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System Substation Battery

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The technical content of this document has been approved by the relevant ARTC engineering authority and has also been endorsed by the ARTC Safety Committee.

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About This Standard

This specification details the whole of life performance requirements for a stationary battery for use in ARTC system substations. System substations include traction substations, sectioning huts and substations that have a voltage greater than 2 kV and include a high voltage circuit breaker as an item of equipment.

The stationary battery is used to maintain the electrical supply for essential equipment within the substation in the event of the loss of the substation normal ac supply. The usual battery voltage is a nominal 120 V_{dc} system but this specification does not exclude other voltages.

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1 References

The following Australian and International Standards are either referenced in this specification or can provide further information.

1.1 Australian Standards

AS 2191- 1978	Stationary batteries of the lead-acid Plante positive plate type.
AS 2668- 1983	Water for use in secondary batteries.
AS 2676.1-	1992 Guide to the installation, maintenance, testing and replacement of secondary batteries in buildings: Vented cells.
AS 2676.2 - 1992	Guide to the installation, maintenance, testing and replacement of secondary batteries in buildings: Sealed cells.
AS 3011.1 - 1992	Electrical installations - Secondary batteries installed in buildings - Vented cells.
AS 3011.2 - 1992	Electrical installations - Secondary batteries installed in buildings - Sealed cells.
AS 3731.1 - 1995	Stationary batteries - Nickel cadmium: Vented type.
AS 3731.2 -	1995 Stationary batteries - Nickel cadmium: Valve regulated type.
AS 4029.1 - 1994	Stationary batteries - Lead-acid: Vented type.
AS 4029.2 - 1992	Stationary batteries - Lead-acid: Valve regulated sealed type.
AS 4029.3 - 1993	Stationary batteries - Lead-acid: Pure lead positive pasted plate type.

1.2 International Standards

IEEE Std 485-1983	Recommended Practice for Sizing Large Lead Storage Batteries for Generating Stations and Substations.

1.3 Drawings

The following drawings can provide further information:

C 80339	120V Battery Stand M.S. Details.
B 81483	120V Battery Stand Type 1 MS Details.
B 81655	Sectioning Huts 120V Battery Stand Type 2 MS Details.

2 Definitions & Abbreviations

Cell	The basic electrochemical unit, characterised by an anode and a cathode used to receive, store and deliver electrical energy. For a lead acid system, the cell is characterised by a nominal 2 V potential. For a nickel-cadmium cell the nominal voltage is 1.2 V.
Battery	A unit consisting of one or more cells connected in series, parallel, or seriesparallel arrangement to supply the voltage and current requirements of the connected load.
SCADA	Supervisory Control and Data Acquisition system.
Duty cycle	The load currents a battery is expected to supply for specified time periods.
Design margin	Additional capacity above requirements to allow for unforeseen additions to the dc system and less than optimum operating conditions due to improper maintenance, recent discharge, or ambient conditions lower than anticipated.
Temperature	The standard temperature for stating cell capacity is 25^{o}C.
Correction	A cell size correction factor shall be applied at the lowest expected temperature.
Ageing factor	Compensation to ensure that a battery shall still supply its rated capacity at the end of its design life.
Margin	The combination of design margin, temperature correction and ageing factor used to determine the battery's initial capacity requirements.
Capacity	The total number of ampere-hours that can be withdrawn from a fully charged battery at a specific discharge rate and electrolyte temperature, and to a specific end-of-discharge voltage.
Design Life	The period during which a fully charged battery is capable of delivering at least 80% of its capacity.
Self discharge	The amount of capacity reduction occurring per unit of time due to internal chemical reactions (local action).

3 Background

The stationary battery covered by this Specification is used in system substations to provide a supply to substation control equipment. The substations convert electricity from the ARTC high voltage a.c. network to supply its railway system at a nominal 1500 $V_{dc.}$ The major equipment using the battery supply are the controls for the rectifiers and switchgear, consisting of alternating current circuit breakers and direct current circuit breakers. SCADA equipment is used to provide remote open and close signals for the control of the substation equipment and also monitor indication and

alarm conditions. Emergency lights, supplied by the battery, may be switched on if a technician is carrying out maintenance in the substation.

The most common dc system voltage used in ARTC system substations is nominally 125 V_{dc} but is usually referred to as 120 $V_{dc.}$ A nominal 50 V_{dc} system is also common in some areas of the ARTC network. In both cases the system is unearthed.

There is no restriction on the voltage to be used for the design of new substations.

4 Functional Characteristics

4.1 General

The battery is used for standby service in full float operation, that is, the system is operated with the battery, battery charger and load all connected in parallel and the battery charger supplying the normal dc load plus any self discharge or charging current, or both, required by the battery. The battery will deliver current only when the load exceeds the charger output.

The battery dc system load consists of:

- a varying continuous load from a SCADA system;
- continuously energised coils in switchgear and indicating lights;
- a non-continuous load from emergency lighting;
- random momentary operations of switchgear.

The battery and battery charger must be compatible. Technical information concerning the most common type of battery charger used in the ARTC system is detailed in section 6.2. However, in some circumstances, when replacing an existing battery, it may be shown to be more economical to also replace the battery charger. If the battery charger is being replaced then it must be ensured that the proposed battery charger:

- will recharge the battery from its design end-of-discharge voltage to full charge in 5 hours;
- will not cause a voltage to appear across the load that is higher than the withstand voltage of any components of the load if the battery becomes open-circuit.

4.2 Whole-of-Life Cost

The selection of the most suitable battery, or battery and battery charger combination, shall be made on the basis of minimising the whole-of-life cost.

The following factors must be considered in determining this:-

- Initial purchase price.
- Cost of changes to the Technical Maintenance Plan & Service Schedules or the creation of new manuals & schedules.

- Cost of manuals.
- Cost of maintenance.
- Cost of replacement parts.
- Cost of inventory spares.
- Environmental costs.
- Electrical Losses.
- Cost of installation.
- Reliability and cost of failures.
- Cost of modifications to other parts of the installation.
- Lifetime of equipment.
- Discount Rate.
- Cost of staff training.
- Cost of Decommissioning and Disposal.
- Cost of special tools.

5 Performance Characteristics

The battery shall supply the electrical requirements of the system substation when there is no output from the battery charger. This may be due to a loss of the ac supply to the substation or a fault in the battery charger or its supply. Under these conditions the battery shall supply the loads listed in section 4.1 as well as any other loads deemed necessary for a minimum period of 10 hours. The battery shall then be able to reclose all high voltage circuit breakers necessary to restore supply to the battery charger. At some locations power is supplied from an external low voltage supply so no extra power is required for the restoration of supply. However at some locations before power can be restored to the battery charger several circuit breakers may need to be reclosed, including the rectifier ac and dc circuit breakers.

The calculation of the required battery capacity shall include a margin to ensure system integrity. This margin shall include a design margin of a minimum of 20% and a temperature correction and an ageing factor which shall be obtained from the battery manufacturer. Refer to section 0 for the definitions of these terms.

The battery shall be suitable to be recharged from its design end-of-discharge voltage to full charge in 5 hours.

All other performance aspects shall meet the requirements of AS 4029.1 and AS 4029.3 or any other Australian Standard applicable for the type of cell construction.

6 Technical Characteristics

6.1 General

The battery shall be installed, maintained and tested to the appropriate Australian Standard and any other references stated in this specification.

6.2 Battery Charger Details

This specification is intended to cover the requirements of the battery only, it does not cover the requirements of the battery charger. However, this section describes the relevant technical details of the most common type of battery charger in use in ARTC traction substations to aid the Maintenance Provider in the situation where an existing battery is required to be replaced but it is not economical to replace the battery charger as well.

Under normal conditions the battery charger output voltage is set at 127 V_{dc} but can be adjusted by +/- 5 Vdc.

The maximum output conditions are dependent on the type of charger and are either 20 A or 10 A at 140 $V_{dc.}$ The output voltage is maintained within +/- 1 V_{dc} for variations in load from zero to maximum amperes, up to 140 Vdc.

The battery charger output voltage is not temperature compensated. Note: The batteries are boost charged with the load connected.

6.3 Battery Dimensions

There is a large variation in battery room dimensions within the various traction substations in the ARTC network. All batteries shall be placed on shelves in accordance with the relevant Australian Standard. Drawings are available for some installed shelves, refer to section 1.3.

6.4 Battery Accessories

All connecting materials, including bolts, nuts and bars/conductors, shall be considered as a part of the battery set. These items shall be of inherently corrosion resistant material, or shall be protected against corrosion to ensure the battery life is not compromised.

All cable and connectors shall be of sufficient gauge to carry the maximum specified load current. When two or more battery groups are connected in parallel, they shall be connected to the load through equal lengths of cable and each cable shall be equipped with a fuse.

7 Maintenance

7.1 General

The relevant ARTC Technical Maintenance Plans shall be adhered to for the maintenance of the type of installed battery. Where a new type of battery is purchased and installed that is not covered by the TMP then a new service schedule shall be created and the TMP updated. This shall include:

- The “Maintenance Policy”, defining the practical means of maintaining the equipment.
- The tasks to be performed at each level of maintenance and staff skill levels required.
- Test equipment and tools.

It is preferable that the period for routine maintenance shall not be more frequent than for the types of batteries currently detailed in the ARTC Technical Maintenance Plan.

7.2 Electrolyte Level Indication

Where the proper maintenance of a battery requires the monitoring of the electrolyte level, then the electrolyte level, with maximum and minimum indications, shall be clearly visible.

7.3 Cell Type and Voltage

All cells in a battery shall be of the same type. Where a cell is being replaced and the new cell has a terminal voltage significantly less than the other cells in the battery then it will need to have an equalizing charge before it can be used with the rest of the battery. The critical terminal voltage value is dependent on the type of battery and the battery manufacturer should be consulted. For a standard pasted positive plate lead acid cell a difference in terminal voltage of approximately 5% can be considered as the critical value.

8 Tests

8.1 Acceptance Tests

Acceptance tests shall be carried out in accordance with the relevant Australian Standard and the manufacturer’s recommendations.

8.2 Periodic Tests

Refer to ARTC Technical Maintenance Plan.

9 Data Set associated with the Equipment

The following data shall be maintained for each battery. This data shall be the property of ARTC and maintained by the Maintenance Provider responsible for the installation in which the battery is installed.

9.1 Design Calculations

All design calculations relating to the sizing of the battery shall be retained, including margin factors for:

- temperature correction
- design margin
- ageing factor

9.2 Equipment Manuals

The Equipment Manuals must be provided for the installation and shall include full instructions for the preventative, surveillance and corrective maintenance, comprehensive fault diagnosis, rectification procedures and staff training requirements. It shall include all drawings needed for the above. All drawings shall show sufficient detail to enable satisfactory maintenance of the equipment.

9.3 Test Results

The results of all tests, including acceptance tests and periodic and corrective maintenance tests, shall be recorded and maintained.

9.4 Life Cycle Costing

All the data and assumptions pertaining to the determination of the whole-of-life cost calculations shall be recorded.

9.5 Technical Schedule

The information listed in the attached Technical Schedule shall be maintained for each battery.

10 Technical Schedule

10.1 Manufacturer Details

Manufacturer ..... _____

Manufacturer's type designation ..... _____

10.2 Battery Details

Battery type (lead acid/nickel cadmium etc.) ..... _____

Battery construction (vented/valve regulated etc.) ..... _____

Total number of cells used in each battery ..... _____

Nominal capacity ..... _____ Ah

Actual capacity

- 10 hour rate ..... _____ Ah
- 3 hour rate ..... _____ Ah
- 1 hour rate ..... _____ Ah

Type of intercell connection (bolted/welded/both) ..... _____

Maximum voltage drop across intercell connectors ..... _____ V

Maximum Operating ambient temperature ..... _____ ºC

Minimum Operating ambient temperature ..... _____ ºC

Recharge time ..... _____ Hrs

Battery charger recharge time based on ..... _____

Short-circuit current ..... _____ A

Design life ..... _____Yrs

10.3 Cell Details

Number of positive plates per cell ..... _____

Number of negative plates per cell ..... _____

Type of positive plate (Plante/Flat/Tubular) ..... _____

Internal resistance of cell ..... _____ Ω

Electrolyte ..... _____

- Full charge density..... _____
- Density range..... _____
- Litres/cell..... _____ L

Self discharge rate @ 25 ºC ..... _____

Rated capacity on first discharge..... _____%

Time on float to achieve 95% of rated capacity ..... _____Yrs

Time on float to achieve 100% of rated capacity ..... _____Yrs

Container material ..... _____

Separator material..... _____

Dimensions

- Overall height (including terminals) ..... _____ mm
- Overall width (including terminals) ..... _____ mm
- Overall depth ..... _____ mm
- Total weight (wet)..... _____ kg
- Total weight (dry) ..... _____ kg
- Total weight of leads (including connectors)..... _____ kg