A Division of Transnet SOC Limited

TECHNOLOGY MANAGEMENT

SPECIFICATION

TECHNICAL USER REQUIREMENTS FOR BATTERY BANK AND CHARGER SYSTEMS FOR TRACTION AND DISTRIBUTION SUBSTATIONS

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1.0 SCOPE

1.1 This specification details Transnet Freight Rail's technical user requirements for the supply, installation, commissioning, and testing of battery and battery charger units that are theft and vandal proof for 3 kV DC traction substations, 25 kV AC traction substations, and 6.6 kV or 11 kV AC distribution substations.

2.0 BACKGROUND

2.1 All traction and distribution substations have two dedicated supplies, namely:

a) Traction or distribution (3 kV DC, 25 kV AC, 6.6 kV or 11 kV AC) – for traction or distribution loads.
b) Auxiliary (400 V AC or 230 V AC) – Connected to the building for lighting and auxiliary systems within the substation.

2.2 The auxiliary supply is used to power the battery chargers, which supplies the battery bank installed. These batteries operate in float mode to continuously supply all the protection, control and indication equipment. Where the battery is rated to supply these loads independently, for a minimum of 8 hours, during an interruption to the auxiliary supply. The output voltage level and capacity requirement vary based on the substation auxiliary load requirements, ranging from a voltage level between 110 V DC and 48 V DC with a capacity requirement of 29 –150 Ah.

2.3 The currently approved battery and charger technologies implemented in 3 kV DC, 25 kV AC, and 11 kV AC substations are based on older technology that cannot provide the lifespan, power and energy density, and minimised maintenance available in newer technology solutions. In addition, many of the existing battery systems installed, are based on technologies that are prone to theft due to their variety in application. Therefore, newer battery, charger and management systems must be piloted and tested over a period of time, to allow for a more feasible, functional solution to be implemented.

2.4 For 3 kV DC traction substations, there are two approved battery technologies in use, namely vented lead acid (Plantè) and valve-regulated lead acid (gel-electrolyte). These batteries are rated between 100-150 Ah, with a capacity requirement of 8 hours (C = 8). 2 V cells are recommended, to allow for 110 V DC output voltage, as is required from the various loads, which is compliant with BBH 3236 Version 2. The compatible battery charger for the 53 - 55 cell operation is in accordance with BBB 2502.

2.5 For 25 kV AC traction substations, due to the loads being considerably lower in comparison to the 3 kV DC substation requirements, the specified battery and charger technology used is either Nickel Cadmium or lead-acid, with a self-contained charger unit in compliance with CEE 0085. The batteries are rated between 10 Ah- 49 Ah, with a capacity requirement of 8 hours (C = 8). The output voltage requirement is 48 V DC or 110V DC based on the substation equipment ratings, which will further determine the battery charger requirements. Due to their switchgear and protective equipment operational load requirements, the existing capacity is currently insufficient for the various loads of single- and double-unit substations.

2.6 There are fewer protection equipment installed for 6.6 kV or 11 kV AC distribution substations, allowing for the same technology of batteries as the 25 kV AC traction substations to be used. Based on the load requirements, allowances for 48 V or 110 V DC outputs are available, with a self-contained battery charger unit applicable. The Nickel Cadmium or lead-acid batteries are in accordance with CEE 0085. The existing rated capacity of the batteries are insufficient for the load requirements and need to be reassessed.

2.7 Load tests to determine the correct capacity requirements in order to size the batteries have been conducted in 3 substations, namely Cedarmont, Doornpoort, and Bon Accord. For the 25 kV AC substations, a paper-based calculation has been conducted. Therefore, all the technical requirements of a new battery supply system have been researched, and the

functionality of a new battery needs to be tested over time to be rolled out long-term in traction and distribution substations.

3.0 ABBREVIATIONS

3.1.1 SoC – State of Charge

3.1.2 DoD- Depth of Discharge

3.1.3 PSoC- Partial State of Charge

3.1.4 TFR- Transnet Freight Rail

3.1.5 SoH- State of Health

3.1.6 r.m.s – root mean square

4.0 NORMATIVE REFERENCES

Unless otherwise specified all materials used, equipment developed and supplied shall comply with the latest edition of the relevant International Electro-technical Commission (IEC), International Organization for Standardization (ISO), South African National Standards (SANS) or Transnet publications.

4.1 SANS STANDARDS:

4.1.1 SANS 1274

4.1.2 SANS 61056-1.

4.1.3 SANS 60896- 11

4.1.4 SANS 61850

4.2 TRANSNET SPECIFICATIONS:

4.2.1 BBB 2502 – 3 kV DC battery charger specification

4.2.2 CEE 0085 – Self-contained battery and battery charger

5.0 SERVICE CONDITIONS

5.1 ENVIRONMENTAL CONDITIONS

Altitude:	0 - 1800 m above sea level
Relative humidity:	10% to 90%
Ambient temperature:	-10° C to +55° C
Wind pressure:	750 Pa
Lightning conditions:	20 ground flashes/km2 per annum
Pollution:	Heavily salt laden with industrial pollutants including diesel- electric locomotive emissions.

5.2 MECHANICAL SERVICE CONDITIONS

5.2.1 The batteries shall be designed to withstand all mechanical stresses, vibrations and shocks occurring in normal transportation, handling and use in accordance with clause 4 of SANS 60896- 11.

5.3 ELECTRICAL SERVICE CONDITIONS

5.3.1 Batteries shall be connected to the battery charger with a 110 V DC supply with voltage regulation in accordance with clause 7.4.1 of BBB 2502.

5.3.2 All battery components, connectors and terminals shall be designed for current ratings as specified in SANS 61056-1.

6.0 TECHNICAL REQUIREMENTS

6.1 GENERAL REQUIREMENTS

6.1.1 Installation of a battery and battery charger system with battery management functionalities for each type of substation (3 kV DC, 25 kV AC, and 11 kV AC).

6.1.2 Battery technology proposed shall be based on a self-contained construction type, with minimal maintenance requirements, with readily available replacements of individual components.

6.1.3 The battery supply shall have a minimum C-rating of 8 (C8), to allow for sufficient supply for the duration of the power interruption.

6.1.4 Based on the load types being fast-switching, high current and intermittent to accommodate the various circuit breakers and relays, the batteries shall have a good power density characteristic to handle the load requirements.

6.1.5 The battery bank shall have a front terminal type construction to allow easy testing and measurements access.

6.1.6 The associated battery charger for each battery type installed shall be easily configurable for different cell voltages, to allow for the chargers to be easily available for spares.

6.1.7 The batteries shall have a minimum DOD of 80%, with a minimum of 400 cycles per bank and a capacity of 80% at end of lifespan.

6.1.8 The batteries shall have a low toxicity level, with a protection system to prevent thermal overloading of individual cells and all cells' health status of the cells.

6.1.9 The battery type chosen shall be operable in the environmental conditions noted in 6.1, with an option to regulate the room temperature based on the substation layout. (3 kV DC substations have separate battery rooms, where ventilation can be controlled)

6.1.10 All batteries proposed shall have a high PSoC characteristic that allows for a slow discharge rate, that can be extended over the C-rating of the battery. (Typically, 8 hours)

6.1.11 The battery system shall have charge current regulation, low voltage discharge current cut-off limits, cell balancing

6.1.12 The battery bank shall be installed to ensure that the system is theft-deterrent per requirements of 6.6.??

6.2 3 kV DC Traction Substation Auxiliary Supplies

6.2.1 The requirement for 3 kV DC substations is a stationary, rechargeable standby battery with a 100-150 Ah capacity, and a minimum C-rating of 8.

6.2.2 Any individual cell voltage is allowable, provided that the output voltage is 110 V DC, which is the supply voltage required for all individual relays, protection, and control circuits.

6.2.3 The battery chemistry shall be of a high-power density, with fast charge capabilities.

6.2.4 The battery bank should be supplied by a compatible battery charger, capable of float and boost charge operation, connected to the auxiliary AC supply in the traction substation of the following:

6.2.1.1 Single phase 230 V AC ± 10% r.m.s – 50 Hz

6.2.1.2 Three phase 400 V AC± 10% r.m.s – 50 Hz

6.2.5 The battery charger shall be of a self-contained construction, suitable for floor or wall mounting, with theft-deterrent, vermin-proof and tamper-proof features.

6.2.6 The battery charger cubicle shall be powder-coated in accordance with SANS 1274, with the interior having a type 4 corrosion-resistant coating.

6.2.7 The battery charger cubicle shall accommodate adequate ventilation through natural cooling to prevent overheating the associated internal components.

6.2.8 Provision shall be made within the charger cubicle to ensure that a suitable conduit or cable entry for the input AC and output DC supply, with an earthing terminal welded to the frame to allow for the connection of a 95 mm^2 earthing cable using a M12 lug.

6.2.9 The battery charger shall allow for up to 130 V DC based on boost charger operation.

6.2.10 A battery management system to perform condition monitoring of the cell health, internal resistance, temperature requirements, SOC and DOD. This system should be integrated with the existing communication system and future wireless communication systems, in accordance with SANS 61850.

6.3 25 kV AC Traction Substation Auxiliary Supplies

6.3.1 48 V or 110 V DC output requirement from battery bank, with a capacity of 49-70 Ah. The number of cells depends on the cell voltage of the battery supplied.

6.3.2 For single unit substations, a minimum of 49 Ah batteries must be implemented.

6.3.3 For double unit substations, up to 70 Ah must be used.

6.3.4 Battery banks should be supplied by a compatible battery charger, capable of float and boost charge operation, connected to the auxiliary AC supply in the traction substation of the following:

6.3.1.1 Single phase 230 V AC ± 10% r.m.s – 50 Hz

6.3.1.2 Three phase 400 VAC± 10% r.m.s – 50 Hz

6.3.5 A battery management system to perform condition monitoring of the cell health, internal resistance, temperature requirements, SOC and DOD. This system should be integrated with the existing communication system and future wireless communication systems, in accordance with SANS 61850.

6.4 11 kV AC Traction Substation Auxiliary Supplies

6.4.1 48 V or 110 V DC output requirement from battery bank, with a capacity of 29-60 Ah. Number of cells is dependent on the type of battery supplied.

6.4.2 Battery banks should be supplied by a compatible battery charger, capable of float and boost charge operation, connected to the auxiliary AC supply in the traction substation of the following:

6.4.1.1 Single phase 230 V AC ± 10% r.m.s – 50 Hz

6.4.1.2 Three phase 400 VAC± 10% r.m.s – 50 Hz

6.5 Battery Management System

6.5.1 The battery system requested by TFR shall be equipped with a monitoring system that will provide specific parameter measurements at a maximum of 5-minute intervals.

6.5.2 The battery management system shall output the following measurements:

SOC
Individual cell SOH
Cell temperature
Cell and bank Current measurements
Cell and bank Voltage measurements

Cell resistance
Maintenance alert
Time

6.5.3 This system should be integrated with the existing communication system and future wireless communication systems, in accordance with SANS 61850.

6.5.4 Measured parameters shall be stored for at least one month, after which older data may be overwritten.

6.5.5 Data shall be downloadable locally on site to a standard laptop or smartphone, via cellular modem connectivity or standard network connections.

6.5.6 Data shall be downloadable and manipulated via a user-friendly interface and also be exportable in a readily useable format such as delimited text or spreadsheet format.

6.6 THEFT-DETERRENT FUNCTIONALITY

6.6.1 The battery bank and charger system shall have mechanical security features based on installation methods to mitigate theft and vandalism.

6.6.2 The system shall be installed with monitoring and alarm features that are triggered remotely in the event of tampering or theft occurrences.

6.6.3 The disconnection or malfunction of any battery cell shall trigger a remote alarm function that is sent to the Telecontrol system.

6.6.4 The remote communication between the battery system and Electrical Control shall be compatible with the existing wired network (Telecontrol) and have allowances for future wireless communication systems implemented by TFR.

6.6.5 The battery system shall incorporate the tracking device element feature.

7.0 DOCUMENTATION

7.1.1 Installation Manual and Maintenance Manual for all individual components supplied.

7.1.2 Detailed Schematic and wiring diagrams of the equipment

7.1.3 Data Sheets of all supplied equipment

7.1.4 Battery performance and functionality tables and documents.

7.1.5 Battery manufacturer’s test graphs and tables

7.1.6 Additional detailed information on the following for each battery technology:

7.1.6.1 Ventilation requirements

7.1.6.2 Protection requirements - Protection Index (IP)

END