Eskom	Standard	Technology

Title: **STANDARD FOR POLE MOUNTED, SINGLE PHASE, STEP AUTOMATIC VOLTAGE REGULATORS PART 2: TELECONTROL REQUIREMENTS**

Unique Identifier:	**240-71083832**
Alternative Reference Number:	**34-2111**
Area of Applicability:	**Engineering**
Documentation Type:	**Standard**
Revision:	**2**
Total Pages:	**17**
Next Review Date:	**August 2021**
Disclosure Classification:	**Controlled Disclosure**

Compiled by	Approved by	Authorized by
Isaiah Ndou	**Steven Papadopoulos**	**Richard McCurrach**
Senior Supervisor	**PTM&C: Control and Automation T&S Manager**	**Senior Manager PTM&C**
Date: 25/07/2016	Date: 2/08/2016	Date: 3/8/2016

Supported by SCOT/SC

Marlini Sukhnandan

SCOT/SC Chairperson

Date: 27/07/2016

PCM Reference: **240-44509543 – PCM Design Systems**

SCOT Study Committee Number/Name: **Telecontrol and SCADA Study Committee**

Content

Figures

1. Introduction

This document presents the Telecontrol requirements for the Pole Mounted, Single Phase, Step Automatic Voltage Regulators.

2. Supporting clauses

2.1 Scope

This specification covers Distribution Group requirements for single-phase, outdoor, pole-mounted voltage regulators with programmable protection features and Integrated Remote Telecontrol operation capability. These voltage regulators are intended for source and down-line duty on rural distribution networks at nominal AC voltages of 6.6 kV, 11 kV, 22 kV and 33 kV.

2.1.1 Purpose

This standard stipulates the Telecontrol requirements for Voltage Regulators.

2.1.2 Applicability

This document shall apply throughout Eskom Holdings Limited Divisions.

2.2 Normative/informative references

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

2.2.1 Normative

[1] IEEE 1815-2012

[2] NRS 083-1:2007 Code of Practice for the Application of Electromagnetic Compatibility (EMC) Standards and Guidelines in Electricity Utility Networks – Equipment Standards

[3] SANS (IEC) 61000-4-4:2004 Electromagnetic compatibility (EMC): Testing and measurement techniques – Electrical fast transient/burst immunity test

[4] 240-64038621 - Remote Device Communication Standard for Data Retrieval and Remote Access

[5] 240-55410927 - Cyber Security Standard for Operational Technology

2.2.2 Informative

None

2.3 Definitions

2.3.1 General

Definition	Description
Automatic Voltage Regulator (AVR)	A mechanical switching device to provide continuous regulating capability by either increasing or decreasing the downstream system voltage at a pre-set voltage.
Bi-directional	The operation of a bi-directional voltage regulator is independent of the side to which the primary source is connected

Definition	Description
Complementary 2-output control	Has two virtual or physical outputs, named close and trip. One or the other output is set active momentarily depending upon which command is received [DNP3-2007 Vol. 6,].
Complementary Lash Control:	Has a single virtual or physical output that remains latched in an active or non-active state depending upon which command is received [DNP3-2009 Vol. 6,].
Data Communications Equipment (DCE)	Devices that provide the functions required to establish, maintain and terminate a data transmission connection (e.g. radio, modem, etc.).
Data Terminal Equipment (DTE)	Devices acting as a data source, or data sink, or both.
Local Control	A mechanical switching device, capable of making, carrying and breaking currents under normal circuit condition
Remote Control	Control of an operation at a point distant from the controlled switching device [IEV 441-16-07]
Supervisory	Remote control and the reporting of indications by means of an RTU and a telecommunications link
Voltage regulation	Ability to maintain the voltage deviation of the steady state R.M.S voltage to remain within desired upper and lower limits

2.3.2 Disclosure classification

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

2.4 Abbreviations

Abbreviation	Description
AVR	Automatic Voltage Regulator
CPU	Central Processing Unit
DCE	Data Communications Equipment
DNP	Distributed Network Protocol
DTE	Data Terminal Equipment
HMI	Human Machine Interface
PC	Personal Computer
RTU	Remote Terminal Unit
SCADA	Supervisory Control And Data Acquisition
VR	Voltage Regulator

2.5 Roles and responsibilities

Not applicable.

2.6 Process for monitoring

Not applicable.

2.7 Related/supporting documents

Not applicable.

3. Pole Mounted, Single Phase, Step Automatic Voltage Regulators: Telecontrol Requirements

A voltage regulator (VR) is considered to consist of two main subcomponents, i.e. a voltage regulator can with a tap-changing mechanism and a control cabinet. In order to distinguish between the two main subcomponents and the combined product, the following terminology will be utilised in this specification:

Voltage regulator tap-changer tank – the mechanical switching device, which includes the insulator bushings and mounting bracket

Voltage regulator control – the control cubicle and its entire contents, including the control cable to the voltage regulator tap-changer tank

3.1 General Requirements

3.1.1 External antenna connection

a) The control box shall allow for an external antenna.

b) Entry and exit holes on any metal part of the voltage regulator for antenna connections shall be blanked off with blanking plugs that shall be knock-outs.

c) Provision shall be made for panel mount surge arrestors with N-type connections.

3.1.2 Remote Controls and Indications

a) The AVR shall have remote raise and lower pulse-type controls

b) The AVR shall have an inhibit function which can be remotely controlled using a complementary latched type control to enable or disable automatic voltage regulation. This function shall not prevent the voltage regulator from being manually or remotely tapped.

3.1.3 Remote Indications

a) The AVR shall indicate when the local supervisory switch is switched OFF.

b) The AVR shall indicate the following modes which shall be changed via a local panel switch:

1) AUTO: In the auto position, the AVR shall automatically regulate the voltage

2) MANUAL: In the manual position, the AVR shall be operated locally not automatically nor remotely

3) REMOTE: In the remote position, the AVR shall be operated remotely and not locally

4) OFF: In the OFF position, the remote, auto and manual functions shall be inhibited

c) An alarm shall be reported when a control is sent to disable automatic voltage regulation

d) An alarm shall be reported when a bypass condition is unsafe

e) The AVR shall indicate when the power flow is in the reverse direction.

f) The AVR shall report when it is in an unhealthy condition. This is a condition wherein the AVR cannot perform automatic voltage regulation nor perform any Telecontrol functions. The supplier shall provide the conditions for which an unhealthy state is generated.

g) The AVR shall report when motor or any mechanical failure occurs

h) The AVR shall report when motor or any mechanical failure occurs

i) Status changes shall be reported and recorded in the event buffer in the sequence in which they occur.

j) The AVR shall provide the facility to enable only those indications that are to be reported to the master station

k) The AVR shall provide non-volatile indication change history storage. The minimum requirement is the last 50 events.

l) It shall be possible to download and upload the operating parameters for the indication sub- system remotely as well as locally. The configuration parameters shall be stored in non-volatile memory. There shall be no necessity to re-download configuration parameters if the device is reset or restarted.

m) All indications marked for unsolicited reporting shall be queued. Internal buffers shall have a minimum capacity to queue at least 50 indication events.

3.1.4 Controls

a) The control output sub-system shall support both Direct Operate and Select Operate controls. The selection of type will be made at the master station.

b) Failure of any one component shall not, under any conditions, result in an undesired control output.

c) It shall be possible to download the operating parameters for the control output sub-system remotely as well as locally. The configuration parameters shall be stored in a non-volatile memory. There shall be no necessity to re-download configuration parameters if the device is reset or restarted.

d) The AVR shall report when motor or any mechanical failure occurs

e) Status changes shall be reported and recorded in the event buffer in the sequence in which they occur.

f) The AVR shall provide the facility to enable only those indications that are to be reported to the master station

g) The AVR shall provide non-volatile indication change history storage. The minimum requirement is the last 50 events.

h) It shall be possible to download and upload the operating parameters for the indication sub- system remotely as well as locally. The configuration parameters shall be stored in non-volatile memory. There shall be no necessity to re-download configuration parameters if the device is reset or restarted.

i) All indications marked for unsolicited reporting shall be queued. Internal buffers shall have a minimum capacity to queue at least 50 indication events.

3.1.5 Analogues

a) All analogues shall have a resolution of at least 16 bits.

b) The AVR shall report analogue changes on the transgression of a configurable moving window (delta range) relative to the last reported value (event or poll). This parameter shall be provided per individual analogue.

c) The moving analogue window (delta range) setting shall be a percentage of the full-scale value.

d) In addition it is preferred that the AVR shall report analogue changes on the transgression of either of two configurable thresholds (HIGH and LOW), the operation of which shall be independent from the configurable moving window, described above. These thresholds shall be provided per individual analogue. The reporting function must feature hysteresis that inhibits repeated reporting of small changes around the thresholds. The desired functionality is explained by means of Figure 1. The high analogue value is reported when the HIGH threshold is exceeded i.e. at H1. It is only reported again when the value falls below HIGH – hysteresis i.e. at H2. The low analogue value is reported if the value falls below the LOW threshold i.e. at L1. The analogue value is only reported again when it rises above the LOW + hysteresis threshold i.e. at L2.

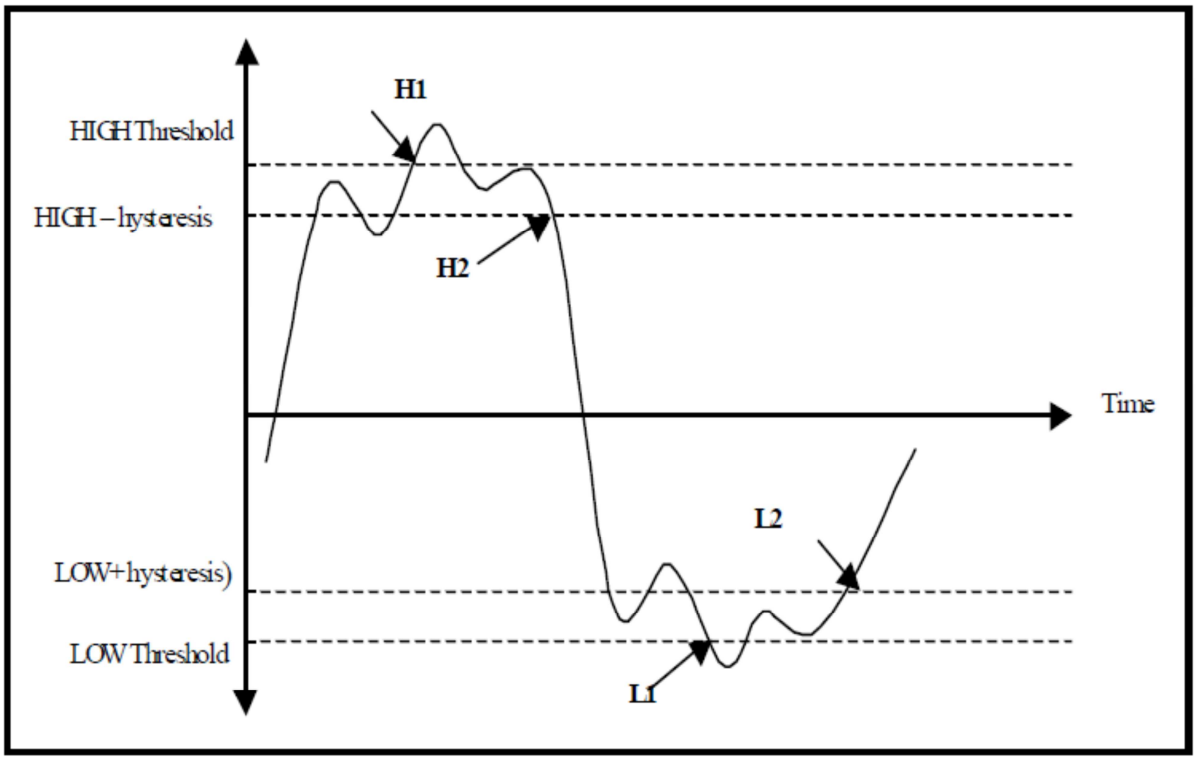

Figure 1: Analogue Threshold reporting

a) The AVR shall provide the facility to enable only those analogues that are to be reported to the master station

b) It shall be possible to download the operating parameters for the analogue input sub-system remotely as well as locally. The configuration parameters shall be stored in non-volatile memory. There shall be no necessity to re-download configuration parameters if the device is reset or restarted.

3.1.6 Communication requirements

a) The communications system should be modular and flexible with regard to functional configuration. It should only be necessary to install those communications sub-systems, which are required for the specific application of the AVR.

b) Considering the AVR to be a DTE, any Data Communications Equipment (e.g. Telephone modems, radio modems etc.) Shall be physically separable from the DTE to allow Eskom to supply or select the appropriate DCE.

c) The functioning or performance of the AVR and user application programs shall not be compromised by any communication activity.

d) The AVR shall provide for the following simultaneous communications links

1) One Remote Master Station port;

2) One diagnostic/configuration port (for local and remote use e.g. via GSM cellular modem);

e) The above ports shall be suitably isolated. The Tenderer shall provide full details of the isolation on each of the above ports

f) The Tenderer shall specify the maximum number and type of communications ports.

g) The above ports shall be easily configured to provide the range of required interfaces. Suppliers shall provide details on the options and configuration methods for these interfaces.

h) The above ports shall, as a minimum, be capable of asynchronous EIA-232 communication with hardware handshaking. Optional EIA-485 configuration may be considered.

i) The Tenderer shall provide information on any alternative interfaces supported.

j) The AVR shall support communications over the following media:

1) Shared half duplex radio modem links.

2) Dedicated point to point links (including fibre optic cable).

3) GPRS modems.

k) The Tenderer shall detail any alternative communication mediums supported.

l) The data communication speed on all communication ports shall as a minimum be configurable between 1200 bits per second and 19 200 bits per second.

m) Data Communication Equipment will either be “free-issued” by Eskom to the supplier for fitment, or will be installed by Eskom once the device has been delivered to Eskom stores. The supplier’s quality plans and test procedures shall make provision for both the above options. Eskom will audit these test procedures and inspections may be effected by Eskom.

3.1.7 Control Cabinet

a) The control cabinet and associated electronics shall have been type tested in accordance with SANS (IEC) 61000-4-4:2004 Electromagnetic compatibility (EMC), Part 4-4: Testing and measurement techniques – Electrical fast transient/burst immunity test.

b) Space and a mounting plate shall be provided on which to mount the following data communications equipment simultaneously:

1) One radio modem measuring 190 x 170 mm foot print, 60 mm high and weighing 1.6 kg.

2) A GPRS modem measuring 130 x 90 mm foot print, 40 mm high and weighing 0.5 kg.

3) Consideration must be given to the safe routing of the power and the antenna connections and for providing easy access to the connections. The mounting of communication devices shall in no way obscure the visibility of any of their indication lights.

3.1.8 Telecontrol Protocol

a) The AVR shall provide support for a slave implementation of DNP3.

b) The DNP3 implementation shall support solicited and unsolicited reporting.

c) The DNP3 implementation shall conform to Subset Level 3 as described in the IEEE 1815 - 2012-". The supplier's implementation shall also comply with the latest and most applicable DNP IED Certification Procedure.

d) The DNP implementation shall support Application Layer retries.

e) Tenderers shall provide a Device Profile as described in IEEE 1815 - 2012 Profile", clearly defining what services and functions if any are not supported. Any deviations from the subset shall be clearly documented in the proposal.

f) Proof of testing and verification of the protocol functionality shall be provided by the Tenderer. Eskom shall verify the results by conducting independent tests at the Tenderer's premises.

g) Collision avoidance and channel access shall comply with the DNP3 Specification. Details of the channel access algorithm must be provided.

h) The AVR shall record the following communications statistics related to the Telecontrol communications port; the number of received messages, the number of received messages with CRC errors, the number of transmitted messages and the number of retried messages.

i) The AVR shall support the ability to configure the DNP3 Class of each point in the database.

j) Since these devices will communicate over unencrypted radios there is a need to increase the security of these communications. IEEE 1815 – 2012 (Secure Authentication) addresses this need and therefore Eskom requires this facility. If not yet supported, details must be provided on when this facility will be supported.

3.1.9 Power Supply Requirements

a) The AVR controller shall be supplied directly from the voltage regulator tap-change tank

b) The Tenderer shall provide full details regarding the power consumption for the AVR controller in its entirety (i.e. including AVR power consumption). The maximum current drawn by the controller shall be stated by the Tenderer and shall be determined based upon worst case conditions regarding power consumption. Additional inrush current parameters shall also be stated.

c) The Tenderer shall make provision for a power supply output for communication equipment operating at 12V and 3.5A average current.

d) Restoration of the primary supply voltage and under-voltage conditions in the primary supply shall in no way damage or cause spurious operation of the equipment.

e) Systems in which steps are taken to minimise power consumption will be preferred. The Tenderer shall detail any design elements geared for minimising power consumption.

3.1.10 Configuration Software

The AVR systems shall be supplied with configuration software that meets the following requirements

a) All software supplied with the system shall be documented comprehensively, with all the features and functions discussed.

b) The software should be menu driven and user friendly to the extent that only basic computer knowledge should be required to operate it.

c) The software shall be compatible with MS Windows 7.

d) The software shall have an auto-install feature whereby a setup program will prompt for options and the software will automatically be extracted to the appropriate directories with program groups and icons created (for Windows).

e) The software shall maintain backup files of the configuration information. This function, together with an automated disaster recovery procedure, shall be integrated within the software. It shall be possible to store these backup files on a removable diskette or tape system.

f) A list of minimum computer hardware requirements shall be provided with the specification.

g) The supplier shall specify how aspects like bug fixes, new firmware releases and version control of software/firmware will be handled over a period of say up to 10 years.

h) Separate passwords for the Protection and Telecontrol settings are required.

i) There are no limitations or requirements for the protocol used between the AVR and configuration tool (when either directly connected or when used in remote fashion). This is provided that the minimum functionality of the configurator can be met.

3.1.11 Remote Configuration:

a) To facilitate remote configuration via standard Data Communication Equipment (DCE), the configuration port shall be a standard DB9 type, EIA-232, male connector. The configuration port shall be configured as Data Terminal Equipment (DTE). The AVR controller shall therefore be able to connect to a modem using a modem cable (straight through), and to a PC using a null modem cable (cross over). The use of dongles is not acceptable.

b) The configuration port shall as a minimum be capable of asynchronous EIA-232 communication with hardware handshaking.

c) The configuration port shall be capable of operating at the following data communication speeds (i.e. baud rate): 1 200, 2 400, 4 800, 9 600 and 19 200.

d) AVR controllers are required to provide full functionality of the configuration software via a GSM or GPRS modem.

3.1.12 AVR functional requirements

This section documents Eskom's requirements for the functionality of the AVR not defined in other sections, in particular in the protocol specification(s).

a) The AVR shall be configurable both locally and remotely. The configuration parameters shall be stored in non-volatile memory, and it shall not be necessary to download the parameters if the device is reset or restarted.

b) The downloading of configuration changes should come into effect once the new parameters are perceived as being valid and without requiring a system reset or restart.

3.2 Technical Manuals

The following technical manuals shall be submitted.

a) A manual covering all Telecontrol aspects of the voltage regulator and configuration software

b) The I/O point DNP database assignments

3.3 Tests

3.3.1 Testing requirements and test systems

3.3.1.1 Prototype testing

a) The successful supplier will be required to demonstrate the basic operation of the AVR using the existing analogue and digital radio repeater networks, and GPRS systems before being awarded a contract for supply to Eskom.

b) The Tenderer shall make available for evaluation purposes, on Eskom premises, components of the offered system or the offered system as a whole (as selected by Eskom) before contract award.

c) All equipment shall undergo thorough functional and performance testing at the contractor's premises after awarding the contract and before delivery of any units to Eskom.

d) Test Sets to test all functionality as specified shall be made available

3.4 Marking, labelling and packaging

For Marking, labelling and packaging refer to standard 240-75660124 - Pole-Mounted, Single-phase, Step, Automatic Voltage Regulators Standard.

3.5 Spares

For spares also refer to standard 240-75660124 - Pole-Mounted, Single-phase, Step, Automatic Voltage Regulators Standard.

4. Authorization

This document has been seen and accepted by:

Name and surname	Designation
Ian Naicker	Chief Engineer: PTM&C - Control and Automation
Tertius Hyman	Engineer: Distribution - WCOU
Jason Hector	Senior Engineer: PTM&C – Control and Automation
Danie Du Plessis	Tx Grid Representative
Busi Green	Gx Representative
Simphiwe Mbanga	ECOU SI
Kashveer Jagdaw	KZNOU SI
Thendo Ramulondi	LOU SI
Colin Charles	WCOU SI
Natasha Zlobinsky	GOU SI
Tjaart Van Der Walt	NCOU SI
Niel Myburgh	FSOU S
Kenneth Brown	Senior Engineer: PTM&C - Control & Automation

5. Revisions

Date	Rev	Compiler	Remarks
Aug 2016	2	NI Ndou	Document review after reaching its review date of November 2015
Nov 2013	1	T Mabasa	Final Document approved with new document number.
Feb 2011	0	T Mabasa	Original doc 34-2111 The voltage regulator specification has been divided into two parts, where Part 1 specifies the general and protection requirements and Part 2 specifies the Telecontrol requirements.

6. Development team

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

- F Ismail – (Not in Eskom anymore)
- A Roberts – (Retired)
- T Mabasa – (Not in Eskom anymore)

7. Acknowledgements

Not applicable.

Annex A – Compliance schedules

(Normative)

A clause by clause statement of compliance is required from the supplier. The attached compliance schedule shall be used for this purpose.

Column 1: The relevant sub-clause of this document.

Column 2: Statement of compliance (Yes or No). If not filled in, it will be assumed that the tender does not comply with the specific clause.

Column 3: Stipulate deviations and any other relevant information as required by the specification.

If "Yes" is indicated in column 2, supporting information shall be provided in column 3 as proof that the product complies with the specified requirement. Blank cells in column 3 are not acceptable.

Example

Specification:

1) The control cabinet shall be stainless steel to eliminate corrosion. (critical requirement)

2) The control cabinet shall be lockable. (non-critical requirement)

3) The control cabinet shall have four earth terminals. (non-critical requirement)

Compliance schedule:

1	2	3
Clause	**Comply**	**Comments/Deviation**
1	Yes	A grade 316 cabinet is offered
	No	A glass fibre control cabinet is offered. It is believed that this cabinet will also eliminate corrosion.
	No	A galvanised steel control cabinet is offered. It is believed that this cabinet will also eliminate corrosion.
2	Yes	The cabinet is pad lockable.
3	No	The standard control cabinet have only three earth terminals

Annex B – Impact Assessment

Impact assessment form to be completed for all documents.

1) Guidelines

- All comments must be completed.
- Motivate why items are N/A (not applicable)
- Indicate actions to be taken, persons or organisations responsible for actions and deadline for action.
- Change control committees to discuss the impact assessment, and if necessary give feedback to the compiler of any omissions or errors.

2) Critical points

2.1 Importance of this document. E.g. is implementation required due to safety deficiencies, statutory requirements, technology changes, document revisions, improved service quality, improved service performance, optimise costs.

Comment: Document Revision

2.2 If the document to be released impacts on statutory or legal compliance - this need to be very clearly stated and so highlighted.

Comment: No Impact

2.3 Impact on stock holding and depletion of existing stock prior to switch over.

Comment: N/A

2.4 When will new stock be available?

Comment: N/A

2.5 Has the interchangeability of the product or item been verified - i.e. when it fails is a straight swop possible with a competitor's product?

Comment: N/A

2.6 Identify and provide details of other critical (items required for the successful implementation of this document) points to be considered in the implementation of this document.

Comment: N/A

2.7 Provide details of any comments made by the Regions regarding the implementation of this document.

Comment: N/A

3) Implementation timeframe

3.1 Time period for implementation of requirements.

Comment: Ongoing

3.2 Deadline for changeover to new item and personnel to be informed of DX wide change-over.

Comment: This is an already existing product

4) Buyers Guide and Power Office

4.1 Does the Buyers Guide or Buyers List need updating?

Comment: No

4.2 What Buyer's Guides or items have been created?

Comment: N/A

4.3 List all assembly drawing changes that have been revised in conjunction with this document.

Comment: N/A

4.4 If the implementation of this document requires assessment by CAP, provide details under 5

4.5 Which Power Office packages have been created, modified or removed?

Comment: None

5) CAP / LAP Pre-Qualification Process related impacts

5.1 Is an ad-hoc re-evaluation of all currently accepted suppliers required as a result of implementation of this document?

Comment: No

5.2 If NO, provide motivation for issuing this specification before Acceptance Cycle Expiry date.

Comment: This is not a specification

5.3 Are ALL suppliers (currently accepted per LAP), aware of the nature of changes contained in this document?

Comment: N/A

5.4 Is implementation of the provisions of this document required during the current supplier qualification period?

Comment: N/A

5.5 If Yes to 5.4, what date has been set for all currently accepted suppliers to comply fully?

Comment: N/A

5.6 If Yes to 5.4, have all currently accepted suppliers been sent a prior formal notification informing them of Eskom's expectations, including the implementation date deadline?

Comment: N/A

5.7 Can the changes made, potentially impact upon the purchase price of the material/equipment?

Comment: No

5.8 Material group(s) affected by specification: (Refer to Pre-Qualification invitation schedule for list of material groups)

Comment: None

6) Training or communication

6.1 Is training required?

Comment: No

6.2 State the level of training required to implement this document. (E.g. awareness training, practical/on job, module, etc.)

Comment: None

6.3 State designations of personnel that will require training.

Comment: None

6.4 Is the training material available? Identify person responsible for the development of training material.

Comment: N/A

6.5 If applicable, provide details of training that will take place. (E.G. sponsor costs, trainer, schedule of training, course material availability, training in erection / use of new equipment, maintenance training, etc.).

Comment: N/A

6.6 Was Technical Training Section consulted w.r.t module development process?

Comment: No

6.7 State communications channels to be used to inform target audience.

Comment: Email and Technical Meetings

7) Special tools, equipment, software

7.1 What special tools, equipment, software, etc. will need to be purchased by the Region to effectively implement?

Comment: None as the software is already available

7.2 Are there stock numbers available for the new equipment?

Comment: N/A

7.3 What will be the costs of these special tools, equipment, software?

8) Finances

8.1 What total costs would the Regions be required to incur in implementing this document? Identify all cost activities associated with implementation, e.g. labour, training, tooling, stock, obsolescence

Comment: N/A

Impact assessment completed by:

Name: Isaiah Ndou

Designation: Telecontrol Senior Supervisor