Eskom	**Standard**	**Technology**

Title: **STANDBY BATTERY STORAGE AND COMMISSIONING IN ESKOM**

Unique Identifier:	**240-137465740**
Alternative Reference Number:	**N/A**
Area of Applicability:	**Engineering**
Documentation Type:	**Standard**
Revision:	**1**
Total Pages:	**34**
Next Review Date:	**November 2023**
Disclosure Classification:	**Controlled Disclosure**

Compiled by	Approved by	Authorized by
Christo van Zyl	**Thomas Jacobs**	**Dr. Titus Mathe**
Battery Care group convenor	**Chief Engineer: DC & Auxiliary Supplies**	**SGM Technology (Acting)**
Date: 2 November 2018	Date: 2 November 2018	Date: 08/11/2018

Supported by SCOT/SC

Kashveer Jagdaw

DC & Auxiliary Supplies SC Chairperson

Date: 2 November 2018

PCM Reference: **240-45541534**

SCOT Study Committee Number/Name: **Part 16 / DC & Auxiliary Supplies Study Committee**

Content

Tables

1. Introduction

This document details the requirements for the storage, acceptance and commissioning of all standby battery technologies in Eskom

2. Supporting clauses

2.1 Scope

2.1.1 Purpose

The purpose of this document is to ensure that during the storage and commissioning of standby batteries certain criteria's are met and processes followed to ensure optimal battery performance over the batteries lifespan. Noncompliance with these instructions might lead to poor performance of the standby batteries during emergency operations, cancellation of battery supplier warrantees or reduced operational lifetime.

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] ISO 9001 Quality Management Systems.

[2] IEC 1632-1: 2005, Batteries Part 1: General information – Definitions, abbreviations and symbols.

[3] SANS 10108:2014, The Classification of Hazardous Locations and the Selection of Apparatus for use in such locations

[4] SANS 10119:2011, Reduction of Explosion Hazards Presented by Electrical Equipment – Segregation. Ventilation and Pressurization

[5] 240-44175132, Eskom Personal Protective Equipment (PPE)

[6] 240-56227923, Battery Quality Requirements

[7] 240-56356510, Definitions of Terms Applicable to DC Emergency Supplies standard

2.2.2 Informative

[8] 240-89797258, The Safe Handling, Transportation and Disposal of Cells, Batteries and Electrolyte

[9] 240-56177186, Battery Room Standard

[10] 240-51999453, Standard Specification for Valve-regulated Lead Acid Batteries

[11] 240-56360034, Stationary Vented Lead Acid Batteries Standard

[12] 240-56360086, Stationary Vented Nickel Cadmium Batteries Standard

The following Technical Instructions has been incorporated into this standard

[13] 240-87495495, Standby Battery Storage in Eskom

[14] 240-95679758, Nickel Cadmium Battery Commissioning sheets

[15] 240-87264294, Ohmic Testing of Battery Connections

2.3 Definitions

2.3.1 General

Definition	Description
Battery Impedance	It is a combination of internal resistance and reactance where internal resistance + reactance, or (L+C), equals impedance when using an AC stimulus. The internal resistance of a battery is made up of two components: electrical or ohmic resistance and ionic resistance.
Cadmium readings	The cadmium readings indicate the plate potential relative to the cell electrolyte which indicates if the cell plates have been properly formed during commissioning. A cadmium rod (stick) is used as reference electrode. When the cadmium electrode is held suspended in the electrolyte and connected to the negative jack of the voltmeter with the positive jack connected through a suitable lead which is pushed against of the positive terminal of the cell, the resultant reading is known as the positive cadmium reading. The negative cadmium reading is obtained by pushing the voltmeter lead from the positive jack to the negative terminal of the cell.
Link Impedance	It is the intercell connection resistance measure across cell posts to enable the detection of any possible loose intercell connections

2.3.2 Disclosure classification

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

2.4 Abbreviations

Abbreviation	Description
AC	Alternating current
DC	Direct current
IDF	Intermediate Distribution Frame
LEDs	Light emitting diodes
MAX	Line on cell indicating the maximum electrolyte level of the cell
MCB	Miniature circuit breaker
MIN	Line on cell indicating the minimum electrolyte level of the cell
NCR	Non-conformance report
OEM	Original Equipment Manufacturer
PPE	Personal protective equipment
SG	Specific gravity
TSS	Technical Specialist Section
UPS	Uninterruptible Power Supply

2.5 Roles and responsibilities

Project management shall appoint a suitably competent and accredited DC person. The appointed DC person shall be responsible for the erection and commissioning of DC systems irrespective of whether this work is done by the supplier, a contractor or Eskom. All commissioning documents or certificates shall be forwarded to the appointed DC person.

If any portion of the commissioning (installing or commissioning of batteries and / or charge and discharge testing of batteries) is carried out by the supplier, it shall be the responsibility of the appointed DC person to approve the work to ensure that it complies with the standards set by the manufacturers and Eskom. Any persons who carry out these commissioning works or any part there off must be fully accredited by Eskom and the local supplier.

Whenever a battery is to be replaced the Battery replacement record form (see Annex N) shall be completed by the appointed DC person for record purposes so that a history of defects can be compiled.

2.6 Process for monitoring

The DC & Auxiliary Supplies SC shall ensure that this document is updated as and when required.

2.7 Related/supporting documents

Not applicable.

3. Requirements

3.1 Standby battery storage requirements

3.1.1 General

Different battery technologies can be stored for different time periods. Nickel Cadmium cells can be stored for up to 12 months without any rejuvenation, after which a refreshing charge must be done. Valve regulated (sealed) and wet (flooded) lead acid batteries can be stored for up to 3 months after which a refreshing charge has to been done. Failure to do so may result in irreversible damage to the battery cells greatly reducing the capacity and service life of the battery.

Dry charged (flooded) lead acid batteries can basically be stored indefinitely if kept in a dry cool place out of direct sunlight, preferably indoors.

Due to the delays in the execution of some projects and power generating plant outages batteries are left in crates (storage) for prolonged periods without being given a refreshing charge during project executions. When a project is delayed, the responsible DC contractor, Eskom section or system engineer shall be informed by Project Management or Outage Management of these battery banks that are kept in storage for extended periods of time. If so, banks are to be rejuvenated as per the OEM instructions and then returned to storage until installation and commissioning.

Project Management need to take note of cost implications (either by Eskom or the supplier) and the impact on the equipment warrantees.

3.1.2 Storage of new Nickel Cadmium batteries

The nickel cadmium (Nicad) cells are delivered filled with electrolyte and in a charged state. While in storage, the state-of charge of any cell on open circuit slowly decreases with time due to self-discharge. This decrease in state-of-charge is relatively rapid during the first two weeks, but then stabilises to approximately 2% per month at 20 °C. This means that after a year in storage, a Nicad cell would have an estimated 76% of its initial capacity available. A NiCad’s cell rate of self-discharge increase with an increase in temperature.

At an electrolyte temperature of 40 °C, a Nicad cell will have about 50% of its initial capacity available after a period of 175 days. Due to these factors certain storage and commissioning requirements need to be complied with to prevent damage to the cells and ensure optimum battery performance over its designed lifespan.

It is recommended that the storage time should not exceed 24 months.

3.1.2.1 Prolonged storage requirements for Nickel Cadmium cells

The prolonged storage of nickel cadmium cells is not recommended, however if prolonged storage is inevitable, then the following recommendations shall be adhered to:

- Cells can be stored in original packing crates until required for installation or recharging, however the lid and the packing material on top of the cells must be removed.
- Store the cells indoors in a dry, clean, preferred cool (0 °C to +30 °C) environment.
- Do not store the cells in direct sunlight or expose it to excessive heat.
- Never drain the electrolyte from the cells.
- This means that crates that were normally stacked (up to the maximum recommended limit) shall now be packed next to each other with their lids and packing material removed – this will require more space in terms of floor area.

The prolonged storage of nickel cadmium cells is not recommended. Therefore it is critical that project planning is optimised in order to ensure that the period of storage is kept to an absolute minimum.

Table 1: Nicad storage requirements

Storage Period [Months]	Instructions
6 or less	• The Nicad cells are delivered fully charged and ready for immediate use. • The cells may be put directly into service on float charge. Therefore, under these conditions, a commissioning charge before putting the cells into service is not necessary but recommended.
More than 6, but less than 12	Commissioning charge on installation will be required
12 and more	• Freshening Charge • Repack and return the cells to storage • Repeat this cycle every 12 months

Note: All Generation battery banks will be discharge tested as part of commissioning.

3.1.2.2 Commissioning charge of Nickel Cadmium cells

Nicad cells are to be given a commissioning charge to prepare the cells for installation after prolonged storage of more than 6 months The Nicad cells shall be given the following discharge/charge cycle:

- Discharge the cells at 0.2C5 A to an average end-of-discharge voltage of 1.00 V/cell.
- Recharge the cells at 0.1C5 A (maximum) for 16 hours until the cells have accepted a capacity of 1.6C5 Ah. Voltage control must not be applied as this is a current controlled charge and therefore cell voltages may reach up to 1.85V per cell.
- At the end of the recharge top up the electrolyte levels to the MAX mark with de-ionised water if necessary.
- The cells will then be ready for installation.

3.1.2.3 Freshening charge cycle of Nickel Cadmium cells

The Nicad cells are normally given a freshening charge to rejuvenate the cells and prepare it for further storing after 12 months storage. This is basically the same as the commissioning charge.

- Discharge the cells at 0.2C5 A to an average end-of-discharge voltage of 1.00 V/cell.
- Recharge the cells at 0.1C5 A (maximum) for 16 hours until the cells have accepted a capacity of 1.6C5 Ah. Voltage control must not be applied as this is a current controlled charge and therefore cell voltages may reach up to 1.85V per cell.
- At the end of the recharge top up the electrolyte levels to the MAX mark with de-ionised water if necessary.
- Repack and return the cells to storage

3.1.3 Storage of new flooded Lead Acid batteries

Flooded Lead Acid batteries can be ordered as "wet" or "dry" cells. Dry cells are cells without sulphuric acid electrolyte added to the cell. The electrolyte is delivered separate from the cells in containers. These cells can basically be stored indefinitely until required for initial charge and commissioning, note some special initial charging is suggested by some suppliers. This method is recommended when project execution time frames are uncertain.

When Lead Acid cells are ordered in the "wet" state, they are delivered filled with electrolyte, initial charged, tested and delivered in a fully charged state. They will however self-discharge over a short time period which can lead to sulphation of the plates and greatly reduced capacity and expected service life.

3.1.3.1 Prolonged Storage requirements for flooded Lead Acid cells

The prolonged storage of "wet" flooded lead acid cells is not recommended, however if prolonged storage is inevitable, then the following recommendations shall be adhered to:

- Cells can be stored in original packing crates until required for installation or recharging, however the lid and the packing material on top of the cells must be removed.
- Store the cells indoors in a dry, clean, preferred cool (0 °C to +30 °C) environment.
- Do not store the cells in direct sunlight or expose it to excessive heat.

3.1.3.2 Storage period of less than 3 months for flooded Lead Acid cells

The "wet" flooded lead acid cells are delivered fully charged and ready for immediate use and provided that they had not been stored for more than 3 months, they may be put directly into service on float charge. Therefore, under these conditions, an equalizing charge before putting the cells into service is not necessary. A normal Boost charge cycle for 4 hours is recommended.

Note: All Generation battery banks will be discharge tested as part of commissioning.

3.1.3.3 Storage period in excess of 3 months for flooded Lead Acid cells

To prevent damage to "wet" flooded lead acid cells an equalizing charge must be performed after a maximum storage period of 3 months. If the storage period extends over several months the equalizing charge has to be repeated every 3 months. It is recommended that the storage time should not exceed 24 months.

3.1.3.4 Equalizing charge for flooded Lead Acid cells

- Charge the cells at 0.07C10 A continuously for up to 72 hours. At this point the cells should be gassing vigorously with voltages in the region of 2.5 to 2.75 volt per cell. Voltage control must not be applied as this is a current controlled charge.

- Continuously monitor the cell electrolyte temperature and if the temperature exceeds 50 °C, interrupt the charging process or continue with a reduced current.
- The end of equalizing charge is reached when the electrolyte densities and cell voltages no longer changes within a 2 hour period.
- Top up the electrolyte levels to the MAX mark with de-ionised water if necessary.

3.1.4 Storage of new Valve Regulated Lead Acid (VRLA) Lead Acid batteries

VRLA batteries will self-discharge over a 6 months period at 20 °C which can then lead to sulphation of the plates and greatly reduced capacity and expected service life. The storage temperature for VRLA batteries however is very critical, as an increase of 8 °C will reduce the storage time by 50%.

3.1.4.1 Prolonged Storage requirements for VRLA Lead Acid cells

The prolonged storage of VRLA lead acid cells is not recommended, however if prolonged storage is inevitable, then the following recommendations shall be adhered to:

- Cells can be stored in original packing crates until required for installation or recharging.
- Store the cells indoors in a dry, clean, preferred cool (0 °C to +30 °C) environment.
- Do not store the cells in direct sunlight or expose it to excessive heat.

3.1.4.2 Storage period of less than 3 months for VRLA Lead Acid cells

The VRLA lead acid cells are delivered fully charged and ready for immediate use and provided they had not been stored for more than 3 months, they may be put directly into service on float charge. Therefore, under these conditions, an equalizing charge before putting the cells into service is not necessary.

3.1.4.3 Storage period in excess of 3 months for VRLA Lead Acid cells

To prevent damage to VRLA lead acid cells, an equalizing charge shall be performed after a maximum storage period of 3 months. If the storage period extends over several months, the equalizing charge has to be repeated every 3 months. It is recommended that the storage time should not exceed 24 months.

3.1.4.4 Equalizing charge for VRLA Lead Acid cells

The standard equalization charge would be for 24 hours at a constant voltage of 2.35 Volt per cell at 20 ºC or 2.33 Volt per cell at 25 ºC.

3.2 Commissioning Checklists

3.2.1 General

This section refers to Annexes A to G .The checklists are to be completed by a competent and accredited person that has been tasked to perform the work. The responsible DC person shall keep originals or copies of all commissioning documents.

3.2.2 Battery room

Before the erection of battery stands and batteries, the battery room shall be checked for compliance with the order (Scope of works) and Battery room standard specifications as far as possible. A Battery room acceptance checklist shall be completed (see Annex B).

3.2.3 Batteries, battery cubicles and stands

Before installing the battery, the battery cubicle or battery stands and cells shall be checked for any damage, compliance with the order (Scope of works) and specification. A Battery stand acceptance checklist and a Battery acceptance checklist shall be completed (see Annex C and D). A full battery commissioning checklist shall be completed for commissioning the battery (see Annex A).

3.3 Commissioning measurement equipment

3.3.1 General

All measurement equipment shall have a valid calibration status traceable to National Standards, which can be produced on request at any stage during or after the measurement.

3.3.2 Voltage measurement

Voltmeters shall be class 0,5% with resistance greater than 1 000 Ω/V.

3.3.3 Current measurement

Ammeters shall be class 0,5%. Any shunt employed shall be class 0,5% or better.

3.3.4 Temperature measurement

The scale resolution of the thermometer shall be not less than 1ºC with maximum calibration error of 0.5 ºC over the whole range. Alcohol or other approved non-intrusive thermometers that meet the accuracy requirements may also be used.

3.3.5 Specific gravity measurement and electrolyte

The scale resolution of the hydrometer shall be not less than 0,005 kg/l. The calibration error shall be better than 0,005 kg/l over the entire range.

3.3.6 Time measurement

For battery discharge tests an error of one minute per hour is acceptable.

3.3.7 Battery water conductivity

The conductivity of the battery water shall be measured with a maximum limit of ten micro Siemens per centimetre (µS/cm).

3.3.8 Discharge test equipment

For battery discharge tests an error of ±1% or better is acceptable.

3.4 Battery Installation

3.4.1 Battery Cubicles

1) Position cubicle correctly in accordance with the applicable drawings.
2) Ensure that cubicles are perfectly level over the length and width.
3) Cubicles must then be securely mounted to wall or trench
4) Earthing of the battery cubicle to station earth must be done via the earthing stud provided on the cubicle

3.4.2 Battery stands

1) Assemble and position stands correctly in accordance with the applicable drawings.
2) Plug holes in stands with plugs provided, but where screw holes remain these shall be plugged with putty.
3) Touch up paintwork where necessary.
4) Ensure that stands are perfectly level over the length and width.

3.4.3 Batteries

3.4.3.1 Transportation of batteries

All transporting of batteries shall be done in accordance with 240-89797258, The Safe Handling, Transportation and Disposal of Cells, Batteries and Electrolyte.

3.4.3.2 Unpacking of the batteries

1) Check for cracked jars or damaged lids or damaged terminals.
2) Check that cell polarities are correct and clearly marked.
3) Check cell plates are still intact.
4) Check that all accessories are correctly supplied, i.e. nuts, bolts spring washers, inter cell connectors, cell numbers.
5) Clean off any dust with a paper towel. (Scouring powders or solvents, e.g. Handy Andy, shall not be used for cleaning the jars or lids as scratching or damage to the surface of the container may result)
6) Ensure that the batch manufacturing dates on the cells correspond.

3.4.3.3 Packing and linking the cells

1) Pack the cells such that the edges of the plates are clearly visible.
2) Apply a thin layer of petroleum jelly or no-oxide grease to inter cell connectors and terminals. Connector and terminal coating shall be according to the manufacturer’s recommendations.
3) Fit inter cell connectors and hand-tighten nuts and bolts.
4) Line cells up straight and neatly ensuring that the specified distance between cells is maintained. Ensure that the correct polarities are maintained.
5) Tighten to the manufacturer’s prescribed torque settings using an insulated torque wrench.
6) Fit inter-row connectors and the battery terminating set.
7) Battery connectors shall be colour-coded red for positive, blue for negative and white for inter-row connectors and the monitoring tap. Connectors can be solid copper bars or flexible cable. Where flexible connectors are used, the crimped lugs must be sealed with adhesive heat shrink. Colour code flexible cables on the ends with coloured heat shrink. Note: The cable size should be properly sized for the battery load.
8) Number the cells with number one starting at the positive end. It is important to ensure that the numbers are visible and do not hide the cell maximum and minimum lines.
9) Mount the battery identification label. The label must be clearly visible and mounted above the battery bank, on the wall, or on the battery stand.
10) The battery is now ready to be filled.
11) Complete the Battery stands acceptance checklist and the Battery acceptance checklist (see Annex C and D).

3.5 Battery Commissioning

3.5.1 Safety requirements

1) The prescribed personal protective clothing as indicated in 240-44175132, Eskom Personal Protective Equipment (PPE), shall be worn when commissioning batteries.
2) The use of naked lights, naked flames, cigarettes, welding equipment and any other equipment capable of generating sparks is prohibited within the confines of the battery room or in close proximity of a battery enclosure.
3) Final connection shall be made at the rectifier and not at the battery to avoid an explosion risk in the battery room due to sparks.
4) Use only well insulated tools when working on a battery.
5) Do not place anything whatsoever on top of the battery.
6) Avoid bodily contact with the battery terminals, cell connectors and busbars.
7) Before taking voltage measurements, ensure that the voltage range selected on the digital multimeter provides adequate resolution and ensure that the selector switch is selected to voltage measurement and not current measurement.
8) Never use the same topping-up equipment or hydrometer on lead acid batteries as on nickel cadmium batteries. Keep the equipment clean, separate and labelled accordingly.
9) Care shall be taken with the disposal of electrolyte, particularly alkaline electrolyte. The requirements of local authorities shall be obtained and adhered to. All disposals of electrolyte and redundant batteries must be done according to 240-89797258, The Safe Handling, Transportation and Disposal of Cells, Batteries and Electrolyte.
10) Adequate ventilation of the battery room shall be available at all times, particularly during initial charging.
11) All measuring instruments shall be calibrated at least once a year.
12) Water shall always be available.
13) The emergency shower, where installed, shall be operational.

3.5.2 Charging of batteries

1) Ensure that the current limits are set correctly.
2) Ensure that all voltage charge levels are set correctly. The setting on the charger should be higher than the minimum acceptable limit for the battery allowing the voltage on the battery to develop as high as the chemical reaction would allow.
3) With the charger on, verify the polarity of the charger DC output. The battery shall still be disconnected.
4) Connect the battery with the AC supply switched off. The charging system can now be used to commission the batteries in accordance the batteries OEM requirements.
5) Ensure that the battery room ventilation system is operational.

3.5.3 Initial charging for Dry charged, flooded lead acid batteries

3.5.3.1 Filling the cells

1) During this phase of the commissioning process, it is important that the appropriate personal protective equipment is used. Adherence to the Eskom standard 240-89797258, The Safe Handling, Transportation and Disposal of Cells, Batteries and Electrolyte shall apply.
2) ADHERE TO ALL PPE AND SAFETY REQUIREMENTS AT ALL TIMES.

3) Check and log the SG of the electrolyte in each container before it is used to fill the cells. The SG value shall comply with the manufacturer's specification and not vary by more than ± 5 points between cans. Shake container or stir electrolyte to mix the acid before taking the SG readings. When checking the SG's, ensure that temperature correction is taken into consideration.

4) Clean all filling equipment with distilled water and ensure that it is operational. Ensure that all couplings are secure and hoses are in good working order (acid pump).

5) Fill the cells with electrolyte to the maximum mark. Be careful not to overfill cells above the maximum mark. If cells were accidentally overfilled the excess electrolyte should be removed using the hydrometer. Log the date, time, electrolyte temperature and ambient temperature after filling.

6) Never overfill the cells to compensate for trapped air bubbles. Each cell behaves differently and overfilling will affect the SG level of the electrolyte.

3.5.3.2 Resting the batteries

Leave the filled cells standing for a minimum of 4 hours and a maximum of 24 hours.

3.5.3.3 Initial charging

1) Before commencing with the initial charge, ensure that the cell temperatures are as near to ambient temperature as possible. Do not commence initial charge until the electrolyte temperature is below 40°C.

2) If the ambient temperature is a limiting factor for initial charging, reduce the charging current and try to perform the charging process during cooler periods of the day (early mornings or evenings).

3) Before commencing initial charging, check electrolyte level and top up to the maximum mark with electrolyte if necessary. Acid can only be added before commencing with initial charge, thereafter use only approved de-ionised water.

4) Complete initial charge log sheets. Select the correct battery commissioning sheet and complete a sheet/ set of sheets at each time interval. Select fixed time intervals for readings of cell voltages, current, SG's and electrolyte temperatures of pilot cells, so that changes in cell readings have a reference from which adjustments can be made.

5) Take a full set of open circuit readings and note abnormalities. The electrolyte shall be on the maximum mark when taking readings.

6) Confirm the correct polarity of the cells by checking the open circuit voltages. Contact the project leader if the polarity is incorrect to the terminal identification on the cell.

7) Select pilot (reference) cells. These will be the cells with abnormally high or low SG and voltage readings. Ensure that there is at least one reference cell at the end of the bank (i.e. more subject to ambient) and one reference cell in the middle of the bank (warmer than outside cells). It is advisable to use every 6th cell.

8) It is recommended that 4 sets of pilot cell readings be taken every 24 hours. Recommended times for taking readings are 08:00, 12:00, 16:00 and 23:00.

9) Set the charging system to "initial charge" mode, a constant current charge, switch ON and log time.

10) Start charging at 7% of the rated capacity (C10). Adjust the initial charging current between 3,5% and 15% of the ampere-hour rating of battery at the 10h rate. Ensure that the temperatures of the electrolyte of the pilot cells do not exceed the OEM maximum value. Whenever the electrolyte temperature does exceed the maximum specified value, reduce the current setting or stop charging until the electrolyte temperature has dropped.

11) Take a full set of battery cell readings. Thereafter take a set of pilot cell readings at the recommended (mentioned above) or selected times for the remainder of the initial charge.

12) Continue taking readings and charging as recommended above until the OEM recommended minimum charge has been accepted by the battery and the cell voltages and SG's have stabilised, at approximately 2,6V to 2,7V per cell between three consecutive hourly readings. The initial charge voltage must be set higher than 2.8V per cell to ensure constant current charge is maintained and the cell voltages will develop as high as the chemical reaction will allow.

13) On each set of readings document the calculation of the Amp-hours accumulated at that reading interval. This will serve as reference to the minimum period of charge before consecutive readings will be evaluated to monitor if voltages and SG's have stabilized and the initial charge process can be stopped.

14) If the charging current is reduced in order to control the temperature the initial charge time and number of readings will increase until the battery is deemed fully charged.

15) If neither the voltage nor the SG's stabilise after continuous charging to a maximum of 5 x C10, the non-compliant cells are not acceptable and they shall be replaced.

16) Take a full set of readings including cadmium readings at a charging current of 7% C10 (refer to section cadmium sticks). Results are to be noted on Cadmium Test Sheet. Select the correct system voltage sheet/set of sheets (for 220V) from Annex F.

17) The charger shall then be set to the float mode at the correct float voltage for a minimum of 12 h to allow the battery to stabilise (e.g. temperature, voltage, etc.).

Note: A **full set of readings** will include the following:

Note: 1) All cell voltages

Note: 2) All cell SG's

Note: 3) Pilot cell electrolyte temperatures

Note: 4) Ambient temperature

Note: 5) Battery voltage

Note: 6) Battery current

Note: 7) Amp-hours accumulated

Note: A set of pilot cell readings will include the following:

Note: 1) All cell voltages

Note: 2) Pilot cell SG's

Note: 3) Pilot cell electrolyte temperatures

Note: 4) Ambient temperature

Note: 5) Battery voltage

Note: 6) Battery current

Note: 7) Amp-hours accumulated

3.5.3.4 SG Adjustments

SG adjustments are necessary only when the specific gravities (SG's) of the cells, after initial charging, are not within the recommended ranges, as specified by the manufacturer.

Note: The SG of a cell should only be adjusted once in its life after commissioning and never again. The only other time SG can be adjusted down is when the SG has increased due to SG creepage. SG creepage should be investigated and the supplier contacted. A non-conformance report (NCR) shall be logged.

It is recommended that the adjustments be done slowly.

3.5.3.4.1 SG Adjustment Procedure

1) Top the cells up to the “MAX” mark.
2) Boost charge the batteries for a minimum of 2 hours to ensure that the electrolyte is thoroughly mixed.
3) Perform SG adjustments with the cells gassing.
4) Take a full set of SG readings.
5) Verify that the SG values are within the specified ranges. If not, then proceed with SG adjustments.
6) If the SG is high, adjustment is done by removing the calculated volume of electrolyte and replacing it with an equal volume of de-ionised water. Add a small amount of water at a time, with the cells gassing, to help mix the water with the acid. When thoroughly mixed, read the SG.
7) If the SG is too low, remove the calculated volume of electrolyte and replace it with an equal volume of stronger sulphuric acid in small amounts gassing (mixing) as described above.
8) Repeat the process until the specified tolerance (see table) is achieved.
9) When the adjustment has been completed, ensure that the electrolyte levels are on the “MAX” mark and the charger is set to the float mode.
10) The following equation may be used to determine the amount of electrolyte that must be removed and the amount of acid or water to replace it with for cells with electrolyte level on “MAX”:

$$V_2 = \frac{S_1 V_1 (C_3 - C_1)}{S_2 (C_2 - C_3) - S_1 (C_1 - C_3)} \qquad \text{..................1)}$$

where: S_1 = Specific gravity of acid to be adjusted

V_1 = Volume of acid to be adjusted

C_1 = % H_2SO_4 of acid to be adjusted

S_2 = Specific gravity of added acid or water

V_2 = Volume of electrolyte removed and volume of added acid or water

C_2 = % H_2SO_4 of added acid or water

C_3 = % H_2SO_4 of required acid

3.5.3.5 Temperature correction of SG

1) Rule 1: For every 10°C above 25°C, add 7 points (0.007) to the reading.
2) Rule 2: For every 10°C below 25°C, subtract 7 points (0.007) to the reading.

$$SG_2 = SG_1 + \frac{0.007(T_1 - 25)}{10} \qquad \text{...................2)}$$

where:

SG_1 = Specific gravity of electrolyte at the actual electrolyte temperature

SG_2 = Specific gravity of electrolyte corrected to 25°C

T_1 = Actual electrolyte temperature

3) Refer to Annex K for examples of SG adjustment calculations. Annex M shows an SG adjustment table that can be used instead of formula 1).

3.5.3.6 Cadmium readings

For flooded lead acid cells take cadmium readings of all cells. Cadmium Tests should be done at 7%IC10 just before the initial charge process is terminated. This will give evidence of the correct formation of the positive and negative plates as the voltage will be influenced by the final SG and state of charge of each cell.

3.5.4 Initial charging for wet, flooded lead acid batteries

Vented lead acid batteries delivered wet, meaning cell electrolytes has been filled, has already been initial charged and is delivered in a fully charged state. The only concern is that the manufacturer's prescribed storage prescriptions must be followed i.e. refreshing/rejuvenating charges to be done. Refer to item 3.1.3 Storage of new flooded Lead Acid batteries.

3.5.5 Initial/commissioning charging for valve regulated lead acid batteries

Valve regulated lead acid batteries has already been initial charged and is delivered in a fully charged state. The only concern is that the manufacturer's prescribed storage prescriptions must be followed i.e. refreshing/rejuvenating charges to be done. Refer to item 3.1.4 Storage of new Valve Regulated Lead Acid (VRLA) Lead Acid batteries. During the commissioning phase a commission charge as per the manufacturer's recommendation will be required to ensure that all the cells are in a 100% fully charged state.

3.5.6 Initial/commissioning charging for Nickel Cadmium batteries

Nickel Cadmium batteries has already been initial charged and is delivered in a fully charged state. The only concern is that the manufacturer's prescribed storage prescriptions must be followed i.e. refreshing/rejuvenating charges to be done. Refer to item 3.1.2 Storage of new Nickel Cadmium batteries. During the commissioning phase a commission charge as per the manufacturer's recommendation will be required to ensure that all the cells are in a 100% fully charged state.

3.6 Discharge tests

Suitable values of constant discharge current, discharge duration and final cell voltage shall be decided on before the test in accordance with the relevant standards or the battery manufacturer's specifications. The discharge current shall be held constant within 1% throughout the duration of the test. The constant current shall be maintained by using a discharge test set. The battery bank voltage shall be captured via an automated discharge voltage logging that is date and time stamped.

The rated capacities of cells for vented lead acid cells are specified at 25°C over the 10 hr rate (C10) to a final end-of-discharge voltage of 1,80V/cell, valve regulated lead acid cells are specified at 20°C, over the 10 hr rate (C10) to a final end-of-discharge voltage of 1,80 V/cell. Nicad cells are specified at 20°C over the 5 hr rate (C5) to a final end-of-discharge voltage of 1,00V/cell.

3.6.1 Prerequisites for capacity testing

1) Batteries shall be commissioned and installed in accordance with the manufacturer's recommendations.
2) The cells shall be fully charged before each test according to the manufacturers recommended procedure, which is acceptable to Eskom.
3) Batteries or cells are deemed fully charged if, whilst being charged above the gassing voltage at a voltage value as recommended by the manufacturer, the terminal voltage as well as the specific gravity in the case of flooded lead acid cells remains constant over a period of four hours.
4) Temperature deviations from the reference temperature have to be compensated for.

3.6.2 Selecting the correct discharge current

1) Each cell is made up of a series of parallel connected plates, connected together by the group bar. The plate area and thickness determine the Ah capacity of the plate. Different numbers of plates are connected in parallel to make up the required cell capacities. There is always one more negative plate than positive plates, which means that the negative plates are the outer plates of the cell.

2) In the case of vented lead acid cells the number of positive plates can easily be determined from the cell type number which designates either the amount of positive plates or total amount of positive and negative plates contained in each cell according to different manufacturers.

3) Battery manufacturers supply discharge table with each battery type, which can be used for design purposes as well as discharge testing purposes. Discharge tables can be supplied per individual cell type or per plate size for a range of cells that contain this plate size. In the former case, the discharge current per cell will be specified and in the latter case, the discharge current per positive plate will be specified. These discharge tables are specified for a specified SG(in the case of flooded lead acid cells), electrolyte temperature, end-of-discharge voltage and over period of time.

4) The capacity, expressed in ampere-hours (Ah) varies with the conditions of use (discharge current and voltage, and temperature).

5) Recommended t-values used for specifying rated capacity of lead acid cells are:

t = 240h, 20h, 10h, 8h, 5h, 3h, 2h, 1h, 0,5h.

One value from these values of t is selected and the capacity is specified at this value, known as Crt. In the case of lead acid batteries, the rated capacity is denoted as C10 which means that t = 10h. The discharge current corresponding to the rated capacity, Crt, at the chosen reference temperature of 20°C or 25°C to the final discharge voltage Uf (End-of-discharge voltage) is:

$$I_{rt} = \frac{C_{rt}}{t} \qquad \text{..................3)}$$

6) After the discharge test has been completed, the measured capacity, C (Ah), at the initial electrolyte temperature, θ, is calculated as the product of the discharge current (in amperes) and the discharge time (in hours).

7) If the initial average electrolyte temperature, θ, is different from the reference temperature (20°C or 25°C), the measured capacity shall be corrected by means of equations 4) or 5) to obtain the actual capacity, Ca, at the chosen reference temperature of 20°C or 25°C.

$$C_{a20°C} = \frac{C}{[1+\lambda(\theta - 20°C)]} \quad Ah \qquad \text{..................4)}$$

or

$$C_{a25°C} = \frac{C}{[1+\lambda(\theta - 25°C)]} \quad Ah \qquad \text{................5)}$$

8) The coefficient, λ, shall be taken as 0,006 for discharges slower than the 3h rate, and 0,01 with discharges with faster rates.

9) A new battery being repeatedly discharged and charged as specified by the manufacturer, shall supply at least Ca = 0,95 Crt at the first cycle and Ca = Crt at the second cycle.

10) All battery bank cells are required to meet the minimum cell voltage requirement during the final discharge test. On replacement of cells not meeting the discharge test, the new replacement cells shall be initial charged and discharged tested at supplier to confirm that they meet required minimum capacity, however once the noncompliant cells are replaced the bank will not be required to be discharge tested again.

3.6.3 Discharge test procedure

1) Switch the battery charger off and disconnect the battery from the battery charger.

2) Take a full set of open circuit battery readings.

3) Connect the discharge test set to the battery and set the discharge test set to the recommended discharge current.

4) The discharge test can be conducted over the ten or five hour period. The manufacturer provides these capacities as well as final voltages (end-of-discharge voltages). Refer to tables in technical manuals.

5) Note: If the battery application requires a discharge at any other rate, the battery should be discharged at that rate, in accordance with the manufacturer's data.

6) Discharge shall commence at earliest after 1 hour and before 24 hours after completion of the initial charge.

7) Start the discharge test set, check the discharge current and log the time. The discharge current shall not deviate more than ± 1% from the set value over the whole discharge period. Short term deviations of within ± 5% of the set value shall be tolerated.

8) Battery bank voltage, cell voltages, current and pilot cell temperature readings shall be taken at least at 25%, 50% and 80% of the calculated discharge time, and thereafter at intervals that allow the reaching of the final voltage to be detected. A recommendation is that readings shall be taken at 30 minutes intervals during the last hour. Readings are to be recorded on the correct battery technology commissioning sheets with a sheet/set of readings that is selected from Annex H, Annex I or Annex J for each time interval.

9) The discharge test shall be complete when the predetermined time of discharge has elapsed or when all cell voltages fell below the final end-of-discharge voltage before the discharge time has lapsed.

10) After the completion of the discharge test, switch the discharge test set off and disconnect it from the battery. A Discharge Summary Sheet (Annex F) must be completed after completion of the test.

11) For flooded lead acid cells take a full set of SG and pilot cell temperature readings.

12) Connect the battery to the battery charger.

13) Set the battery charger current limit to 7% C10 and commence recharge until the battery has accepted at least 1,5 x C10. Take cell temperature into consideration upon recharging.

14) Set the battery charger to float and take a full set of readings.

3.6.4 Acceptance

All battery bank discharge tests to be conducted with automated bank voltage data capture that is date and time stamped.

If any cell's voltage falls below the manufacturer's recommended final voltage per cell within the discharge period specified in the purchase contract, the cell will be classified as faulty and shall be replaced. A new battery being repeatedly discharged and charged as specified by the manufacturer, shall supply at least Ca = 0,95 Crt at the first cycle. If this is not reached the bank will be seen as failed and replaced. If the bank achieved more than 0,95 Crt it must achieve Ca = Crt at the second cycle to pass.

If a contractor does the discharge test, Eskom will only witness one discharge test to prove that a cell can supply 100% capacity. Guarantee and warrantee agreements shall be according to the latest contract between Eskom and the supplier.

3.7 Final checks

a) Check the voltage settings for the float and equalise modes.

b) Make sure that all cells are clean, dry and apply an approved coating material as per manufacturers.

c) Take a full set of impedance –, conductance – or internal resistance readings for the individual cells and the connecting links. These measurements will provide the following benefits:

  1) Documented proof of correct torqueing of cells.

  2) Documented proof of no cell damage during transport and commissioning of cells.

  3) Baseline ohmic measurement of internal cell plates for future reference.

d) Connect load.

e) Hand over to customer.

f) Until such time as the substation or new installation is handed over it shall be the responsibility of the DC Section to carry out routine maintenance on the batteries and chargers in accordance with the 240-108614750, Rev 1: DC supply equipment maintenance standard.

g) Complete the Battery In/Out Commissioning Sheet (Annex N) and forward a copy to the Plant Management Section to update the assets management database.

h) A final comment is that although several commissioning sheets has been developed and made available in the annexes to provide a standardised data collection format, automated data collected for cell readings which are date and time stamped are preferred. If the specific meter provides for information such as the project & site name, they can be printed and used for the commissioning data as is.

4. Authorization

Name and surname	Designation
Prince Moyo	Power Delivery Engineering GM
Richard McCurrach	Senior Manager – PTM&C CoE
Edison Makwarela	Metering, DC & Security Technologies Manager (Acting) – PTM&C CoE
Prudence Madiba	Senior Manager Electrical and C&I Engineering
Kashveer Jagdaw	DC & Auxiliary Supplies SC Chairperson

5. Revisions

Date	Rev	Compiler	Remarks
Nov 2018	1	C van Zyl	New document

6. Development team

Eskom Battery Care group

7. Acknowledgements

Not applicable.

Annex A – DC Equipment Commissioning Cover Sheet

Eskom	BATTERY COMMISSIONING COVER SHEET	Page		
		1	of	6

Project / Works Order / Task Order No.:		**Starting Date:**	
Site Name:			
Drawing No.:			
Battery Function:			
Battery Manufacturer:		**Model:**	
Standards/Specifications:	**240-56360034, Stationary Vented Lead Acid Batteries Standard** **240-56360086, Stationary Vented Nickel Cadmium Batteries Standard** **240-51999453, Standard Specification for Valve-Regulated Lead Acid Cells** **240-56177186, Battery Room Standard**		

Number	Item	Contractor	Eskom
1	Battery Room Acceptance Checklist		
2	Battery Stand / Cubicle Acceptance Checklist		
3	Battery Acceptance Checklist		
4	VLA Battery Initial charge Checklist 1)		
5	Battery Discharge Checklist		
6	Battery Commissioning Sheets 1)		
7	Battery Cadmium Sheets 2)		
8	Battery In/Out Commissioning Sheet		

Notes:

Applicable items to be signed off by contractor and Eskom representative

Checklists 1-5 to be completed where applicable

1) Selected applicable battery technology commissioning sheets, to be used for charge and discharge logging

2) Only applicable to VLA batteries

Done by Contractor	Signature	Date
Approved by Eskom	**Signature**	**Date**

Annex B – Battery Room Acceptance Checklist

Eskom	BATTERY ROOM ACCEPTANCE CHECKLIST	Page		
		2	of	6

Project / Works Order / Task Order No.:		**Date:**	
Site Name:			
Drawing No.:			
Standard/Specification:	**240-56177186, Battery Room Standard**		

Number	Item	Contractor	Eskom
1	Battery Room construction as per design drawing		
2	Battery room requirements as per divisional specifications		
3	Floor sloping towards chemical resistant gulley		
4	Chemical resistance epoxy floor coating, light grey colour		
5	Door entrance elevated to ensure electrolyte containment		
6	Walls painted with acid resistant primer and white enamel		
7	Running water provided [1)]		
8	Taps with sink with acid trap [2)]		
9	Deluge shower & eyewash installed and operational [1)]		
10	Ventilation will be as per battery room specification [3)]		
11	Safety signs provided and positioned as per battery room standard		
12	The luminaires shall be mounted in parallel with the battery stands, but not over the battery stands		
13	Electrical installations in battery rooms issued with a Certificate of Compliance (CoC).		
14	Battery rooms with alarms installed shall comply with battery room standard[(1)]		
15	Battery maintenance and safety equipment holder or enclosure provided		

Notes:
1) Not a requirement for Eskom Distribution and Eskom Telecommunication
2) Only sink required for Eskom Distribution and Eskom Telecommunication
3) Can be forced or natural ventilation depending on the design, design to comply with battery room standards

Done by Contractor	Signature	Date
Approved by Eskom	**Signature**	**Date**

Annex C – Battery Stand and Battery Cubicle Acceptance Checklist

Eskom	BATTERY STAND / CUBICLE ACCEPTANCE CHECKLIST	Page		
		3	of	6

Project / Works Order / Task Order No.:		**Date:**	
Site Name:			
Drawing No.:			
Standards/Specifications:	**240-56360034, Stationary Vented Lead Acid Batteries Standard** **240-56360086, Stationary Vented Nickel Cadmium Batteries Standard** **240-51999453, Standard Specification for Valve-Regulated Lead Acid Cells**		

Number	Item	Contractor	Eskom
1	Battery stand		
1.1	Battery stand complies to standards and as per drawings		
1.2	All battery stand components delivered and correct		
1.2	Battery stand correctly positioned and level		
1.3	Bolt and screw holes plugged		
2	Battery Cubicles		
2.1	Battery cubicle complies to standards and as per drawings		
2.2	Battery cubicle inspected for any damage		
2.3	Battery cubicle installed as per design layout drawings		
2.4	Battery cubicle level and securely mounted		
2.5	Battery cubicle safety signs fitted		

Note: Mark the non-relevant portions just as N/A

Done by Contractor	Signature	Date
Approved by Eskom	**Signature**	**Date**

Annex D – Battery Acceptance Checklist

	BATTERY ACCEPTANCE CHECKLIST	Page 4 of 6

Project / Works Order / Task Order No.:		**Date:**	
Site Name:		**Battery Order No.**	
Battery Function:			
Battery Manufacturer:		**Model:**	
Standards/Specifications:	**240-56360034, Stationary Vented Lead Acid Batteries Standard** **240-56360086, Stationary Vented Nickel Cadmium Batteries Standard** **240-51999453, Standard Specification for Valve-Regulated Lead Acid Cells**		

Number	Item	Contractor	Eskom
1	Type, make, Ah rating and number of cells correct as per design		
2	No visible damage to cells		
3	All battery components delivered and correct		
4	Cells positioned correctly, lined up straight and neat		
5	Inter-cell, inter-row and battery terminating devices fitted and torqued to the correct settings		
6	Intercell connection and cell impedance measurements taken as per standards after commission done		
7	Approved protective coating applied to intercell connectors, bolts and nuts		
8	Recombination units inserted on the vent plugs of the VLA battery cells		
9	All battery cells cleaned and neat		

Note: Recombination units only applicable to VLA batteries, mark as N/A for other battery types

Done by Contractor	Signature	Date
Approved by Eskom	**Signature**	**Date**

Annex E – VLA Battery Initial charge Checklist

Eskom	VLA BATTERY INITIAL CHARGE CHECKLIST	Page		
		5	of	6

Project / Works Order / Task Order No.:		**Date:**	
Site Name:			
Battery Function:			
Battery Manufacturer:		**Model:**	
Standards/Specifications:	**240-56360034, Stationary Vented Lead Acid Batteries Standard**		

Number	Item	Value
1	Average SG of electrolyte in containers	
2	Average temperature of electrolyte in containers	°C
3	Initial charging current (Ideal 7% of C_r Max 15% of C_r)	A
4	Time and date of filling cells	Time Date
5	Time and date of commencing charge	Time Date
6	Time and date of cells starting to gas	Time Date
7	Time and date of when current set at 7% of C_r	Time Date
8	Time and date when voltage & SG stabilised	Time Date
9	SG corrections done (Yes/No)	Yes/No
10	Time and date of Cadmium readings	Time Date
11	Time and date when 12 hour float charge initiated	Time Date
12	Resting period before start of discharge test	Hours

Note: VLA batteries is the only battery technology initial charged by contractors or Eskom, all other battery types are initial charged at the OEM factories

Done by Contractor	Signature	Date
Approved by Eskom	**Signature**	**Date**

Annex F – Battery Discharge Checklist

		Page		
Eskom	**BATTERY DISCHARGE CHECKLIST**	6	of	6

Project / Works Order / Task Order No.:		**Date:**	
Site Name:			
Battery Function:			
Battery Manufacturer:		Model:	
Standards/Specifications:	**240-56360034, Stationary Vented Lead Acid Batteries Standard** **240-56360086, Stationary Vented Nickel Cadmium Batteries Standard** **240-51999453, Standard Specification for Valve-Regulated Lead Acid Cells**		

Number	Item	Value
1	Nominal capacity rating: (C_{10} for VLA batteries; C_8 for VRLA batteries; C_5 for Nickel Cadmium batteries)	Ah
2	Selected Discharge time / t_{table}	h
3	Selected Discharge current (from Discharge Tables) / $I_{discharge}$	A
4	Expected Discharged capacity / $C_e = I_{discharge} \times t_{table}$	Ah
5	Minimum cell voltage (from Discharge Tables)	V
6	Has the battery been fully charged	Yes/No
7	Cell Temperature before start of discharge	°C
8	Time discharge started / t_{start}	hh:mm
9	Time discharge stopped / t_{end}	hh:mm
10	Discharge duration / $t_{discharge} = t_{end} - t_{start}$	h
11	Achieved Capacity / $C_{test} = I_{discharge} \times t_{discharge}$	Ah
12	Achieved Capacity / $C = C_{test}/C_e \times 100$	%
13	Discharge log sheets completed	Yes/No
14	Battery passed the discharge test?	Yes/No

Remarks:

IEC 60623 Tests and requirements for vented nickel-cadmium prismatic secondary single cells

IEC 60896 Tests and requirements for VLA and VRLA prismatic secondary single cells

Done by Contractor	Signature	Date
Approved by Eskom	**Signature**	**Date**

Annex G – Vented Lead Acid Battery Commissioning Sheets

Eskom	**VENTED LEAD ACID BATTERY COMMISSIONING SHEET**	Sheet number		
			of	

Project / Works Order / Task Order No :		**Date &Time:**			
Site Name:		**Charge** [1)]		**Discharge** [1)]	
Battery Manufacturer:		**Model:**			
Manufacturing Date:		**Ambient Temperature** [°C]			

Charging Voltage [V]		**Charging Current [A]** [1)]		**Pilot Cells Electrolyte Temperature**	**#**				
		Discharge Current[A] [1)]			**[°C]**				

#	Volts	SG	#	Volts	SG	#	Volts	SG	#	Volts	SG
1			27			53			79		
2			28			54			80		
3			29			55			81		
4			30			56			82		
5			31			57			83		
6			32			58			84		
7			33			59			85		
8			34			60			86		
9			35			61			87		
10			36			62			88		
11			37			63			89		
12			38			64			90		
13			39			65			91		
14			40			66			92		
15			41			67			93		
16			42			68			94		
17			43			69			95		
18			44			70			96		
19			45			71			97		
20			46			72			98		
21			47			73			99		
22			48			74			100		
23			49			75			101		
24			50			76			102		
25			51			77			103		
26			52			78			104		

Comments / Remarks: 1) Sheet to be used for both charging and discharge cell data logging, tick correct box		Capacity charged [Ah]: Capacity discharged[Ah]:
Done by	**Signature**	**Date**

Annex H – Valve Regulated Lead Acid Battery Commissioning Sheet

Eskom	**VALVE REGULATED LEAD ACID BATTERY COMMISSIONING SHEET**	Sheet number	
			of

Project / Works Order / Task Order No.:		**Date & Time:**			
Site Name:		**Charge [1]**		**Discharge [1]**	
Battery Manufacturer:		**Model:**			
Manufacturing Date:		**Ambient Temperature [°C]**			

Charging Voltage [V]		**Charging Current [A] [1]**		**Block**	**2V**		**6V**		**12V**		
		Discharge Current[A] [1]									

String 1			**String 2**			**String 3**			**String 4**		
String Voltage [V]			**String Voltage [V]**			**String Voltage [V]**			**String Voltage [V]**		
String Current [mA]			**String Current [mA]**			**String Current [mA]**			**String Current [mA]**		
#	**Volts**	**Temp [°C]**	**#**	**Volts**	**Temp [°C]**	**#**	**Volts**	**Temp [°C]**	**#**	**Volts**	**Temp [°C]**
1			1			1			1		
2			2			2			2		
3			3			3			3		
4			4			4			4		
5			5			5			5		
6			6			6			6		
7			7			7			7		
8			8			8			8		
9			9			9			9		
10			10			10			10		
11			11			11			11		
12			12			12			12		
13			13			13			13		
14			14			14			14		
15			15			15			15		
16			16			16			16		
17			17			17			17		
18			18			18			18		
19			19			19			19		
20			20			20			20		
21			21			21			21		
22			22			22			22		
23			23			23			23		
24			24			24			24		
25			25			25			25		

Comments / Remarks: 1) Sheet to be used for both charging and discharge cell data logging, tick correct box		Capacity charged [Ah]: Capacity discharged[Ah]:
Done by	**Signature**	**Date**

Annex I – Nickel Cadmium Battery Commissioning Sheet

Eskom	NICKEL CADMIUM BATTERY COMMISSIONING SHEET	Sheet number		
			of	

Project / Works Order / Task Order No.:		**Date & Time:**			
Site Name:		**Charge [1]**		**Discharge [1]**	
Battery Manufacturer:		**Model:**			
Manufacturing Date:		**Ambient Temperature [°C]**			

Charging Voltage [V]		**Charging Current [A] [1]**		**Pilot Cells Electrolyte Temperature**	**#**				
		Discharge Current[A] [1]			**[°C]**				

#	Volts	#	Volts	#	Volts	#	Volts	#	Volts	#	Volts	#	Volts	#	Volts
1		26		51		76		101		126		151		176	
2		27		52		77		102		127		152		177	
3		28		53		78		103		128		153		178	
4		29		54		79		104		129		154		179	
5		30		55		80		105		130		155		180	
6		31		56		81		106		131		156		181	
7		32		57		82		107		132		157		182	
8		33		58		83		108		133		158		183	
9		34		59		84		109		134		159		184	
10		35		60		85		110		135		160		185	
11		36		61		86		111		136		161		186	
12		37		62		87		112		137		162		187	
13		38		63		88		113		138		163		188	
14		39		64		89		114		139		164		189	
15		40		65		90		115		140		165		190	
16		41		66		91		116		141		166		191	
17		42		67		92		117		142		167		192	
18		43		68		93		118		143		168		193	
19		44		69		94		119		144		169		194	
20		45		70		95		120		145		170		195	
21		46		71		96		121		146		171		196	
22		47		72		97		122		147		172		197	
23		48		73		98		123		148		173		198	
24		49		74		99		124		149		174		199	
25		50		75		100		125		150		175		200	

Comments / Remarks: 1) Sheet to be used for both charging and discharge cell data logging, tick correct box		Capacity charged [Ah]: Capacity discharged[Ah]:
Done by	**Signature**	**Date**

Annex J – Vented Lead Acid Battery Cadmium Sheets

Eskom	VENTED LEAD ACID BATTERY CADMIUM SHEET	Sheet number		
			of	

Project / Works Order / Task Order No :		**Date &Time:**	
Site Name:			
Battery Manufacturer:		**Model:**	
Manufacturing Date:		**Ambient Temperature [°C]**	

Charging Voltage [V]		**Charging Current [A]**		**Pilot Cells Electrolyte Temperature**	**#**				
					[°C]				

#	Positive	Negative	#	Positive	Negative	#	Positive	Negative	#	Positive	Negative
1			27			53			79		
2			28			54			80		
3			29			55			81		
4			30			56			82		
5			31			57			83		
6			32			58			84		
7			33			59			85		
8			34			60			86		
9			35			61			87		
10			36			62			88		
11			37			63			89		
12			38			64			90		
13			39			65			91		
14			40			66			92		
15			41			67			93		
16			42			68			94		
17			43			69			95		
18			44			70			96		
19			45			71			97		
20			46			72			98		
21			47			73			99		
22			48			74			100		
23			49			75			101		
24			50			76			102		
25			51			77			103		
26			52			78			104		

Comments / Remarks:		Capacity Charged :
Done by	**Signature**	**Date**

Annex K – SG adjustment examples

Example 1:

Consider the adjustment of SG from 1,240 to 1,250 in a FHP19 cell, using topping-up acid of 1,400. The assumptions are that all the electrolyte temperatures are 25°C and that the electrolyte levels are on “MAX”.

S1 = 1,240

V1 = 26,8 litres (Read from manufacturer specification sheet)

C1 = 32,6 (Read from table in Annex M)

S2 = 1,400

V2 = To be calculated

C2 = 50,5 (Read from table in Annex M)

C3 = 33,8 (Read from table in Annex M)

Temperature correction of the SG values is not required as they are already at 25°C.

From the problem statement, we deduce that we need to adjust the SGs *upwards*. Use equation 1) from section 4.6 to calculate the amount of electrolyte to remove from the cell and the amount of topping-up acid to replace it with.

From 1):

$$V_2 = \frac{S_1 V_1 (C_3 - C_1)}{S_2 (C_2 - C_3) - S_1 (C_1 - C_3)}$$

$$= \frac{(1{,}240)(26{,}8)(33{,}8 - 32{,}6)}{1{,}400(50{,}5 - 33{,}8) - 1{,}240(32{,}6 - 33{,}8)}$$

= 1,62 litres

Example 2:

Consider the adjustment of SG from 1,260 to 1,250 in a FCP13 cell, using de-ionised water. The assumptions are that all the electrolyte temperatures are 25°C and that the electrolyte levels are on “MAX”.

S1 = 1,260

V1 = 4,6 litres (Read from manufacturer specification sheet)

C1 = 35,0 (Read from table in Annex M)

S2 = 1,000

V2 = To be calculated

C2 = 0 (Read from table in Annex M)

C3 = 33,8 (Read from table in Annex M)

Temperature correction of the SG values is not required as they are already at 25°C.

From the problem statement, we deduce that we need to adjust the SGs downwards. Use equation 1) from section 4.6 to calculate the amount of electrolyte to remove from the cell and the amount of de-ionised to replace it with.

From 1):

$$V_2 = \frac{S_1 V_1 (C_3 - C_1)}{S_2 (C_2 - C_3) - S_1 (C_1 - C_3)}$$

$$= \frac{(1{,}260)(4{,}6)(33{,}8 - 35{,}0)}{1{,}000(0 - 33{,}8) - 1{,}260(35{,}0 - 33{,}8)}$$

= 0,2 litres

Example 3 (Temperature correction):

Consider the adjustment of SG from 1,240 @ 15°C to 1,250 @ 25°C in a FHP19 cell, using topping-up acid of 1,400 @ 15°C. The assumptions are that all the electrolyte temperatures are 25°C and that the electrolyte levels are on “MAX”.

Use equation 2) from section 4.6 to do temperature correction on all electrolyte SGs to bring it to 25°C.

Cell electrolyte SG @ 25°C = 1,240 – 0,007 = 1,233

Filling acid SG @ 25°C = 1,400 – 0.007 = 1,393

S1 = 1,233

V1 = 26,8 litres (Read from manufacturer specification sheet)

C1 = 31,7 (Read from table in Annex M)– interpolation may be required.

S2 = 1,393

V2 = To be calculated

C2 = 49,7 (Read from table in Annex M)

C3 = 33,8 (Read from table in Annex M)

From the problem statement, we deduce that we need to adjust the SGs *upwards*. Use equation 1) from section 4.6 to calculate the amount of electrolyte to remove from the cell and the amount of topping-up acid to replace it with.

From 1):

$$V_2 = \frac{S_1 V_1 (C_3 - C_1)}{S_2 (C_2 - C_3) - S_1 (C_1 - C_3)}$$

$$= \frac{(1{,}233)(26{,}8)(33{,}8 - 31{,}7)}{1{,}393(49{,}7 - 33{,}8) - 1{,}233(31{,}7 - 33{,}8)}$$

= 2,83 litres

Annex L – % Sulphuric Acid for a SG value at 25°C

SG	% H_2SO_4	SG	% H_2SO_4	SG	% H_2SO_4	SG	% H_2SO_4
1	**0**	1.225	30.8	1.355	45.8	1.485	58.8
1.1	14.7	1.23	31.4	1.36	46.3	1.49	59.2
1.105	15.4	1.235	32	1.365	46.9	1.495	59.7
1.11	16.1	1.24	32.6	1.37	47.4	1.5	60.2
1.115	16.8	1.245	33.2	1.375	47.9	1.505	60.6
1.12	17.4	1.25	33.8	1.38	48.4	1.51	61.1
1.125	18.1	1.255	34.4	1.385	48.9	1.515	61.5
1.13	18.8	1.26	35	1.39	49.5	1.52	62
1.135	19.4	1.265	35.6	1.395	50	1.525	62.5
1.14	20.1	1.27	36.2	1.4	50.5	1.53	62.9
1.145	20.7	1.275	36.8	1.405	51	1.535	63.4
1.15	21.4	1.28	37.4	1.41	51.5	1.54	63.8
1.155	22	1.285	37.9	1.415	52	1.545	64.3
1.16	22.7	1.29	38.5	1.42	52.5	1.55	64.7
1.165	23.3	1.295	39.1	1.425	53	1.555	65.2
1.17	23.9	1.3	39.7	1.43	53.5	1.56	65.6
1.175	24.6	1.305	40.3	1.435	54	1.565	66
1.18	25.2	1.31	40.8	1.44	54.5	1.57	68.5
1.185	25.8	1.315	41.4	1.445	55	1.575	66.9
1.19	26.5	1.32	41.9	1.45	55.5	1.58	67.4
1.195	27.1	1.325	42.5	1.455	55.9	1.585	67.8
1.2	27.7	1.33	43.1	1.46	56.4	1.59	68.2
1.205	28.3	1.335	43.6	1.465	56.9	1.595	68.7
1.21	29	1.34	44.2	1.47	57.4	1.6	69.1
1.215	29.6	1.345	44.7	1.475	57.8		
1.22	30.2	1.35	45.3	1.48	58.3		

Annex M – SG Adjustment Table

Desired SG @ 25°C	1.210	1.250
SG of adding acid @ 25°C	1.400	1.400
SG of water @ 25°C	1.000	1.000
End of charge SG	**ml / l**	**ml / l**
1.180	129.66	302.67
1.185	111.88	288.50
1.190	89.95	270.90
1.195	70.14	255.09
1.200	49.27	238.44
1.205	27.26	220.86
1.210	**0.00**	198.99
1.215	24.52	179.16
1.220	48.06	158.14
1.225	70.66	135.83
1.230	92.39	112.11
1.235	113.29	86.83
1.240	133.40	59.84
1.245	152.77	30.96
1.250	171.43	**0.00**
1.255	189.42	21.79
1.260	206.78	42.82
1.265	223.54	63.12
1.270	239.72	82.72
1.275	255.36	101.66
1.280	270.48	119.98
1.285	282.83	134.85
1.290	297.05	152.10
1.295	310.83	168.79
1.300	324.17	184.95
1.305	337.09	200.61
1.310	347.70	213.40
1.315	359.91	228.20
1.320	369.95	240.31

Annex N – Battery In/Out Commissioning Sheet

BATTERY IN/OUT COMMISSIONING SHEET

SUBSTATION ____________________ DC Function ____________________

Works order number ____________________

OLD EQUIPMENT		NEW EQUIPMENT	
Decommission Date	____________________	Commission Date	____________________
Battery Make	____________________	Battery Make	____________________
Battery Type	____________________	Battery Type	____________________
Order no	____________________	Order no	____________________
ENC Contract no	____________________	ENC Contract no	____________________
Rating	____________________	Rating	____________________
Manufacture Date	____________________	Manufacture Date	____________________
Lead acid/Nicad	____________________	Lead acid/Nicad	____________________
Number of cells	____________________	Number of cells	____________________
Type of stand/cubicle	____________________	Type of stand/cubicle	____________________

Remarks ____

Name ____________________

Signed ____________________

Tel no ____________________ Responsible DC person ____________________

Date ____________________ Plant Manager ____________________