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1. Introduction

This document specifies the minimum requirements for voltage, current and alarm settings to be applied to all battery charger, inverter, convertor and uninterruptible power supply systems.

2. Supporting clauses

2.1 Scope

The document specifies the basic DC chargers, UPS, inverter, convertor and battery equipment settings, enabling effective protection of the equipment without compromise to the critical load applications. The document describes the Eskom philosophies and principles that influence these settings ensuring optimized equipment performance, reliability and life expectancy.

The document excludes the power electronic and software configuration methods as these are product specific and detailed by the equipment manufacturer.

2.1.1 Purpose

The purpose of the document is to guide the engineering practitioner in the application of the recommended or typical settings values, thus ensuring optimized system performance, reliability and equipment life expectancy.

These settings shall be documented, authorised and archived in the site based settings sheet, enabling retrieval and verification of the design base during system maintenance or fault diagnosis activities.

The document further provides guidance on the terminology and settings to be applied for older equipment within the fleet considering current authorised equipment specifications, technology terms and references. Due to specific system applications and equipment variances in product manufacturers it is comprehensible that not all the equipment settings are covered in this document and thus additional parameters shall be comprehensively detailed or referenced within the site based settings document.

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] TX 3.3:Vantex New Generation Ni-Cd Battery Technical Manual – June 2013; (for cells delivered before May 2012, use VTX 3.1 – September 2010)

[2] V3.4: Vantage ultra-low maintenance batteries Technical manual

[3] S3.4: L/M/H Single Cell Range Technical manual – April 2007

[4] Hoppecke: Installation, commissioning and operating instructions for vented stationary lead-acid batteries.

[5] First National Battery: Standby Power Batteries, Installation and Maintenance Instructions.

[6] Haze: Stationary 2 Volt Batteries, Installation and Operating Instructions.

[7] ISO 9001 Quality Management Systems.

[8] 240-53114248 Thyristor and Switchmode Chargers, AC/DC to DC/AC Converters and Inverter/Uninterruptible Power Supplies Standard

[9] 240-137465740 Standby Battery Storage and Commissioning in Eskom

[10] 240-170000055 Installation and Commissioning of Power Electronics Equipment

[11] 240-134093286 Cordex CXC HP Battery Charger Settings Work Instruction

[12] 240-56360034 Specification for vented lead acid cells

[13] 240-51999453 Standard specification for valve-regulated Lead-acid cells

[14] 240-56360086 Specification for vented and semi-sealed Nickel-Cadmium cells and batteries

[15] 240-170000371 Technical Bulletin 28 Day Auto Boost on NiCad's

[16] DC and Auxiliary Supplies Website:

http://eng.eskom.co.za/sites/scot/tcptmc/scdcas/SitePages/Home.aspx

2.2.2 Informative

[17] IEE 1376 Guide for the Protection of Stationary Battery Systems

[18] SANS 10108: 2017 The Classification of Hazardous locations and the selection of equipment for use in such locations

[19] 240-141330136 Installation and Commissioning of the Battery Theft Monitoring Alarm

2.3 Definitions

2.3.1 General

Definition	Description
AC Fail Alarm	The alarm is activated if the single or dual AC supply to the power electronic device is interrupted or out tolerance.
Battery Voltage High	The alarm is activated when the battery voltage exceeds the normal safe limits and trips the rectifier module causing the over voltage by sensing the high voltage.
Battery Voltage Low	The alarm is initiated when the battery voltage is lower than the normal float charge mode. The low battery voltage settings are thus set lower than the float voltage parameters and higher than the battery voltage low urgent alarm setting.
Battery Voltage Low Urgent	The battery voltage low alarm is set just before the knee point on the cell's discharge curve indicating imminent DC supply loss to the loads. The low battery voltage urgent setting set below the battery voltage low alarm setting and above the load / battery disconnect pre-set value.
Boost voltage	Boost voltage is set higher than float to ensure that the battery recharges faster than in float. A secondary outcome of boost charging for flooded cells is the mixing of the electrolyte of the cell. There is no distinction between manual boost and auto boost voltage settings.
Charger Fail	The grouped alarm is initiated due to a single or multiple charger faults such as a rectifier module MCB trip, rectifier shutdown or failure, high ripple, low or high load voltage and low or high battery voltage.
DC High Volts 1	The high volts 1 alarm voltage level is set just below the boost voltage setting and is only activated if the DC bus voltage remains above this level for a period of (12-16) hours. Its function is to indicate battery chargers stuck in the boost charge mode in order that corrective action can be taken.

Definition	Description
DC High Volts 2	The high volts 2 alarm voltage level is set just below the maximum load voltage level to protect equipment from voltage control loss on battery chargers as it will immediately initiate a charger shut down.
Equalise voltage	The equalizing voltage is the voltage level required to bring cells back into step which could not be achieved under normal boost conditions. This is a supervised charge conducted by the DC technician with the load disconnected and supplied by an alternative temporary DC source. The temperature of the cells must be monitored not to exceed 40°C during supervised charging.
Float charge	A constant voltage charge ideally sufficient to maintain a cell or battery in a fully charged state.
Flooded / vented cell	A cell with liquid electrolyte in which the gaseous products of electrolysis and evaporation are allowed to escape freely into the atmosphere as they are generated. Sometimes also referred to as a vented cell which requires periodic topping up of the electrolyte level with de-ionised water.
Load Voltage High	Load voltage high is the load voltage value at which the rectifier shutdowns to protect the load from damage. An alarm shall be generated that indicates the rectifier has shut down as a result of the high voltage.
Load Voltage Low	Load voltage alarms when the load voltage is lower than normal and alarm initiated to alert the operator of the abnormal plant conditions.
Load Voltage Low Urgent	Load voltage low urgent is the load voltage value at which the load equipment starts to shut down. An alarm needs to be generated indicating that the load equipment will be disconnected as a result of low load voltage.
Mains Fail	Same as AC Fail alarm.
Semi-Semi sealed Nickel cadmium cell	In this cell, the gaseous products of electrolysis and evaporation are not allowed to escape freely into the atmosphere as they are generated under normal charging conditions. The cell uses recombination technology to recombine evolved hydrogen and oxygen thereby significantly extending the topping up period. Depending on the recombination technology employed, these cells may be pressurised.
Static Bypass Input Failure	The alarm is initiated when the UPS static input voltage and frequency are out of tolerance.
Valve regulated lead acid cell	A sealed cell with gel or absorbed glass mat electrolyte in which the gaseous products of electrolysis and evaporation are not allowed to escape freely into the atmosphere as they are generated under normal charging conditions. Sometimes also referred to as a starved-electrolyte cell in which periodic topping up is not possible.
0.7C10	This is a typical example of how 70% of C10 or 0.7*C10 is written. A current value specified at this notation would represent 70% of the rated 10-hour capacity at the reference temperature.

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
BVL 1	Battery Voltage Low
BVL 2	Battery Voltage Low Urgent
C10	Rated battery capacity at the 10 hr discharge rate
C5	Rated battery capacity at the 5 hr discharge rate
CFA	Charge Fail alarm
DC	Direct Current
DC-DC	Direct Current to Direct Current
DX	Distribution
GX	Generation
H2	Hydrogen
HVA 1	High Volts Alarm 1
HVA 2	High Volts Alarm 2
LVR	Load Voltage Regulator
mA	Milli Amp
MFA	Mains Fail Alarm
NiCad	Nickel Cadmium
RMS	Root Mean Square
Tx	Transmission
UPS	Uninterruptible Power Supply
V	Volts
Veod	Cell End of Discharge voltage
Vinv max	Maximum Inverter Input voltage
Vinv min	Minimum Inverter Input voltage
VLA	Vented Lead Acid
Vmax load	Maximum Load Input voltage
Vmin load	Minimum Load Input voltage
VRLA	Valve Regulated Lead Acid

2.5 Roles and responsibilities

It is the responsibility of the delegated engineering practitioner in collaboration with stakeholders to compile, implement and archive the settings set out within this document. Each division or business unit shall determine the processes required for the authorisation of the settings document.

2.6 Process for monitoring

The document shall be updated in accordance with the Eskom document review process and monitored through technical audits and design review processes.

2.7 Related/supporting documents

Not Applicable.

3. Functional Settings

3.1 Rectifier Settings and Limits

1) The parameters provided are recommended to ensure optimal operation and protection of the equipment deployed.
2) The OEM recommended equipment settings shall take precedence on the final settings to be applied and these final settings shall be recorded in the settings sheet accordingly.
3) Before the final settings are applied the DC and Auxiliary Supplies website site [16], shall be consulted to verify that there are no OEM specific settings to be applied. In the absence of such a document the settings prescribed in this document shall be applied.

3.1.1 Float mode

3.1.1.1 Float Voltage Settings

The recommended float voltage settings shall be applied to ensure optimum battery charge levels and minimum water usage. The recommended float voltages for the VLA, VRLA, and NiCad technologies are provided in Tables (1 - 4) respectively. It is recommended that the selected number of cells and battery float settings do not exceed the maximum load input voltage, necessitating undesirable continuous diode / load voltage regulation.

3.1.1.2 Temperature Compensation

Temperature compensation senses the battery or ambient temperature and adjusts the float voltage in accordance with the stipulated battery manufacturer's temperature compensation slope curves. Where temperature compensation is applied the relevant battery technology slope setting shall be documented in the settings sheet.

The selected float voltage may result in the following:

1) Lower float voltage settings may be permitted for higher ambient temperatures.
2) Higher float voltage settings may be permitted for lower ambient temperatures.

3.1.1.3 Float current limits

In order to ensure optimum battery performance, the battery charging current magnitude across all charging regimes is limited by the rectifier controls. With constant voltage charging modes the battery current should gradually decrease as the battery becomes fully charged, taper off and stabilise at a low value <1% of the rated battery Ah.

The current limits are applied to safeguard the battery by limiting the applied battery charge current dependant on the charging regime. The current limiter will regulate the battery charge current and is only active for the charging regimes and not during discharge of the battery.

The float current limits are provided in Tables (1 - 4) respectively.

3.1.2 Boost mode

3.1.2.1 Boost voltage

The boost voltage is set higher than the float voltage to ensure that the battery recharges faster than in float mode restoring availability of the battery reserve in the shortest time possible. A secondary outcome of boost charging for flooded cells is the mixing of the cell electrolyte. There is no distinction between the manual boost and auto boost voltage settings.

1) The boost mode voltages shall be in accordance with Tables (1 - 4) for the respective battery technologies.
2) In boost mode the voltage must not exceeded the maximum load input voltage which may result in load equipment malfunction or damage. The use of load voltage regulators / dropping diode control [3.4.3] shall then be applied to protect the load during the boost mode operation.

3.1.2.2 Boost current limits

The charger boost current limits are provided in Tables (1 - 4) for the respective battery technologies.

3.1.2.3 Boost Timers

3.1.2.3.1 Boost Initiate Timer

1) Periodically every 28 calendar days, the charger automatically initiates a boost charge.
2) With reference to [15] it is recommended that the 28-day auto boost cycle be disabled for the Nicad battery technologies.
    a) Equipment that does not permit disablement of the 28 day auto boost timer without affecting the boost after mains failure functionality, the 28 day boost timer settings shall be set at the maximum time setting possible meaning that that the system will auto boost less often.
    b) In cases where the disabling of the 28 day timer also disables the auto boost after mains failure functionality, the 28 day auto boost timer function shall be left enabled.

3.1.2.3.2 Boost Duration Timer:

The charger shall maintain the boost mode for a period of four (4) hours, revert to float mode and reset the autoboost duration timer.

3.1.2.3.3 Total Boost Duration Timer / Autoboost Fail:

The functionality serves as a safeguard to ensure that the total autoboost sequence is not exceeded. The time period may be adjusted between (12-16) hours to suit application conditions.

1) Deviations to the recommended durations due to site specific conditions shall be noted documented in the settings worksheet.
2) Where the charger is unable to raise the cells to the prescribed autoboost voltage within the total boost duration timer period, the charger reverts to float and initiates an autoboost failure alarm.

3.1.2.4 Boost trigger voltage

In order to ensure system availability and cell state of charge, cell voltages that fall below the float voltage settings shall initiate or trigger the autoboost charge mode.

A 28 day autoboost cycle is not recommended for the VRLA and Nicad [15], battery technologies however a boost after mains fail is recommended in restoring the battery reserves for adequate operational conditions.

The following autoboost trigger values are recommended.

1) VLA = (1.85 to 1.90) V/cell

2) NiCad = (1.00 to 1.10) V/cell

3.1.3 Equalise mode

The equalizing voltage is the voltage level required to bring cells back into step which could not be achieved under normal boost conditions. This is a supervised charge conducted by the DC technician with the load disconnected and if required, the load supplied by an alternative temporary DC source. The temperature of the cells must be monitored not to exceed 40°C during supervised charging.

3.1.3.1 Equalise voltage

The equalise voltage settings are provided in Tables (1 - 4) respectively.

3.1.3.2 Equalise current limit

The equalise current limits are provided in Tables (1 - 4) respectively.

3.1.4 Initial mode

The initial mode is used when commissioning a new battery bank. The initial charge shall be performed under supervision by the DC technician with the load disconnected and isolated. The temperature of the cells must be monitored not to exceed the manufactures maximum values which vary between (40 - 55) °C during supervised charging.

3.1.4.1 Initial voltage

Where the initial charge functionality is provided on the charger the initial charge voltage settings shall be in accordance with Tables (1 - 4) respectively.

3.1.4.2 Initial current limit

The initial current limits are provided in Tables (1 - 4) respectively.

3.1.5 Vented lead acid batteries

The settings that shall be applied to vented lead acid batteries, at sites without temperature compensation, are indicated in Table 1. The setting value shall be used to determine the charge mode setting of the battery bank, by multiplying the indicated cell charge values by the number of cells in the battery bank.

The reference electrolyte temperature for these settings is 25°C.

Table 1: VLA settings without temperature compensation

Charge Mode Description	Min (V)	Max (V)	Recommended (V)
Float [V/cell]	2.20	2.25	2.23 [1)]
Boost [V/cell]	2.30	2.40	2.40
Equalise [V/cell] (See Note [2])	2.45	2.60	2.55
Float charge current limit [A]	0.1C10	0.2C10	0.14C10
Boost charge current limit [A]	N/A		0.07C10
Equalise charge current limit [A]	N/A		0.035C10
Initial charge [V/cell]	>2.80	See note [3]	Vmax
Initial charge current limit [A]	0.03C10	0.15C10	0.07C10

Notes:

1) Final charge mode settings shall take into consideration the OEM battery charge mode prescripts, regional and site specific conditions. Divisional historical standard prescripts shall also be taken into consideration where for instance DX have traditionally applied a float voltage setting of 2.23V/cell and GX 2.25V/cell.

2) Equalise charge is a supervised charge and should be at a constant current at indicated current limit. This shall be an off-line supervised charge (with the load disconnected and a standby charger connected to the load or load transferred to the backup charger).

3) Initial charge voltage must be set higher than 2.8V/cell to ensure constant current charge is maintained and the cell voltages develop as high as the chemical reaction will permits [9].

3.1.6 Valve regulated lead acid batteries

The charging philosophy is one of the most critical factors that determine the life expectancy of VRLA batteries. It is further recommended that VRLA batteries are only used where the battery charger has temperature compensation facilities in order to prevent over – or undercharging of the batteries under different ambient temperature conditions. This will also ensure compliance with the manufacturer's specifications in case of guarantee / warrantee claims.

The settings that shall be applied to valve regulated lead acid batteries, at sites without temperature compensation, are indicated in Table 2. Note that these settings are applicable to both Absorbed Glass Mat (AGM) and Gel batteries.

Table 2: VRLA settings (AGM and Gel) without temperature compensation

Description	Min (V)	Max (V)	Recommended (V)
Float [V/cell]	2.20	2.27	2.25
Boost [V/cell]	N/A		
Equalise [V/cell] 1)	2.30	2.40	2.35
Float charge current limit [A]	0.1C10	0.2C10	0.1C10
Boost charge current limit [A]	N/A		
Equalise charge current limit [A]	N/A	N/A	0.1C10
Initial charge [V/cell]	N/A	N/A	N/A See Note 2
Initial charge current limit [A]	N/A	N/A	N/A

Notes:

1) Equalise charge is a supervised charge and should be done at a constant voltage at the indicated current limit. This shall be an off-line supervised charge (with the load disconnected and a standby charger connected to the load or load transferred to the backup charger).

2) VRLA cells are initial charged at the factory and delivered in a fully charged state. Stored cells stored shall be recommissioned in accordance with [9].

3) The boost function for VRLA battery technologies is also not applicable.

3.1.7 Nickel cadmium batteries

The settings that shall be applied to nickel cadmium batteries, at sites without temperature compensation, are indicated below.

The setting value shall be used to determine the charge mode setting of the battery charger, e.g. an 85 cells in a nickel cadmium battery bank shall have a float voltage of (85 x 1.42) = 120.7 V.

Table 3: Vented Nickel Cadmium cells without temperature compensation

Description	Min (V)	Max (V)	Recommended (V)
Float [V/cell]	1.40	1.45	1.42
Boost [V/cell]	1.45	1.55	1.50
Equalise [V/cell]	1.55	1.70	1.60
Float charge current limit [A]	N/A		0.2C5
Boost charge current limit [A]	N/A		0.2C5
Equalise charge current limit [A]	N/A		0.2C5
Initial charge [V/cell]	>1.70 See Note 1		
Initial charge current limit [A]	0.2C5 See Note 3		

Table 4: Semi Sealed Nickel Cadmium without temperature compensation

Description	Min (V)	Max (V)	Recommended (V)
Float [V/cell]	1.38	1.45	1.40
Boost [V/cell]	1.40	1.45	1.45
Equalise [V/cell]	N/A		
Float charge current limit [A]	N/A		0.1C5
Boost charge current limit [A]	N/A		0.1C5
Equalise charge current limit [A] (Note [2])	N/A		N/A
Initial charge [V/cell]	>1.70 See Note 1		
Initial charge current limit [A]	0.1C5 See Note 3		

At sites with temperature compensation facilities available on the charger system, the following temperature compensation slope settings shall be applied with the voltages as indicated in

Table 3 and Table 4 as the setting value at a reference temperature of 20°C:

Notes:

1) NiCad cells are initial charged at the factory and delivered in a fully charged state. Stored cells stored shall be recommissioned in accordance with [9].

2) Equalise charge is not performed as the recombination action results in cells being out of step depending of state of recombination.

3) The OEM recommended battery settings shall take precedence on the final settings to be applied and these final settings shall be recorded in the settings sheet accordingly.

3.2 System and Rectifier settings

The settings are intended to provide rectifier parameters to alert and inhibit the rectifier operations during abnormal external system occurrences.

3.2.1 Rectifier current limit

The total rectifier current limit shall be set to 100% nameplate current rating of the system.

The individual charge mode battery current limits are applied in accordance with Tables (1-4).

3.2.2 AC Supply settings

1) The input AC supply shall be of nominal input voltage of 400V/230V ±20%. The AC fail alarm is initiated if the input supply is out of tolerance.

2) Older technology equipment may have lower tolerance limits and thus the specific device OEM manual shall be consulted and final settings documented in the settings sheet.

3.2.2.1 AC voltage high

$$\mathrm{Vphase_{upper\ limit}} \quad = 1.2 \times \mathrm{V_{nom}}$$

3.2.2.2 AC voltage low

$$\mathrm{Vphase_{lower\ limit}} \quad = 0.8 \times \mathrm{V_{nom}}$$

3.2.3 Over temperature

Over temperature monitoring is provided as a protective measure for the power electronics.

Dependant on the charger OEM the over temperature monitoring is typically provided for the following:

1) Thyristor / IGBT stack

2) Dropping diode circuits

3) Battery cabinet

In order to prevent irreparable equipment damage it is recommended that the module / equipment is shutdown under these conditions. Due to the variance in technologies available these associated temperature limits for the above shall be determined by the OEM and recorded in the associated settings sheet.

3.2.4 Bridge load sharing 12 pulse Systems

The load sharing between the two 6-pulse thyristor modules that make up the 12-pulse system shall be within 10% over a range of (10-100) % of the rated charger current.

3.2.5 Parallel system load sharing

1) To increase the system rated current capacity, modules and equipment may be used in parallel.
2) The parallel load current sharing shall be set to within 10% for each parallel system.

3.2.6 Hydrogen level settings

A product of the battery charging process is a release of hydrogen which if not extracted or ventilated may form an explosive gas atmosphere. In accordance with SANS 10108 the volume of hydrogen expressed as a percentage of the total volume of free air in the battery room or battery cabinet necessary to keep the hydrogen concentration below the recommended maximum value of 0.8%.

3.2.6.1 Hydrogen level high

At a pre-set value of ≥ 0.8% of hydrogen concentration, a hydrogen level high alarm is initiated locally by the charger/rectifier and *system abnormal* alarm initiated remotely.

During these conditions the charger or rectifier(s) modules shall:

1) Confirm the continuous (4-20) mA analyser healthy input status.
2) Not shutdown the charger or rectifier modules.
3) Not disable any charge modes for the hydrogen level high status.

3.2.6.2 Hydrogen level high-high

At a pre-set value of 1% hydrogen a hydrogen level high-high alarm is initiated by the charger/rectifier and System Abnormal alarm initiated remotely.

During these conditions the charger or rectifier(s) modules shall:

1) Confirm the continuous (4-20) mA analyser healthy input status.
2) Not shutdown the charger or rectifier modules.
3) Inhibit / disable (boost, autoboost, equalise and initial) charge modes for hydrogen level-high-high status.
4) Revert the system back to float settings, where applicable.

3.3 Battery Protection and Alarm Settings

The battery settings are intended to protect the battery bank and consequently the connected DC load equipment from damage as a result abnormal high or low battery reserve DC voltages.

1) In determining the applicable battery settings a verification of DC load input rating and voltage operating range is required as the battery reserves are expected to support the load over the entire voltage window range.
2) The minimum and maximum DC load input voltage operating range will be used in calculation of the applicable battery settings. The widest possible voltage window optimises the system design.
3) In cases where load voltage regulation (LVR) is not used, ensure that the load input voltage window limits are not exceeded.
4) In UPS systems the battery reserves are coupled to the UPS DC bus between the rectifier output and inverter input, where similarly a verification of the UPS DC bus operating philosophy and configuration, voltage type and operating range is required. Validation of the OEM UPS DC bus parameters is required to assess the minimum and maximum inverter input voltage operating range which shall be applied in calculation of the applicable battery settings.

3.3.1 DC Voltage high

The functionality of the DC voltage high is to initiate an alarm when the battery voltage exceeds the normal safe limits and trips the rectifier module causing the over voltage by sensing the high battery voltage.

3.3.1.1 DC High Voltage 1

The HVA1 timer creates a delay in alarm initiation to avoid unnecessary alarming when transitioning from float to boost charge regimes. The period is determined by the (HVA1) timer which is initiated by the voltage settings recommended below.

1) Where a settable HVA 1 timer is available it shall be set between (12 to 16) hours.
2) The DC high voltage 1 alarm (HVA 1) trigger settings as prescribed below.
1) Lead acid (VLA and VRLA) battery alarm voltage setting = 2.30 V/cell.
2) Vented nickel cadmium alarm voltage setting = 1.48 V/cell.
3) Semi sealed nickel cadmium alarm voltage setting = 1.43 V/cell.
4) DC High Voltage 1 setting < Boost Voltage Setting.

It is recommended that systems not equipped with a HVA 1 timer are set to boost settings as provided in Tables 1-4.

3.3.1.2 DC High Voltage 2

1) DC high voltage 2 (HVA 2) is the voltage value at which the rectifier is required to trip to protect the load from over voltage and damage.
2) The high voltage 2 alarm settings levels are set just below the maximum load voltage levels.
3) An alarm must be generated indicating the charger has shut down as a result of the charger voltage control loss creating an unsafe condition.
4) The settings below should only be applied if the:

   (Setting x Number of cells ≤ to the Max Load Input Voltage)

5) The DC high voltage 2 (HVA 2) trigger settings are as follows:
   a) Lead acid (VLA) HVA 2 setting = 2.55 V/cell.
   b) Lead acid (VRLA) HVA 2 setting = 2.40 V/cell.
   c) Vented Nickel cadmium alarm voltage setting = 1.55 V/cell.
   d) Semi sealed Nickel cadmium alarm voltage setting = 1.50 V/cell.
6) Where this is not the case the calculation to be applied is as follows:

   (Setting = Max load Input Voltage / Number of Cells)

   a) DC high volts 2 setting < Vload max.
   b) DC high volts 2 setting < Vmax inverter (Upper limit).

3.3.1.3 Battery Voltage High

Battery voltage high alarms when the battery voltage exceeds the normal safe limits and trips the rectifier module causing the over voltage. The setting is intended to alarm above boost just below equalise and is disabled during equalise and initial charge modes.

1) Battery voltage high alarm settings levels are set just below the maximum battery voltage level.
2) An alarm must be generated indicating the charger has shut down as a result of the unsafe condition.
3) Battery voltage high trigger settings are as follows:

a) Lead acid (VLA) battery alarm voltage setting = 2.55 V/cell.

b) Lead acid (VRLA) battery alarm voltage setting = 2.40 V/cell.

c) Vented Nickel cadmium alarm voltage setting = 1.55 V/cell.

d) Semi sealed Nickel cadmium alarm voltage setting = 1.50 V/cell.

3.3.2 Hard wired protection backup

The hard wired over voltage and current monitoring functionality is an independent protection feature provided by the charger to ensure that there are no overvoltage conditions that may arise on the DC load or DC port coupled to the reserve battery. The hard wire protection backup trigger voltage settings shall be set slightly higher than the **Error! Reference source not found.** parameters and is dis-abled during equalise and initial charge modes.

1) Lead acid (VLA) battery alarm voltage setting = 2.60 V/cell.

2) Lead acid (VRLA) battery alarm voltage setting = 2.45 V/cell.

3) Vented Nickel cadmium alarm voltage setting = 1.60 V/cell.

4) Semi sealed nickel cadmium alarm voltage setting = 1.55 V/cell.

3.3.3 Battery voltage low

The battery system, approaching the battery end of discharge cycle necessitates monitoring and alarming of the battery systems to avert unexpected disconnection of the critical load. The alarm is activated either due to an AC mains fail or when the DC bus voltage is lower than normal.

The battery low settings ($\boldsymbol{BVL_1}$) are as follows:

1) Normal flooded (VLA) and VRLA alarm voltage setting = 2.10 V/cell.

2) Vented and semi sealed Nickel cadmium alarm voltage setting = 1.35 V/cell.

3.3.4 Battery voltage low urgent

The alarm levels is initiated just before the knee point on the cell's discharge curve indicating imminent DC supply loss to the critical load. The alarm is triggered when the battery voltage has reached a pre-set value close to the minimum system voltage.

The battery low urgent settings ($\boldsymbol{BVL_2}$) are as follows:

1) Normal flooded and VRLA battery alarm voltage setting = 1.85 V/cell

2) Vented and semi sealed Nickel cadmium alarm voltage setting = 1.00 V/cell

3.3.5 Load voltage / Battery Disconnect

The function of the disconnecting device is to protect the system against battery over discharge at the absolute minimum cell voltage.

The setting is only applied to the following battery technology:

1) VRLA battery disconnect voltage setting = 1.60 V/cell

3.3.6 Ripple Settings

The ripple setting applied shall be 1% of the nominal output RMS voltage.

Older technology may have not been specified to achieve the prescribed 1% and may thus as built capability may be sustained.

3.3.7 Battery loss and battery test

3.3.7.1 Battery Test

The battery test functionality and implementation thereof may vary across OEM's. The OEM battery test philosophy document shall be referenced in the settings document.

Typically the battery test functionality entails a partial discharge of the battery on a periodic basis for a predefined time, where the rectifier output voltage is reduced and the battery supplies the load directly or through the inverter in the case of UPS systems. The microprocessor monitors the battery voltage rate of decay or current, confirming that these battery parameters do not decrease below the predetermined battery test threshold. The system would revert back to float on completion of the test period or initiate a battery test fail alarm where required.

3.3.7.2 Battery Loss

The battery loss alarm functionality is initiated when the battery circuit is interrupted and is no longer continuously connected to the system. Under these conditions the battery reserve would be unable to provide reserve power to the load when required.

The battery loss test functionality and implementation thereof may vary across OEM's and OEM philosophy document shall be referenced in the settings document. The test voltage, cycle period and test duration shall be captured in the settings document.

The preferred Eskom philosophy to detect a battery loss is that of implementing the battery centre tap method to detect an open battery circuit. The midpoint battery loss functionality operates as follows:

1) The midpoint voltage is measured from the positive side of the charger (cell 1) to the centre battery and then it is multiplied by (x2) two. This is a calculated value for the battery average voltage.
2) The total battery voltage is also measured inside the charger on the charger output. This reference voltage will always measure the charger output voltage even if the battery is open circuit and cannot be used on its own to indicate a battery loss.
3) The difference between the calculated battery voltage and measured reference battery voltage are calculated and compared to a reference window to determine a fault condition and initiate an alarm.

3.4 Battery Charger DC Load Settings

The DC Load settings are there to protect the load equipment from damage as a result of high DC voltages, to warn against load equipment shut down as a result of a low DC voltage and DC earth faults on floating DC systems. Although the load settings are independent of the battery settings and the load and battery requirements are not the same the battery functions need to be taken into consideration when selecting some of the load functions.

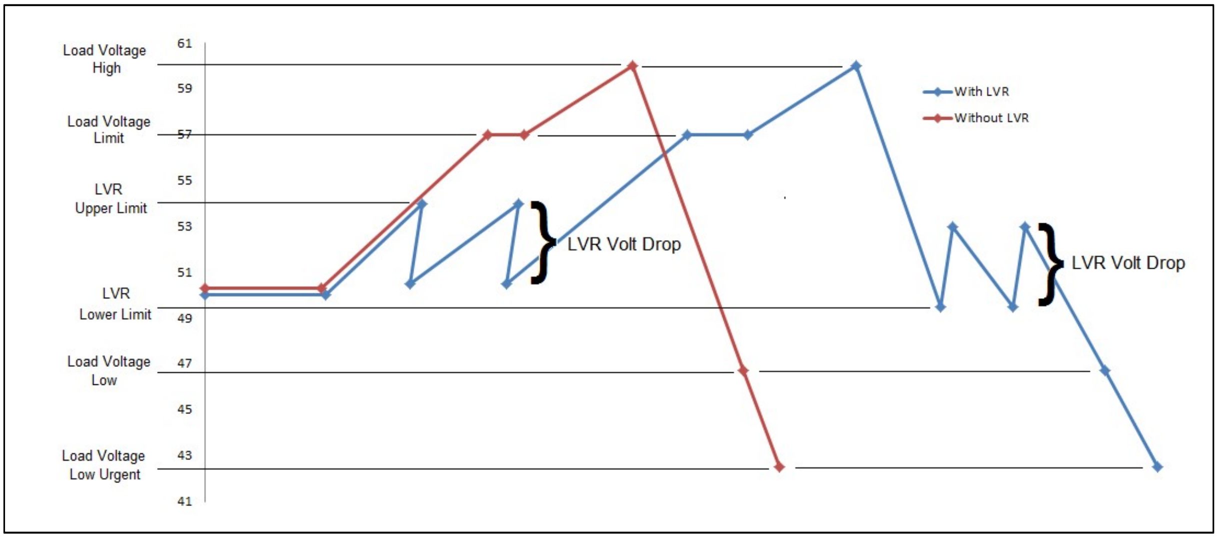

Figure 1: Load Settings Profile

Figure 1 above represents the ideal load settings profile for a system with and without a LVR (Load Voltage Regulator). The LVR and Load Voltage Limiting are optional on a battery charger. The LVR functions are dependent on the load limit requirements and the Load Voltage Limit function is dependent on charger manufacturer.

The sequence of the load settings are dependent on each other and thus are required to operate in a specific sequence and within a set window.

3.4.1 Load voltage window and logical sequence

1) The total load window will be between the load upper limit (Load Voltage High) and the load lower limit (Load Voltage Low Urgent) as represented in 1.
2) As the load voltage increase the first protection is to energise a LVR stage, stepping the load voltage down in specified fixed steps.
3) If the load voltage still increases beyond the LVR’s limits, the Load Voltage Limit initiates to keep the load voltage constant at a safe voltage value. At this stage the battery charger is regulating on the load voltage and not battery voltage.
4) If the load voltage still increases the charger must shut down as it reaches the load voltage upper limit. Logically the charger must not shut down before any of the other overvoltage protection functions.
5) As the load voltage decrease the LVR stages must be de-energised in order to prolong the backup time of the load equipment.
6) As the load voltage still decreases the system operator should be alarmed of the eminent shut down of the load equipment. (Load Voltage Low)
7) Finally when the lower limit is reached the system operator are alarmed that the load equipment is shutting down (Load voltage Low Urgent).

3.4.2 Load limits

To calculate all the load settings the load upper and lower limits are needed. These limits must be obtained from the suppliers of the load equipment. The limits can be provided in a fixed value or a percentage of the nominal voltage.

On a DC system multiple loads will be connected with multiple load limits.

In order to protect all loads select the limits as follows:

1) Upper limit = Lowest upper limit out of all loads connected.
2) Lower limit = Highest lower limit out of all loads connected.

3.4.2.1 Load voltage limit

Some manufacturers have installed a function to prevent the charger from tripping as a result of a high voltage on the load. All battery chargers use the battery/rectifier voltage to regulate the output voltage. When there is an abnormal condition that causes the high voltage, reaching a set value on the load output, the battery charger will use the load voltage to regulate on the set value. At the same time an alarm must be generated to indicate the battery charger is operating abnormally.

This calculated limit values are rounded up to 1 decimal place.

1) Load voltage limit = 95% of load voltage high

3.4.2.2 Load voltage low

Load voltage low is a value indicating that the load voltage is decreasing. An alarm must be generated to warn the operator.

This calculated limit values are rounded down to 1 decimal place.

1) Load voltage low = 10% higher than the Load lower limit

3.4.2.3 Load voltage low urgent

Load voltage low urgent is a value at which the load equipment starts to shut down. An alarm shall be generated indicating that the load equipment will start to fail as a result of low load voltage.

1) Load voltage low Urgent = Lower limit

3.4.2.4 Load voltage high

Load voltage high is a value at which the chargers need to trip to protect the load from damage. An alarm must be generated that indicates the charger has shut down as a result of the load voltage high.

1) Load voltage high = Upper limit

3.4.3 Load voltage regulation (Dropping diodes)

1) Load voltage regulation (LVR) is achieved by installing multiple diodes in series with the load; these diodes are switched in or out of the circuit. When the diodes are in circuit, the current flow creates a volt drop of ± 0.4V to 1.4V per diode. Multiple diodes can then be grouped to create a dropping diode stage.

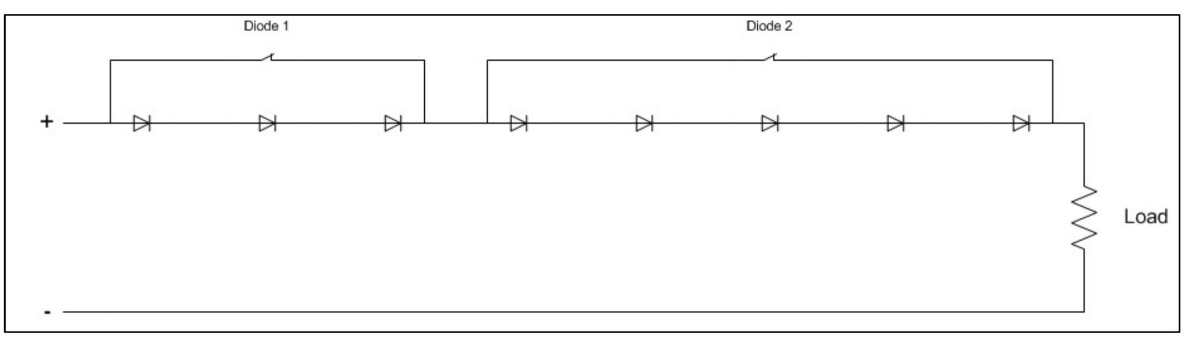

Figure 2: LVR Dropping diode assembly

2) The use of LVR should be avoided as it increases the component count, influencing the capital cost and reducing reliability and efficiency due to the dropping diodes volt drop and heat generation.

3) Make use of a LVR if the float or boost voltage is higher than the load voltage high setting. The number of diodes per stage and the number of stages are selected to keep the load voltage between the load upper and lower limits.

4) The status of the LVR could be indicated locally on the battery charger.

5) The LVR settings are calculated in 3 ways dependent on the control function:

3.4.3.1 Analogue or binary controlled

1) The analogue method is when each dropping diode stage has its own analogue feedback and its own reference settings. In other words each dropping diode stage has an upper limit to enable the stage and a lower limit to disable the stage. Usually the stages are of different sizes and the feedback and reference is to the battery voltage. With this configuration a 3 Stage LVR can be configured with only 2 sets of dropping diodes.

2) Binary control is similar to counting in binary see example used in table below:

Table 5: Binary LVR Control Example

	Dropping diode 2	Dropping diode 1	
No stages	0	0	No diodes enabled
Stage 1	0	1	Diode 1 enabled (3 diodes in circuit)
Stage 2	1	0	Diode 2 enabled (5 diodes in circuit)
Stage 3	1	1	Diode 1 and 2 enabled (8 diodes in circuit)

For the calculation of these settings the specified volt drop per diode is required. If this is not available an assumption is made (0.7 volt drop per diode). These settings can be tweaked during testing phase to accommodate the variation of volt drop in diodes.

3) All calculated upper limit values are rounded up to 1 decimal place.

   a) Stage 1 enable (upper limit 1) = 90% of load voltage high

   b) Stage 2 enable (upper limit 2) = Stage 1 enable (upper limit 1) + (Number of diodes enabled during stage 1 x volt drop per diode)

   c) Stage 3 enable (upper limit 3) = Stage 2 enable (upper limit 2) + ((Number of diodes enabled during stage 2 - Number of diodes enabled during stage 1) x volt drop per diode))

4) All calculated lower limit values are rounded down to 1 decimal place.

   a) Stage 3 disable (lower limit 3) = Stage 3 enable (upper limit) – 0.7 volt

   b) Stage 2 disable (lower limit 2) = Stage 2 enable (upper limit) – 0.7 volt

   c) Stage 1 disable (lower limit 1) = Stage 1 enable (upper limit) – 0.7 volt

   5) Example on how to calculate binary control setting.

   a) The profile for the example been used is represented in 3.

   b) It is a 50V system with load limits +/-15% and 2 sets of dropping diodes as indicated in Table 5.

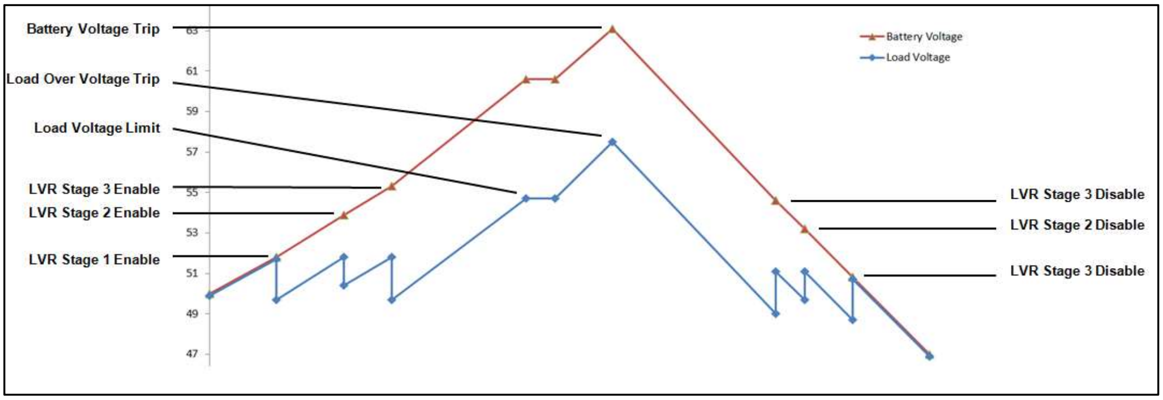

Figure 3: LVR Binary control profile

Table 6: Binary LVR Control Settings Calculation Example

Function	**Setting Calculation**	**Triger Value**	**Battery (V)**	**Load (V) Before** **Load (V) After**
Stage 1 (3 diodes)	= 3 X Volt drop per diode = 3 X 0.70	2.10 V	-	-
Stage 2 (5 Diodes)	= 5 X Volt drop per diode = 5 X 0.7 0	3.50 V	-	-
Stage 3 (8 Diodes)	= 8 X Volt drop per diode = 8 X 0.70	5.60 V	-	-
Load Voltage High	= 115% of 50.00 V	57.50 V	-	-
Load Voltage Low	= 85% of 50.00 V	42.50 V	-	-
Load Voltage Limit	= 95% of Load Voltage High =95% of 57.50 V	54.60 V	-	-
LVR Stage 1 Enable	= 90% of Load Voltage High = 90% of 57.50 V	51.80 V	51.80 V	51.80 V 49.70 V
LVR Stage 2 Enable	=Stage 1 Enable + Stage 1 Volt drop = 51.80 V + 2.10V	53.90 V	53.90 V	51.80 V 50.40 V
LVR Stage 3 Enable	=Stage 2 Enable + (Stage 2 - Stage 1 Volt drop) = 53.90 V + (3.50 V-2.10 V)	55.30 V	55.30 V	51.80 V 49.70 V

Function	Setting Calculation	Triger Value	Battery (V)	Load (V) Before Load (V) After
LVR Stage 3 Disable	= Stage 3 Enable – 0.70 V = 55.3 V – 0.70 V	54.60 V	54.60 V	49.00 V 51.10 V
LVR Stage 2 Disable	= Stage 2 Enable – 0.70 V = 53.90 V – 0.70 V	53.20 V	53.20 V	49.70 V 51.10 V
LVR Stage 1 Disable	= Stage 1 Enable – 0.70 V = 51.80 V – 0.70 V	51.10 V	51.10 V	49.00 V 51.10 V

a) It can be seen from 3 that the load voltage is regulated at ± 50.00 V, well within the load limits.

b) The trigger values can be tweaked to accommodate the number of battery cells, and ensure the least number of stages in circuit without compromising the load.

c) In this example stage 2 enable and disable can be increased to accommodate the float voltage of 24 cells thereby having only one stage active in float mode.

3.4.3.2 Sequential

The sequential method makes use of the load voltage as feedback. There are only one upper and lower setting and each time the load voltage reaches the upper setting the LVR adds a dropping diode stage. If it drops down to the lower setting the LVR removes a dropping diode stage. The dropping diode stages are usually similar in size and to have a 3 stage LVR.

In this instance 3-sets of dropping diodes are required as per table example below:

Table 7: Sequential LVR Control Example

	Dropping diode 2	Dropping diode 1	
No stages	0	0	No diodes enabled
Stage 1	0	1	Diode 1 enabled (3 diodes in circuit
Stage 2	1	1	Diode 2 enabled (6 diodes in circuit

For the calculation of these settings the specified volt drop per diode is needed if this is not available an assumption is made (0.7 volt drop per diode). These settings can be tweaked during testing phase to accommodate the variation of volt drop in diodes.

All calculated upper limit values are rounded up to 1 decimal place.

1) LVR upper limit (Stage enable) = 90% of load voltage high

All calculated lower limit values are rounded down to 1 decimal place.

2) LVR lower limit (Stage disable) = LVR upper limit – 1 – (number of diodes in a stage x volt drop per diode)

3.4.3.3 Intelligent sequential

This intelligent sequential method are exactly the same as the sequential method except that it continuously measures the total volt drop across the dropping diodes and determines on when it is suitable to disable a stage. Therefore there is only a LVR upper limit setting calculated the same as in the normal sequential method.

3.4.4 DC Earth fault

DC earth fault monitoring is implemented on floating systems i.e.: where none of the polarities are connected to earth. Be aware that this setting is not applicable to the earth fault monitoring on the DC distribution boards but only to the monitoring on the battery charger.

An alarm must be generated to warn the system operator.

Traditionally this setting was specified in the battery charger standard as a pick up level of 10 mA, it is most of the time not a settable value as it is embedded in the firmware.

- + Earth fault = 10mA
- - Earth fault = 10mA

3.5 UPS Settings

3.5.1 UPS AC Settings

These settings are applicable to regulation of the AC output voltage and frequency for UPS and inverter systems.

The performance classification is dependent on the critical load voltage variation tolerances and shall be verified and specified by the end user. The performance classification shall be in accordance with SANS 62040-3.

3.5.2 UPS Output voltage

The performance classification is applicable for UPS output voltages unless otherwise specified by the end user. The output voltage and frequency circuity shall be monitored and deviations to these parameters shall be alarmed.

The output voltage is set to a maximum of ±10% Vnom output.

The OEM data sheets may be consulted to further assign more stringent output voltage tolerance levels.

3.5.3 UPS Output frequency

The output frequency is set to a maximum output frequency range to ±5% at nominal frequency 50Hz.

3.5.4 UPS By-pass settings

The expected output voltage regulation is set to a maximum of ±10% Vnom output.

Dependant on client requirements the bypass output voltage may be regulated to more stringent requirements of maximum of ±10% Vnom output.

The settings that indicate the availability of the bypass is set to a maximum of ±10% input voltage and 5% at nominal frequency 50Hz.

3.6 UPS Inverter DC-bus settings

Inverters usually have a wide input voltage tolerance in which it can continue to operate and convert DC power to AC power of a much smaller tolerance. Three different scenarios of the range of the DC voltage are discussed:

3.6.1 Buck-boost fed

Some inverters have a buck-boost charger feeding the inverter section.

In this case the rectifier voltage feeding the inverter when AC mains are present, is uncontrolled and the maximum DC voltage at which it will continue operating is the DC value derived from the rectified AC value at maximum tolerance:

E.g.: Max Vdc = Vac (+20%) x 1.35

= 400 x 1.2 x 1.35

= 648 Vdc

The nominal DC voltage to the inverter would be supplied by the buck-boost charger that would be boosting the decaying DC voltage during a discharging scenario to the point that the buck-boost charger would switch off when the battery has reached its minimum voltage. Therefore this type of inverter would not usually experience a low input DC voltage until the buck-boost suddenly switches off at the end of battery discharge. This buck-boost output nominal voltage differs between suppliers.

3.6.2 Inverter supplied from Rectifier

Some inverters are fed directly from the same DC bus as what is fed by the rectifier to the batteries. Therefore the range of the inverter input voltage is the same voltage range that will be fed to the battery under different charging modes or state of charge. The lowest voltage will be the battery fully discharged voltage and the highest will be the battery under equalise charge mode. Some inverters are inhibited or interlocked when initial charge is selected and others switch off when the high DC voltage alarm is triggered.

3.6.3 Inverter supplied by Rectifier and Battery Voltage

Some inverters are fed from the rectifier when mains is present and the rectifier voltage is higher than the battery voltage and the battery is decoupled from the inverter input by a diode. This battery is charged via a DC-DC Buck converter that is also fed from this rectifier. The battery voltage is then lower than the rectifier voltage, and at the moment of AC supply loss, a sudden decrease in DC voltage to the inverter the battery voltage will then be forward biased through the decoupling diode and the battery will then supply the input voltage to the inverter. From there the lowest input voltage will be dependent on the discharged voltage.

3.6.4 Inverter Input voltage high

This will be the alarm level at which the inverter will be disabled in order to protect it against damage. This voltage varies depending on the type of DC source feeding it as described above. Either slightly higher than the DC voltage derived from the rectifier AC voltage at maximum tolerance or the maximum battery voltage.

3.6.5 Inverter Input voltage low

The inverter must switch of at this voltage in order to stop discharging the battery into the inverter and load. A hysteresis value must be chosen that will prevent the inverter from switching on again when the DC voltage recovers slightly when the discharge stops in order not to start discharging the battery again and then switching on and off in repeated cycles. Often the inverter is locked out in the off state. This will reduce the battery discharge to only what is absorbed by the UPS/inverter electronics.

E.g.: Min Vdc= Nr of cells x V discharged

= 104 x 1.80 Vdc

= 187.20 Vdc

3.7 DC-DC Converter settings

The DC–DC converters are known to have a very stable output voltage independent of fluctuations of the input voltage. If the fluctuation on the input is outside set tolerances the stability of the output will be compromised.

3.7.1 Input voltage settings

The input settings are to protect the DC-DC converter against damage as a result of high input settings and to warn the system operator that the DC-DC converter is about to shut down as a result of low input voltage.

Typically the input settings are based on the designed nominal input voltage (220V, 110V, 50V, 24V).

An alarm must be generated to warn the system operator if the input voltage is going high or low.

The calculated input high value must be rounded up to one decimal place.

- Input voltage High = 120% of the nominal input voltage

The calculated input low value must be rounded down to one decimal place.

- Input voltage Low = 80% of the Nominal input voltage.

3.7.2 Output voltage Settings

The output settings are there to protect the load equipment from damage as a result of high DC voltages and to warn against load equipment shut down as a result of a low DC voltage.

To calculate the output settings the load upper and lower limits are needed. These limits must be obtained from the suppliers of the load equipment. The limits can be provided in a fixed value or a percentage of the nominal voltage.

On a DC system multiple loads will be connected with multiple load limits. In order to protect all loads select the limits as follow:

- Upper limit = Lowest upper limit out of all loads connected.
- Lower limit = Highest lower limit out of all loads connected.

An alarm must be generated to warn the system operator if the output voltage is going high or low.

The calculated output high value must be rounded up to one decimal place.

- Output voltage High = Upper limit

The calculated output low value must be rounded down to one decimal place.

- Output voltage Low = Lower limit.

3.8 Alarm Grouping

The alarm grouping shall be in accordance with 240-53114248 Thyristor and Switchmode Chargers, AC/DC to DC/AC Converters and Inverter/Uninterruptible Power Supplies Standard.

3.9 Settings document format

These settings are captured, authorised and archived in the site based settings sheet, enabling retrieval and verification of the design base during system maintenance or fault diagnosis activities. The settings document is a physical document where the unique combination of equipment will result in a number of settings specifically applicable to that combination, but will have some settings common to other selections of equipment in the same range. For instance current limit settings on chargers are dependent on the size of the batteries supplied with it and the setting would be too high for smaller batteries. Yet the voltage setting will be the identical for the same number of cells irrespective the amp-hour rating of such cells.

The basic settings shall be populated to capture the critical values and features of the different equipment.

The purpose of such a settings document is to ensure that the correct design settings are chosen and documented initially in order to avoid individual preferences and calculations during maintenance activities and to have achieve consistency during different maintenance cycles.

The values documented in the settings document will become the “reference values” stipulated in the equipment maintenance check sheet to which verification is performed. Corrections will be made to values found different to these reference values by 1%.

4. Authorization

This document has been seen and accepted by:

Name and surname	Designation
Dr Titus Mathe	General Manager – Group Technology
Kashveer Jagdaw	DC & Auxiliary Supplies SC Chairperson

5. Revisions

Date	Rev	Compiler	Remarks
June 2021	1	MJ Magano	240-91244886 Battery Settings Standard superseded and contents thereof incorporated for first issue of this standard.

6. Development team

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

- Bathathu Jonga
- Enos Matjie
- Maropeng Moreroa
- Hamus Lourens
- Welman van Niekerk
- Thomas Jacobs

7. Acknowledgements

Not applicable.

Annex A – Summary of Battery Type Settings

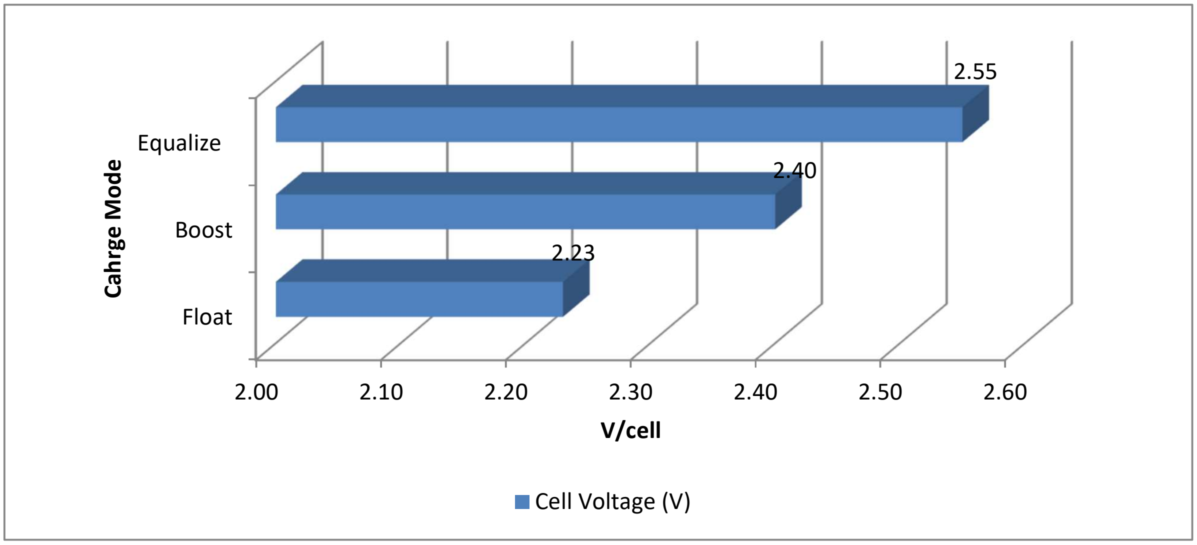

Figure A.1: Charge Mode settings for Vented Lead Acid cells

At sites with temperature compensation facilities available on the charger system, the following temperature compensation slope settings shall be applied:

- For Hoppecke cells, the temperature compensation slope shall be 4mV/°C/Cell with the voltages at a reference at 20°C.
- For Chloride cells, the temperature compensation slope shall be 2.5mV/°C/Cell with the voltages as indicated at a reference at 25°C.
- Alternative type of cells may be permitted and adjudicated to comply with the prescripts defined in [12]

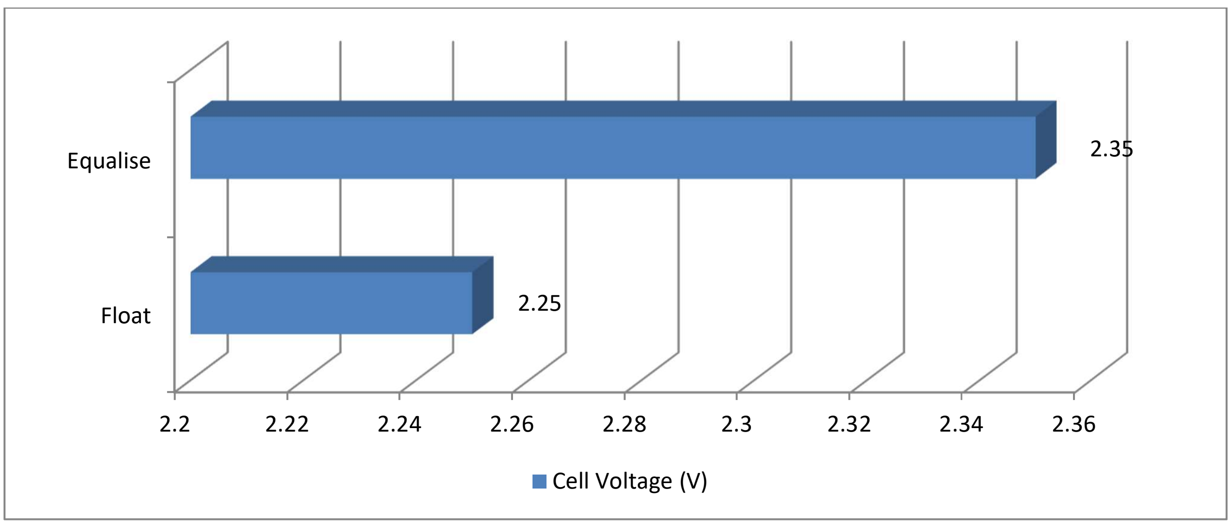

Figure A.2: Charge Mode settings for Valve Regulated Lead Acid cells

The temperature compensation slope shall be -3.5mV/°C/Cell with the voltages as indicated in Table [**Error! Reference source not found.**] as the setting value at a reference temperature of 25°C.

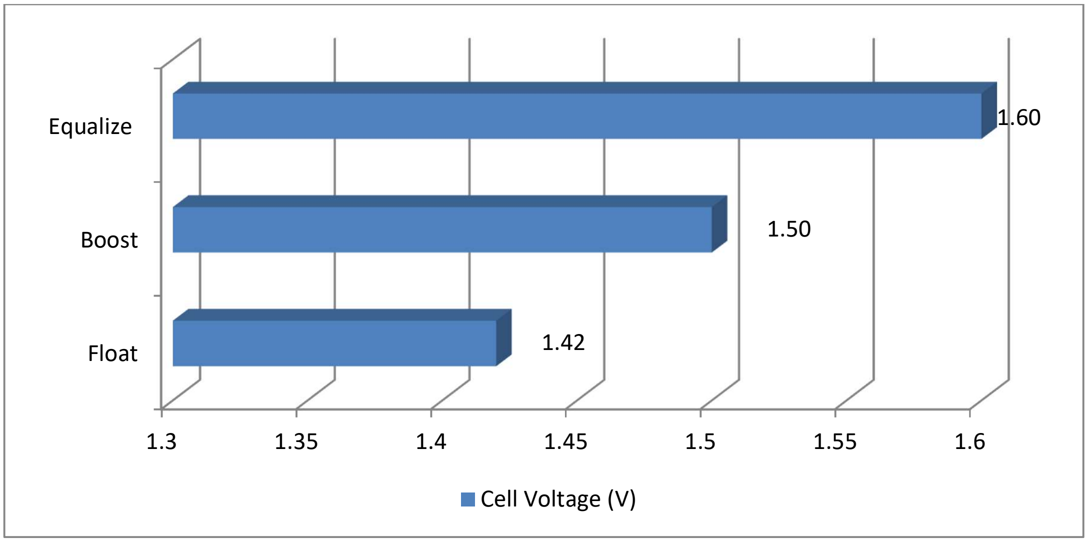

Figure A.3: Charge Mode settings for Vented NiCad cells

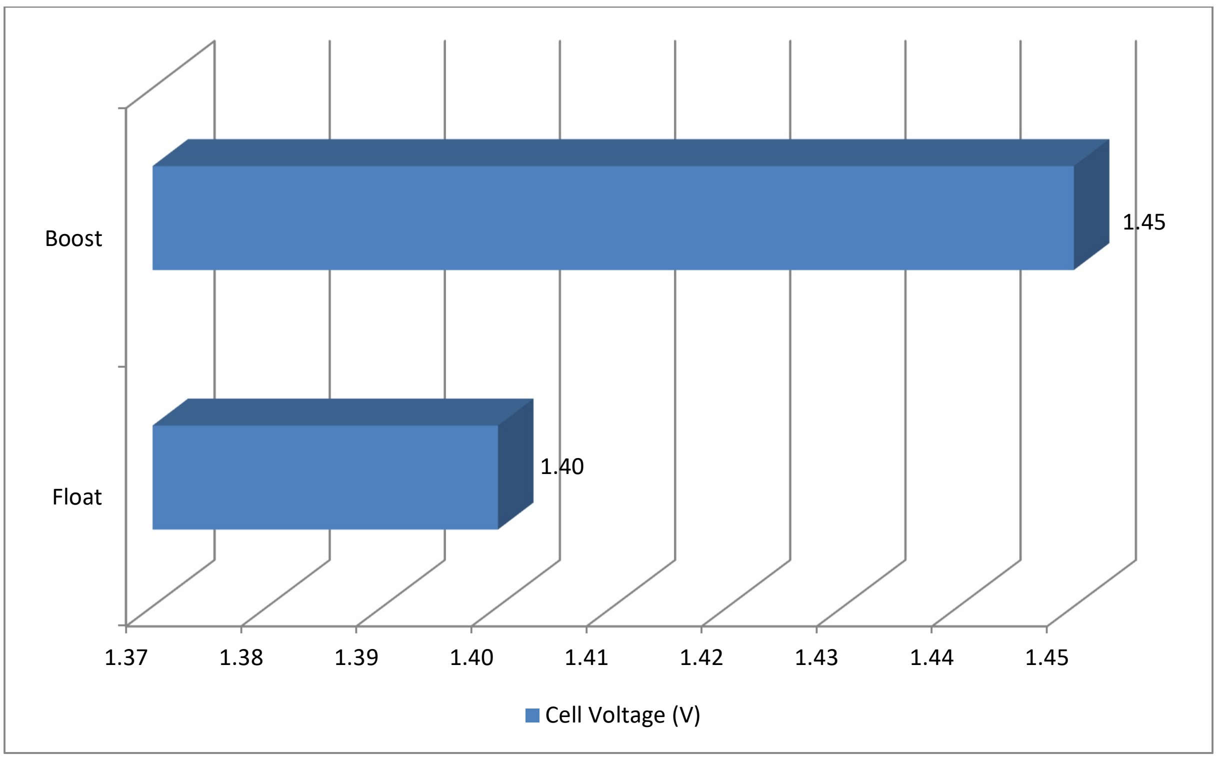

Figure A.4: Charge Mode settings for Semi Sealed NiCad cells

Annex B – Summary of Battery Charger Settings

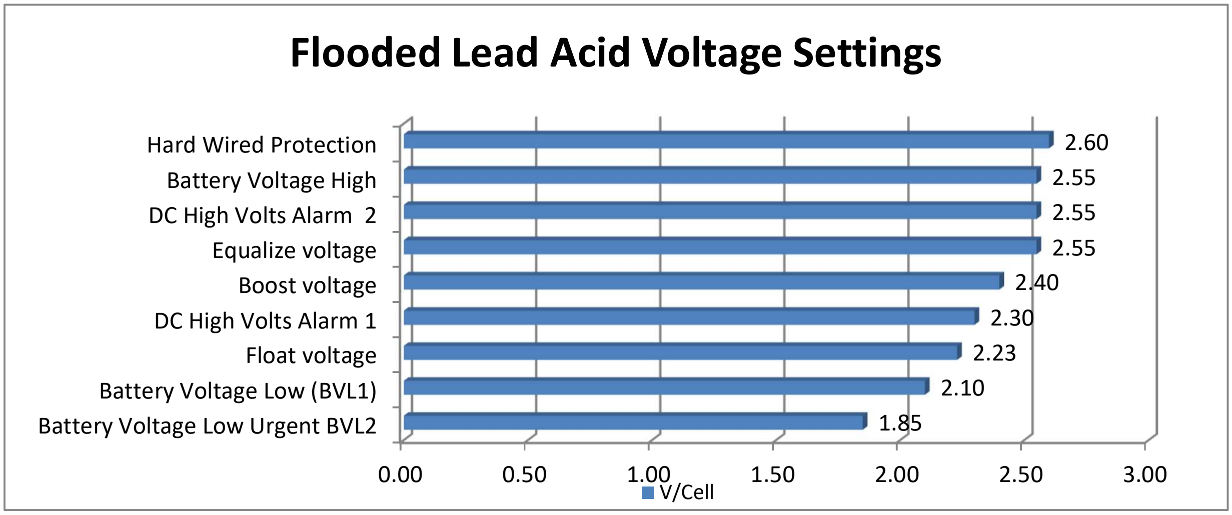

Figure B.1: Settings for Vented Lead Acid cells

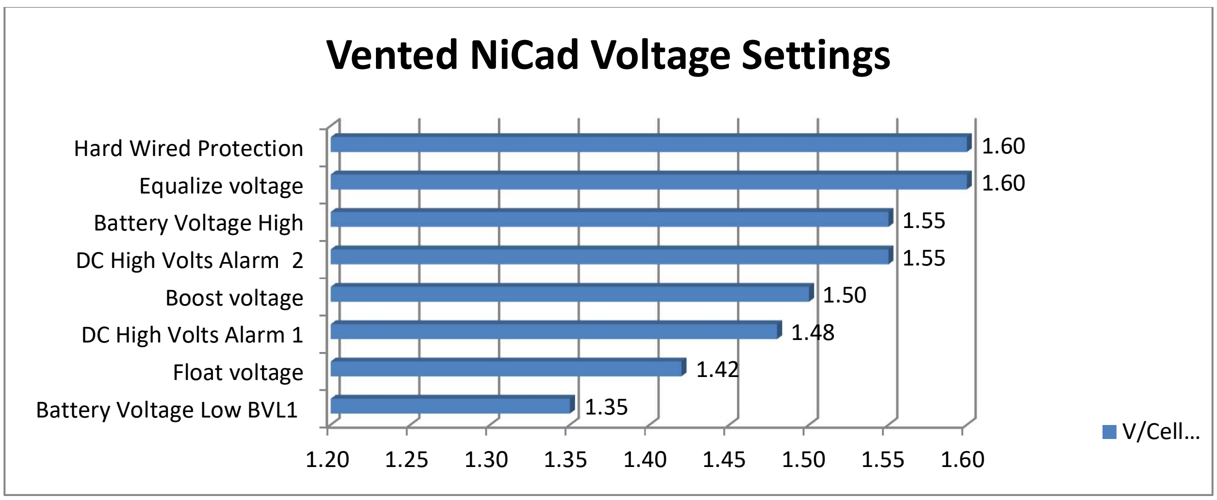

Figure B.2: Settings for Vented Nickel Cadmium cells

1) L, M and H cells temperature compensation slope settings of +3mV/°C/Cell for decreasing temperature and -3mV/°C/Cell for increasing temperature shall be applied.

2) XHP cells temperature compensation slope settings of +2mV/°C/Cell for decreasing temperature and -2mV/°C/Cell for increasing temperature shall be applied.

3) Alternative type of cells may be permitted and adjudicated to comply with the prescripts defined in [14].

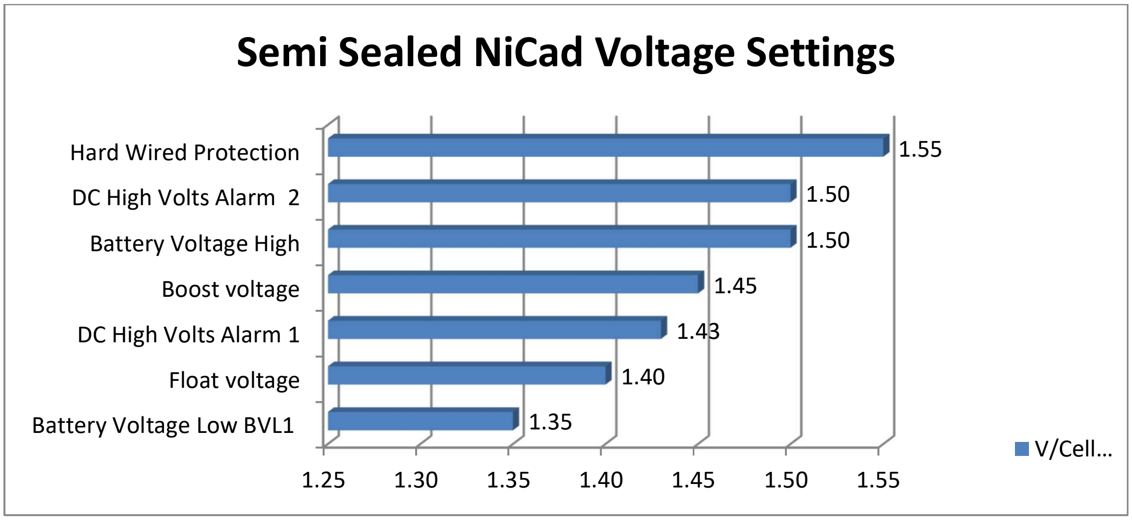

Figure B.3: Settings for Semi-Semi sealed Nickel cadmium cells

1) VTX cells, temperature compensation slope settings of +2mV/°C/Cell for decreasing temperature and -2mV/°C/Cell for increasing temperature shall be applied on VTX cells.

2) VN cells, temperature compensation slope settings of +3mV/°C/Cell for decreasing temperature and -3mV/°C/Cell for increasing temperature shall be applied.

3) Hoppecke cells, temperature compensation slope settings of +3mV/°C/Cell for decreasing temperature and -3mV/°C/Cell for increasing temperature shall be applied.

4) Alternative type of cells may be permitted and adjudicated to comply with the prescripts defined in [14].

Annex C – Settings Document Cover Page

Title:		Unique Identifier:	
		Alternative Reference Number:	
		Revision:	

Compiled by	**Approved by**	**Authorized by**
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Date:	Date:	Date:

REV	DESCRIPTION OF REVISION	COMPLIED BY	APPROVED BY	DATE
	Insert Revision History	Initials and Surname	Initials and Surname	