1. Distributed Control System interfacing drawings and interface to the local control system (HMI).
2. Detailed signal list.
3. Loop Test Plans.
4. General Arrangement drawings.
5. Alarm list.
6. Electrical schematic diagrams showing the interface to the DCS.
7. Ensure sufficient alarm management, where alarms shall be prioritised and rationalised to achieve the following:
    a. Minimal false and nuisance alarms.
    b. Distinguish between operational and maintenance alarms.
    c. Allow for easy operator navigation and understanding of alarms.
8. Complete the following documentation and submit for approval:
    a. Signals List.
    b. Alarm Schedule – including alarm priority, recommended operator response and response times.
    c. Termination Diagrams to the DCS.
9. The list of the existing DCS signals interfacing with excitation system, on both Siemens and ALSTOM Systems, is found on APPENDIX A:

3.3.13.2 Parts of the works which the Contractor is to design

The Contractor's scope of work includes detail design, manufacture or procure, factory acceptance testing (FAT), supply, delivery, off-loading, installation, site acceptance testing (SAT), hot commissioning (Including Grid Code Require tests) and handover the following works namely:

1. The Contractor to design, supply, install and commission the ECS.
2. The Contractor to ensure that the HMI is updated as per the project requirements.

3.3.13.2.1 Standardization

The design of the ECS, Control Panel and HMI updates shall ensure standardization for simplified operation and maintenance and reduce lifecycle management costs. The system shall employ a uniform approach across the units for the ECS and the control panel architecture, basic functional characteristics, system interfaces and documentation.

3.3.13.2.2 Contract Plant

The Contractor shall supply, install and commission his works as detailed in these specifications.

3.3.13.2.3 Contract Documents and Information

The Contractor shall supply documentation and information as per the VDSS.

3.3.13.2.4 Design Services and Engineering Responsibilities for Control Systems

The Contractor is responsible for obtaining all relevant information, via the Employer, of systems outside his supply where it affects his works as detailed in these specifications.

3.3.13.2.5 Erection/installation and Commissioning of Control and Instrumentation Plant

The Contractor shall ensure that the performance of the works is optimized by providing all necessary assistance and test equipment to the Employer.

The installation shall comply with the requirements of the following:

a. 240-57859210 Alarm system Performance of Digital Control Systems for Fossil Plant Standard
b. 240-56355466 Alarm Management System Guideline
c. 240-56355728 Human Machine Interface Design Requirement Standard
d. 240-56355731 Environmental Conditions for Process Control Equipment Used at Power Stations Standard
e. 240-55410927 Cyber Security Standard for Operational Technology
f. SANS 61850 Communication network and Systems for Power Utility Automation
g. SANS 60794 Optical Fibre Cables

3.3.13.3 Scope of Supply

The Contractor shall be responsible for the engineering, procurement, delivery to site, installation, commissioning, testing and rectification work during the Defects Notification Period of the control system for his works as detailed in the specifications.

3.3.13.3.1 Commissioning and Maintenance Spares List

The Contractor shall provide a complete recommended spares list for all equipment forming part of the works for maintaining the ECS and the control panel.

3.3.13.3.2 Procedure for submission and acceptance of Contractor's design

The Contractor is to supply detailed design drawings and information to be first reviewed and approved by the Employer before the Contractor can commence with installation. These design documents should indicate exactly how the upgrade above will be designed, installed, tested and commissioned.

3.3.13.3.3 Other requirements of the Contractor's design

1. The modifications should not influence the current performance negatively of the control system in anyway.
2. Maintainability characteristics to be sufficient for sustaining required availability of 98% – maintenance should thus only have to be performed when the system is not in use.
3. Adequate space to be provided to allow for the execution of required maintenance on the newly installed components/systems.
4. The same equipment must be employed across all units at Medupi Power Station.

3.3.14 Structural Design

1. The Contractor takes full professional accountability and liability for the existing structure for the loads induced by all equipment relocated to the equipment room
2. The Contractor provides the following to the Project Manager for review and acceptance:
3. Consolidated detailed design report signed by a Professional Civil/Structural Engineer with structural engineering projects experience which includes:
4. Survey drawings, existing infrastructure assessment report, 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.
5. Detailed drawings for construction. Drawings are also submitted in CAD formats (Bentley Microsoft DGN).
6. All submitted drawings to be signed by a Professional Civil/Structural Engineer with ECSA registration number stated on drawing. The Professional Civil Engineer must hold BSc /BEng Civil Engineering qualification as minimum requirements with proven experience on design and construction supervision of structural engineering projects.
7. All structural designs to be in accordance with 240-56364545 - Structural Design and Engineering Standard

3.3.14.1 Production of As-Built information required for the design.

1. The Contractor is required to produce as-built structural drawings of the floor structure to the extent required for the structural analysis to determine whether the new equipment will be adequately supported.
2. As-built drawings indicate floor beam sizes, connection details, concrete and reinforcement details as well as positions of existing equipment supported by floor.

3.3.14.2 Analysis of Existing Equipment floor Structure

1. The Contractor conducts an analysis of the floor structure for the imposed load of the new equipment in accordance with the standards referenced in the Works Information.
2. The Contractor is responsible for the design of any modifications for the strengthening of the floor if required.
3. 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 for the instances where structural modifications are required to the existing structure.
4. The Contractor's Designer is responsible for any technical queries that may arise during the works and conducts the necessary level of construction monitoring required to certify that the works are constructed in accordance with the design and provides a Certificate signed by a Professional Engineer in this regard.
5. The Contractor submits the detailed design report and construction drawings for acceptance before any construction can take place.

3.3.15 HVAC design

The Contractor shall review, modify, and provide HVAC for excitation a concept, detail design, supply and installation of equipment its associated ducting, and air conditioning to control the ambient conditions. The performance standards and technical requirements for the HVAC Works are set out in the following specifications:

1. 240-102547991 General Specifications for HVAC Systems Standard
2. 240-70164623 Eskom Heating Ventilation and Air Conditioning (HVAC) Design Guideline

The Contractor shall study these standards and procedures to understand the requirements and constraints pertaining execution of the HVAC Works. Where applicability of these standards and procedures is not clear the Contractor shall query such with Engineer before undertaking Works that are the subject of these documents.

1. The current HVAC installation shall be reviewed for compatibility and effectiveness with the new excitation system.
2. Heat load calculations shall be completed and produced for the room environment with the cooling capacities required.
3. The HVAC design is to operate hand in hand with the cooling/heat extraction methodology of the excitation panel. The final HVAC system capability shall be such that the cooling capacity has an extra 10% sized into it.
4. The contractor shall produce 2 options for the HVAC system which is to be approved by the Engineer.

The Contractor shall submit the following documentation for approval by the Engineer:

1. Control drawings showing zoning, fire interface and connection and smoke extract functionality.
2. Detailed equipment list.
3. Inspection Test Plans.
4. General Arrangement drawings.

5. Alarm list (template supplied by the Employer)
6. Air, chilled water and Cooling water P&IDs including control loops where applicable.
7. Electrical schematic diagrams
8. Ensure sufficient alarm management, where alarms shall be prioritised and rationalised to achieve the following:
    a. Minimal false and nuisance alarms.
    b. Distinguish between operational and maintenance alarms.
    c. Allow for easy operator navigation and understanding of alarms.
9. Provide electrical works as indicated in the Works HVAC specification.
10. Provide Operation & Maintenance Manuals and Training Manuals
11. Complete Aux power schedule for all permanent power requirements
12. Local Control Panel/ Network Control panel that shows the plant status shall be provided showing critical parameters of the system performance and room conditions. The control panel will be linked with the DCS system reporting alarms and shall have trending capabilities.
13. Provisions to be made for the automatic shutdown of the HVAC system when the unit is off, and an automatic start when unit is on load.
14. Complete the following documentation and submit for approval:
    a. Virtual Signals List
    b. Alarm Schedule – including alarm priority, recommended operator response and response times.
    c. Drive and Actuator Schedule.
    d. Instrument Schedule
    e. Cable Schedule
    f. General Arrangements of cubicles.
    g. Hook Up Diagrams.
    h. Panel Interface List.
    i. Termination Diagrams.
15. The contractor shall provide training on the operations and maintenance of the HVAC system supplied inclusive of fault finding, general operations etc.

3.4 OTHER REQUIREMENTS OF THE CONTRACTOR'S DESIGN

3.4.1 Documentation and Configuration Management

3.4.1.1 Document identification

All documents supplied by the Contractor are subject to the Employer's approval. The language of all documentation is required to be 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.

3.4.1.2 Document Submission

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

The Contractor is required to submit documents as electronic and hard copies and both copies must be delivered to the Employer's Representative with a transmittal note.

In addition, the Contractor adheres to the following standards:

1. Documentation Management Review and Handover Procedure for Gx Coal Projects (240-66920003).
2. Project / Plant Specific Technical Documents and Records Management Work Instruction (240-76992014)

3.4.1.3 Email Subject

The Contractor submits all documentation to the Employer's Representative in the following media:

1. Electronic copies are submitted to Eskom Documentation Centre. The email subject as a minimum has the following: (Station_Project Name_Discipline_Subject). Electronic copies that are too large for email are delivered on CD/DVD, large file transfer protocol and/or hard drives to the Project Documentation Centre. In a case where CD has been submitted, a notification email, with the transmittal note attached, is sent to the project generic email address. The Representative is copied on the email as well.
2. Hard copies are submitted to the Employer's Representative accompanied by the Transmittal Note.

3.4.1.4 As-built drawings, operating manuals and maintenance schedules

The Contractor is responsible for the compilation and the supply of all the documentation required during the various project stages and to provide the documentation programmed to link with the milestone dates. Documentation and drawings are programmed for delivery to meet the milestone dates and in accordance with the agreed VDSS.

At Take-over the Contractor provides two full sets of as-built documentation to the Employer.

All documentation, including reports, manuals, etc. is in the English language.

3.4.1.4.1 Documentation System

The Contractor's document system is comprehensive in management and control of the documentation for each of the units based on a master document. This includes controlling the differing stages of modifications that each unit may find itself in.

The KKS plant position codes are identified in the documentation. Automatic prevention of duplication of numbering or ambiguity is built into the system.

All documentation submitted, by the Contractor, is done with a signed documentation transmittal note.

3.4.1.4.2 Documentation Control

The Contractor implements a comprehensive document control of all documents, their revision status and of the document status in relation to the 'as built' and 'as designed' or commonly known as “Approved for Construction” plant status. Procedures, document control, flow diagrams and indexes are included in this system. The drawing register contains the following information and is submitted monthly in a Microsoft Excel format to the Employer:

1. Drawing number (Employer and Contractor’s number)
2. Revision
3. Approval status
4. Location of drawing at that stage
5. Drawing KKS number
6. Drawing description
7. Sheet number
8. Transmittal number
9. Date of submission

The Contractor adheres to the Employer’s Documents and Record Management Procedure (240-53114186 Rev 1) for all documents submitted.

The Contractor provides the following procedures for maintenance activities:

1. Calibration and checking of instrumentation, pneumatic positioners, and electrical actuators including frequency of maintenance interventions.
2. Trouble shooting and replacement of faulty equipment.

3.4.1.4.3 Material Certificates

The Contractor provides a copy of the Materials Test certificates as per EN 10204 for all components to be included in the Data Books this requirement is reflected in all Contractor Purchase orders specifying the appropriate type aligned to the Employer requirement for, Control of Plant Construction Repair and Maintenance Welding Activities Standard 240-56241933, Rev 1.

3.4.1.4.4 Final Data Book

The Contractor is responsible for the provision of a final data book.

The final data book is broken down in two main categories:

1. Technical category
2. Cost and planning category

The document contains all the relevant documentation, designs, drawings, Plant and Materials certificates, NDE tests and results etc. which were applicable during the contract. The Contractor ensures that all relevant documentation is traceable and cross referenced where applicable.

All planning, scheduling, bar charts, milestones, detailed cost breakdown information, packing and transport are included in the final document.

The content is laid out in a logical manner with main and sub-sections where all the relevant documentation is grouped.

The contents are presented in a hard cover file or files.

The data packages are prepared on a daily basis for all completed work.

Two hard copies and one soft copy of the Data Book are handed to the Employer for acceptance.

3.4.1.4.5 Manuals

The Contractor supplies the following manuals:

1. Operating manual
2. Maintenance manual

The manuals conform to the specifications set out in this works and are submitted to the Employer for acceptance.

Types of Documentation to be handed over to the Employer:

1. Operational Documentation:
    a. Operating Procedures.
    b. Emergency operating procedures.
    c. Operating Training Information.
    d. Routine Inspection and Test Procedures.
    e. Re-commissioning Procedures.
2. Maintenance and Engineering Documentation:
    a. Technical Specification Sheets for different equipment to be compiled, inclusive of the KKS Codes relevant to the different equipment.
    b. Routine Inspection Specification.
    c. Service Interval Specification
    d. Bill of Material, Material Number and Supplier.
    e. Equipment lists
    f. Maintenance Plans per system
    g. Overhaul Procedures and Specifications.
    h. Test Procedures and Specifications.
    i. Special Tool Requirements.
    j. Drawings applicable to Plant.

The manuals, which are in English, are complete with:

1. The power station name and order number
2. An index
3. A list of reference drawings
4. Details of all the components
5. General arrangements drawings

6. Installation drawings and instructions
7. Detailed parts lists which must be accompanied by exploded view type drawings clearly detailing the part and uniquely identifying it
8. Technical descriptions of the equipment and components parts with KKS coding.
9. Spare parts ordering information
10. Detailed specifications of the recommended maintenance and test equipment for testing, commissioning, fault finding and routine maintenance of all equipment covered by this specification
11. Routine maintenance schedules are to be provided in detail for each component and a complete description of the operation and use of the test equipment offered.

As a minimum the Contractor supplies the following:

1. 2x electronic copies for each manual indexed PDF format
2. 1x maintenance software for each manual
3. 5x hard covered operating manuals
4. 5x hard covered maintenance manuals

Any special instructions pertaining to the storage of spare parts or to their shelf life is included in the manual and is specifically pointed out in writing with the delivery of the equipment. All drawings required for component locations, dismantling and re-assembly for maintenance are included in the manual. The Contractor identifies all special tools that are required for maintaining and operating the equipment and includes a schedule of the identified tools and spares in the manual.

The Contractor prepares maintenance plans that specify when, at what frequency and how maintenance tasks must be performed on specific systems. The Contractor submits maintenance plans according to this generic maintenance plan as far as possible. Each maintenance plan includes tasks for condition monitoring, failure finding surveillance tasks and descriptions for each task. Each maintenance plan includes inspection schedules.

3.4.1.5 Configuration Management

3.4.1.5.1 Plant Coding

Coding of the design shall be based on the latest revision of 240-93576498 Eskom KKS Coding Standard and the Employer shall undertake the coding in line with its standards. The KKS coding shall be applied during the design review stage(s) and cross referenced to all arrangement drawings, schematics, instructions and manuals and where practical to spare parts list/manuals. The Contractor shall be required to include allocated coding to the electronic design drawings.

3.4.1.5.2 Cable numbering

Cable numbers issued during this project shall be in accordance with agreed cable schedule diagrams and shall not conflict with existing cable schedules on current operational units. Cable numbering shall be in accordance with the standard specification 240-56227443.

3.4.1.5.3 Equipment labelling

The Contractor shall also manufacture and install KKS labels to the new installed system. Labels shall be manufactured and installed according to the Employer's Plant Labelling Standard 240-71432150. The labelling standard shall be supplied as part of the enquiry documents. Contractor shall provide a label sample to be inspected and provided prior to bulk manufacturing of labels.

3.5 HEALTH AND SAFETY REQUIREMENTS

1. The Contractor must ensure that all his personnel attend a Health and Safety Induction Course prior to starting with their work. The Induction course can, on request, be provided by the Employer and will be valid for the duration of one year.
2. The Contractor must ensure that all his employees have a valid medical certificate for the duration of the contract. Medical certificate needs to be done yearly.
3. OHS department has the right and authority to visit and inspect the Contractor's workplace or site establishment to ensure that tools, machinery, and equipment comply with the minimum safety requirements.
4. Service Manager shall be entitled to instruct the Contractor to stop work, without penalty to the Employer, where the Contractor's personnel fail to confirm to safety standards or contravene health and safety regulations. The Service Manager is entitled to cause the Contractor to discipline his employees and to submit disciplinary action and submit a report to Service Manager. The Contractor shall implement additional health and safety precautions where necessary.
5. The Contractor will provide all his personnel with the required personal protective equipment.
6. Risk Assessments, Pre-Job Briefs, Post – Job Briefs & Job Observations will be conducted for all jobs.
7. The Contractor must comply with the following legal and other requirements (but not limited to) throughout the duration of the contract:
    a. Occupational Health and Safety Act 85 of 1993
    b. Eskom Life Saving Rules
    c. Eskom OHS Specification
    d. Eskom SHEQ Induction
    e. COIDA
    f. Eskom Incident Management Procedure – 32-95
    g. Monthly Safety File Evaluation Checklist

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 3 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 demolition.
6. Prepare earthworks for craneage access and working rigging areas. The Contractor disposes of all rubble at a waste disposal site to be approved by the Employer. 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.
7. Store salvaged components 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 his access to the working areas and the Site.
10. Manage his 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.
17. Site visit prior to design and construction is strongly advised to ensure compatibility with existing plant
18. Adhere to period of reply for contract communication
19. Contractor to submit first program fourteen (14) days of contract date and weekly revised programmes
20. Contractor to submit method statement for site establishment and site de-establishment
21. Contractor to submit a key person’s list announcing experience and qualifications
22. Contractor to attend progress and outage meetings
23. Contractor to utilize local based un-skilled and semi skill persons for the project during the construction phase

4.2 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. A register of Defects with those older than 30 days being flagged and an explanation attached
   b. Register of accepted Defects
   c. A register of Non-Conformance Report
   d. Monthly Project Quality Report
   e. Monthly updated Site and pre-site programmes
   f. Inspection dates
   g. Site Acceptance Tests
   h. Inspections completed / outstanding
   i. All quality control documentation is submitted to the Project Manager within 7 days of Contract date.

4.3 HANDOVER

4.3.1 Strengthening of Excitation Room floor

1. The following requirements are applicable should any structural modifications to the excitation room floor be necessary.
2. Apart from any statutory data packages required, the Contractor also compiles a data package of the relevant drawings, test certificates etc. to the Project Manager for acceptance. These include, but are not limited to:
   a. Concrete 7 day and 28 day cube test results
   b. Slump test results
   c. Concrete mix designs including all required test results e.g. aggregate test results
   d. Welding procedure specifications
   e. Welder qualifications
   f. Non-destructive weld test results
   g. Weld test certificates
   h. Steel grade certificates
   i. As-built data and drawings of the completed works upon handover. As-built drawings are submitted in PDF and native CAD formats (.DGN).
   j. Structural Certificate signed by Professional Civil Engineer confirming that works have been constructed in accordance with the design

5. AUTHORISATION

This document has been seen and accepted by:

Name & Surname	Designation
Neo Monini	Manager Site Outage Execution
Johann Jordaan	Senior Engineer PTM Technical Support
Simangaliso Nkosi	Chief Technologist - PTM Central (Excitation Control Systems)
Nkosi Ndika	HVAC Specialist
Kevin Rabbolini	Medupi PTM Section Manager
Portia Lutumbu	Electrical Maintenance Manager
Pontsho Letsholonyane	Manager Contracts Management
Timothy Shekwa	Senior Advisor Engineering Support
Ndivhuwo Tshifura	Quality Management Manager
Tendani Mukhuba	OHS Manager
Nthabi Mashigo	C&I Engineering Manager
Langa Zuma	Auxiliary Engineering Manager
Elaine van der Westhuizen	Design and Spec Engineering Manager

6. DEVELOPMENT TEAM

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

- Conrad Matthee
- Johannes Bruwer
- Ntando Mbatha
- Simangaliso Nkosi

7. APPENDIX

Appendix A – C&I Datapack

Appendix B – HVAC Datapack

Appendix C – Civil Datapack

Appendix D – Electrical Datapack