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ETS 0085

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Revision History

This specification replaces ETS 0085 amendment no 1. All changes are highlighted in this document with grey colouring.

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Contact Information

The latest version of this document and other standards, are located on Endeavour Energy's standards website located at:

<http://www.endeavourenergy.com.au/aspPortal/webengine/au/com/ee/asp/Standards/Standards>.

For any enquiries relating to the content of this document please contact the Standards Coordinator on 13 10 81.

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1 Documentation Scope

The scope of work consists of the design, supply and delivery to site of major substation batteries, chargers and associated equipment.

It is not the intention to specify all the design and construction details related to the equipment, however the equipment supplied shall meet all the requirements specified in this document, including all external standards referenced in section 2. In some circumstances based on local network conditions and experience, this specification is more stringent than that of the Australian and International standards; in this circumstance the requirements of this specification shall take precedence.

The tenderer must state any non-compliance with the specification in the tender submission and any alternative offers should be submitted in full and separately from the main offer. Any proposed variations from this specification will be referred to the Head of Asset Planning & Performance for approval prior to acceptance.

The supplier to this specification and its subcontractors shall supply and deliver to the nominated site at their own expense. The supplier shall pay all duty, insurances, freight, cartage and all other charges in the process.

2 References

External Regulations

ENA National Electricity Network Safety Code (Doc 001-2019)

Work Health and Safety Act 2011 (NSW)

Work Health and Safety Regulation 2017 (NSW)

External Standards

AS/NZS 3000	2018	Electrical installations
AS 2676.2	2020	Guide to the installation, maintenance, testing and replacement of batteries in buildings - Sealed cells
AS 3011.2	2019	Electrical installations - Secondary batteries installed in buildings - Sealed cells
AS/NZS 4029.2	2000	Stationary batteries lead acid - Valve regulated type
AS 4044	1992	Battery chargers for stationary batteries
AS 4506	2005	Metal finishing - Thermoset powder coatings
AS 60529	2004	Degrees of protection provided by enclosures (IP Code)

Company Policies and Procedures

Company Policy (Network) 9.2.5	Network Asset Design
Company Policy (Network) 9.7.1	Network Asset Construction

Company Standards

Substation Design Instruction SDI 513	Substation batteries and battery chargers
Substation Design Instruction SDI 515	Drawings
Substation Design Instruction SDI 534	Manuals, test reports and photographs
Substation Maintenance Instruction SMI 100	Minimum requirements for maintenance of transmission and zone substation equipment
Substation Maintenance Instruction SMI 102	Substation batteries

3 Definitions and Abbreviations

Term	Definition
AC	Alternating current
DC	Direct current
DNP	Distributed Network Protocol 3
FAT	Factory Acceptance Test
SCADA	Supervisory Control and Data Acquisition

4 Actions

4.1 Service Conditions – Substation 110V and 48V Systems

4.1.1 General

The batteries and chargers will be located in substations within the Endeavour Energy franchise area. A suitable space in accordance with AS 3011:2 will be provided by Endeavour Energy for this purpose.

The battery system equipment will generally be mounted indoors, either on concrete flooring or within a prefabricated building.

Equipment offered shall give due regard to safe work practices in compliance with the requirements of the Work Health and Safety Act 2011. The scope includes all equipment and accessories necessary and normally supplied for the safe operation of the equipment, whether specified or not.

The batteries, chargers/rectifiers, DC to DC converters and associated equipment offered in response to this specification shall be manufactured and tested to the standards with the year of publication listed in

section 2 of this document. In the event of inconsistencies and/or conflicts between the requirements outlined within this document and the Australian and/or International standards, the requirements within this document shall take precedence. However, significant inconsistencies should be referred to the tendering Contract Manager who will seek clarification from the relevant sections within Endeavour Energy and respond in writing, clarifying the inconsistencies.

4.1.2 Operating Conditions

The equipment shall be designed for continuous operation in the following conditions.

- 24-hour average temperature range 10 deg. C to 35 deg. C
- Maximum operating temperature range 0 deg. C to 45 deg. C

The battery charger shall be connected to the low voltage station supply. The AC input may be subject to substantially higher AC voltages than nominal due to its proximity to the main power and auxiliary transformer.

Note 1: Older transmission substations may have 433/250Vac auxiliary supplies.

Note 2: Older zone substations may have 415/240Vac +/- 10% auxiliary supplies i.e. a maximum voltage of 264Vac.

The substation may contain audio frequency ripple signal equipment to inject over the 11kV system at variable frequencies up to 1050Hz.

4.1.3 110V System

The battery charger DC output will normally supply the battery bank in parallel with the continual substation base load of approximately 8-10 Amps DC, consisting of protection, SCADA and emergency DC lighting load.

Station DC load will increase during protection operations particularly for circuit breakers driven by solenoids. By example:

- Single circuit breaker tripping requiring a load of 10A for 100msec
- Multiple circuit breaker tripping requiring up to 90A for 100msec
- Single circuit breaker closing requiring a close of 400A for 500msec

The 110V DC system typically contains 54 of 2V cells. Endeavour Energy will allow a float voltage of 125V (2.23V / cell typically) and maximum boost voltage of 135V (2.41V / cell typically).

4.1.4 48V System

48V DC outputs are required on all battery cabinet systems, which will be supplied by the 110V battery charger via a DC-DC converter. The continual base load for 48V communications systems is approximately 5-10A DC. Refer to section 4.2.2 for additional 48V DC requirements.

Stand-alone 48V batteries and chargers are excluded from the scope of this document.

4.2 Technical Requirements

4.2.1 Battery construction requirements

All materials shall be of a type and quality that will give a minimum guaranteed life expectancy of:

- 15 years for 2V DC cells;
- 10 years for 12V DC batteries; and
- 15 years all other equipment in the battery system, including the battery charger, DC-DC converter and communications panel.

The supplier shall provide all necessary items for the operation of the equipment, whether directly specified or not.

4.2.2 Accommodation

Batteries shall be installed in battery rooms or battery cabinets in accordance with AS 3011.2 and SDI 513. The ventilation shall be designed so that the batteries are not exposed to direct sunlight.

Battery rooms

Where 110V substation batteries are located in a battery room, the batteries should be stored in a stand/rack in accordance with Table 1.

Table 1 – Battery stand/rack dimensions

Description	Requirement
Height to top of stand	2100mm maximum
Width	1600mm maximum
Depth	600mm maximum
Finish	Powder Coated

Chargers for substation batteries shall be freestanding and capable of being mounted against a wall without requiring clearance behind the unit. The dimensions of charger enclosures shall be in accordance with Table 2.

Table 2 – Charger enclosure dimensions

Description	Requirement
Height to top of stand	1700mm maximum
Width	750mm maximum
Depth	750mm maximum
Finish	Powder Coated

Battery cabinets

Battery and charger cabinets will be used in locations where a compact battery system is required. The nominal voltage of the battery system should be 110V.

DC distribution boards should be integrated into the charger cabinet. Each charger cabinet should contain 110V DC and 48V DC outputs. The 48V DC outputs should be supplied from the 110V battery charger via a DC-DC converter. The charger cabinet should incorporate the following outputs:

- 110V DC output: 12 x double-pole DC MCB's
- 48V DC output: 6 x double-pole DC MCB's

The design of the battery cabinets should facilitate front access to the batteries, allowing for unrestricted access to battery terminals for testing and the ability to slide individual cells out without the need to dismantle other cells. The preferred battery configuration is single row, horizontally mounted batteries.

The maximum dimensions of the battery/charger cabinets are shown in Table 3. The width noted in table 3 is the total footprint of the battery and charger cabinets for a single system.

Table 3 – Battery/charger cabinet dimensions

Description	Requirement
Height	2100mm maximum
Width (combined)	2450mm maximum
Depth	750mm maximum
Finish	Powder Coated

Adequate ventilation in accordance with AS 2676.2 and AS 3011.2 shall be incorporated in the design of the battery cabinet. Some substation control rooms only have reverse-cycle air conditioning without any ventilation outlets. The supplier shall include an option for ducting the battery cabinets directly to the outside of the building (using natural ventilation). This option should also incorporate sealing of the battery cabinet, to prevent any leakage of gases in the substation control room.

Endeavour Energy requires the ability to connect a mobile battery bank to each 110V DC distribution circuit. Cables from the mobile battery bank are fitted with lugs that have a 12mm hole. Provision for the connection of these cables to a set of terminals shall be made in each cabinet.

4.2.3 Lifting points

Suitable ready to use lifting points shall be provided on all cabinets.

4.2.4 Hardware

Suitable door opening and closing hardware shall be provided on all charger cabinets. Hinged doors shall be used on battery/charger cabinets. Lift-off doors are not acceptable.

4.2.5 Minimum degree of protection

The charger cabinet shall comply with AS 60529 with a minimum degree of protection IP21.

4.2.6 Environment protection of equipment

All ferrous parts shall be treated to provide acceptable surface finish and protection. The supplier shall provide full details of the surface finishing on all component parts.

All insulation shall be of a type and quality that will give normal life expectancy without deterioration.

4.2.7 Meters

Voltage and current measurements shall be clearly visible from the front of the equipment.

For rack mounted equipment this requirement shall be with doors open or closed where fitted.

4.2.8 Controls

All controls shall be readily accessible from the front of the equipment.

All indication lights shall be clearly visible from the front of the equipment and have a minimum viewing angle of 90 degrees.

For rack mounted equipment this requirement shall be with doors open or closed where fitted.

4.2.9 Temperature compensation

Temperature compensated charging shall be provided. The temperature detector shall be mounted in a position that provides the best representation of the battery temperature.

4.2.10 70% voltage take off point

The 110V batteries shall be provided with a take-off point (70% nominal volts), which is used to test equipment operation at minimum volts. This shall be in the form of a tag with a single hole capable of accepting an M12 bolt or a 32A banana plug socket.

4.2.11 Connection of test equipment

Endeavour energy requires the ability to connect test equipment to each battery bank. It should be possible to connect a suitable heavy duty test clamp to the terminals on the first and last batteries in the bank without needing to reposition batteries or dismantle other cells.

4.2.12 Secondary wiring

All wiring associated with SCADA and communications shall be screened cable or wiring enclosed in metal conduit to alleviate the effects of electrical field interference.

All wiring and protection shall comply with AS/NZS 3000.

The screen of the cable shall be earthed at one end only to prevent damage from circulating earth fault currents in the substation earthing system.

Inline joints in any control wiring are not permitted under any circumstances.

4.2.13 Alarms, indication and supervision

Alarms should be reported by:

- Clean contact
- DNP
- Modbus

Alarms shall be provided by the battery charger/DC to DC converter to allow local and remote indication of the following conditions:

- Earth fault detection
- AC available
- AC power failure
- DC low volts warning (suitable for adjustment by Endeavour Energy)
- DC low volts (suitable for adjustment by Endeavour Energy)
- DC high volts (suitable for adjustment by Endeavour Energy)
- Rectifier/charger failure
- Battery open circuit detection
- Over temperature alarm
- DC-DC converter failure

It is preferable for the battery system to include the following automatic testing facilities:

- Battery capacity test
- Impedance test

4.2.14 Labelling

All equipment shall be clearly labelled to show its function in accordance with AS/NZS 4029.2, AS 4044 and AS 2676. This shall include all battery systems, including all circuit breakers, switches, indication lamps, cables, relays, contactors and meters.

Labels shall be a **Traffolyte material** and engraved having black upper-case letters on a white background.

Lettering and numbering on labels shall be as large as practical, and not less than 5mm high.

It is preferred that all labels are of the same size or at least the number of different sizes is kept to a minimum.

Labels shall be fixed using very high bond (VHB) double sided foam tape.

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Labels shall be fixed above the device wherever possible.

Labels shall not be directly fixed to items that are readily removable or interchangeable.

Drawings of the labels shall be submitted to the Endeavour Energy Contract Manager for approval prior to them being used on the equipment.

4.3 Operational Requirements

Battery sets shall be located with sufficient separation to enable maintenance on one battery set without impacting the operation of the other battery.

Where dual battery systems are installed, the design shall incorporate paralleling circuits between the 110V distribution busbars and the 48V distribution busbars. Paralleling switches should be installed on each cabinet. The design should allow for batteries or charger in one system to be disconnected for maintenance or replacement while maintaining DC supply to all loads in both systems. It must be possible to replace the charger in one system without disturbing any DC loads.

The design of the battery system must incorporate two independent 48V busbars, one in each charger cabinet. The 48V busbars must be supplied by independent DC-DC converters and shall be positively earthed. Paralleling switches should be installed on each cabinet, to provide N-1 supply on the 48V supply.

4.4 Health and Safety

All equipment shall be designed so that there is no safety hazard to operating workers.

A copy of the appropriate MSDS shall be provided in PDF format, with a hard copies provided for each site.

4.5 Maintenance & Support

4.5.1 Maintenance

The manufacturer shall provide details of the recommended maintenance procedures.

Refer to SMI 100 and SMI 102 for the routine maintenance requirements and intervals of Endeavour Energy's substation battery systems.

4.5.2 Spare parts/repairs

The supplier shall provide a list of recommended spare parts (and supplier details), special tools, and appliances to be held by Endeavour Energy. The items nominated shall allow the most common defects and recommended maintenance to be expedited effectively over the *whole of life* of the equipment.

Predicted availability of spare parts over the life of the equipment shall be considered. Lists shall be complete with manufacturer's name, part numbers and current prices (in Australian dollars) for each item.

Spares, tools and appliance pricing will be considered separately from the main tender offer pricing.

The final quantity of spares to be supplied will be decided as part of the contract negotiations.

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The Supplier shall provide a repair/replacement facility for failed equipment for a minimum of 10 years after the last unit is delivered.

4.5.3 Training

The supplier shall be required to provide training to Endeavour Energy employee on the safe operation and maintenance of the equipment supplied.

4.5.4 Touch up work

All damaged paintwork shall be touched-up on completion of the works in accordance with an approved paint process.

4.5.5 Firmware

Endeavour Energy requires the ability to maintain the same firmware version across all battery charger systems that are purchased under the contract.

Once a firmware version has been integrated with Endeavour Energy's communication system, it should be possible to continue using the same firmware version on new battery chargers that are purchased, even if a newer firmware version has been released. This is to minimise additional development effort to integrate new firmware versions with Endeavour Energy's communications system.

When firmware upgrades are required, it should be possible for Endeavour Energy to perform the firmware update in-house, rather than relying on the supplier to perform the update.

4.6 Testing

4.6.1 General

All type tests shall be carried out by a testing authority holding appropriate accreditation:

- By NATA Australia; or,
- By an accreditation authority recognised by NATA Australia.

Tests from other testing authorities or tests resulting from a similar standard to those specified (such as EN and IEEE) may be accepted at the discretion of the Head of Asset Planning & Performance. For different standards to be considered, documentation shall be provided to synchronise them with the corresponding standard specified.

All type test reports shall be accompanied by copies of the accreditation certificate/s issued to the testing laboratory. The accreditation certificate/s shall be valid for the relevant test/s and for the duration of the tests.

Type tests shall be less than five (5) years old. Type tests beyond this limit may be acceptable at the discretion of Endeavour Energy's Head of Asset Planning & Performance if sufficient information can be provided to show that the manufacturing process, raw materials, design and quality control processes have not significantly changed since the original test date.

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All documentation submitted such as reports, tests, testing procedures/policies and calibration certificates written in any language other than English shall not be accepted by Endeavour Energy unless the reports are translated into English by a sworn translator.

4.6.2 Type Tests

Type tests shall be carried out on the offered equipment in accordance with the appropriate Australian standard and meet the minimum criteria as indicated in **Appendix 2**.

4.6.3 Factory Acceptance Tests & Commissioning Tests

The battery system shall be tested in accordance with AS 2676.2. The battery shall receive an initial charge in accordance with AS 2676.2 appendix **E** or the manufacturer's instructions – whichever is the most onerous.

FAT and commissioning tests shall be carried out on the equipment in accordance with the appropriate Australian standard; and this shall include but not be limited to tests shown in Appendix 2. FAT should be performed by the battery system supplier for every purchase. Commissioning tests should be performed by the installer of the battery system.

The site test reports shall be checked for compliance by the supplier and the Endeavour Energy Contract Manager. The test reports shall be included as part of the manual.

The Endeavour Energy Contract Manager or representative nominated by Endeavour Energy shall witness the commissioning tests.

4.6.4 Submission of test reports

Type test reports shall be submitted to the Contract Manager for approval.

Applicable certified test certificates for type, routine and special tests including factory and site test reports shall be added to the manual on the completion of each installation. Site test reports shall be in accordance with AS 2676.2 and as specified in the instruction.

Reports written in any language other than English will not be accepted by Endeavour Energy unless the reports are translated into English by a sworn translator.

4.7 Deliverables

4.7.1 Manuals

The supplier shall provide **one** hard copy of the battery system manual at each site. The manual shall be A4 size and complete with test reports, and suitably folded or reduced drawings for filing within the manual. All text, including titles and legends on the documents, shall be in English, with the dimensions in metric.

Hard copy manuals shall be professionally presented in hard cover ring-binder files capable of withstanding normal handling.

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The electronic copy of manuals and factory test reports shall be **provided**. The file format for equipment manuals is Microsoft Office or PDF (Portable Document Format). Drawings shall be AutoCAD in accordance with clause 4.7.2. The manual cover page shall be complete with the following minimum requirements:

- Brief description of the equipment.
- Substation or communication site name as appropriate, for which the equipment was supplied.
- Endeavour Energy contract number.
- Manufacturer's order number.

The manuals shall **meet the requirements of SDI 534, including but not limited to:**

- A comprehensive index.
- MSDS of all hazardous or flammable material used in the equipment.
- Precise instructions on installing, operating, testing, maintenance and disposal.
- Instructions for the routine maintenance and testing of the equipment including calibration data.
- Recommended maintenance regime including maintenance tasks and intervals. This regime shall be based on the mean time between failure (MTFB) and the critical failure modes identified by the failure mode, effects and criticality analysis (FMECA) of the equipment. Details substantiating the FMECA analysis shall be included in the manual.
- Recommended tests to be carried out throughout the life of the battery, including the pass/fail criteria for each test shall be included in the manual.
- Pamphlets.
- A complete list of parts with serial numbers.
- Applicable certified test certificates for type, routine and special tests including factory and site test reports added to the manual on the completion of each installation.
- Work as executed (**as-built**) drawings.
- Equipment manuals from secondary equipment manufacturer if applicable.

4.7.2 Drawings

As a minimum, electronic copies shall be compatible with AutoCAD, and drawn using the parameters indicated in Substation Design Instruction SDI 515 - Drawings.

4.7.3 Completion

The work shall be completed to the satisfaction of Endeavour Energy, and will not be considered complete until:

- The battery systems and associated equipment are supplied, **tested and delivered to Endeavour Energy**.
- Compliant test reports have been received and approved by Endeavour Energy.
- Drawings, manuals and other relevant information required have been received and approved by Endeavour Energy.
- All associated materials, including spare parts have been received by Endeavour Energy.

4.8 Disposal

As required, the supplier shall dispose of all packaging following delivery to site.

5 Authorities and Responsibilities

Chief Asset & Operating Officer has the final authority and responsibility for approving this specification.

Head of Asset Planning & Performance has the authority and responsibility for reviewing this specification in accordance with company policy and making recommendations to the Chief Asset & Operating Officer in respect to this specification.

Engineering Delivery Manager is responsible for:

- keeping the content of this specification up to date;
- approving the equipment used in substations in accordance with this specification; and
- verifying that the equipment purchased through the tender process complies with the requirements of this specification.

Secondary Systems Manager is responsible for approving the number of battery systems and protection requirements for substations in accordance with this specification.

All **Endeavour Energy employees, manufacturers/suppliers and/or contractors** have the authority and responsibility for:

- meeting the requirements of this specification
- working in accordance with local and statutory requirements;
- maintaining public safety; and,
- working in accordance with Endeavour Energy's Electrical Safety Rules.

All **Project Managers** have the authority and responsibility for:

- verifying that the battery systems procured and installed on the Endeavour Energy network comply with the requirements of this specification; and,
- meeting the requirements of this specification within their area of responsibility;
- verifying that Endeavour Energy employee, suppliers/manufacturers and/or contractors engaged to perform the work have appropriate qualifications; and,
- entering appropriate equipment details into the SAP database as part of the work.

6 Appendix 1 - Substation Batteries & Charger Technical Requirements

6.1 Batteries

Description	Substation Systems (110V)	
Applicable standard	AS 2676.2, AS/NZS 4029.2 and AS 4506	
Battery type	Sealed valve regulated lead acid	
Cell construction:		
<i>Post construction</i>	Bolted post	
<i>Plate type</i>	Tubular or flat plate	
<i>Electrolyte</i>	Gel/absorbent glass mat	
Location	Indoor	
Cell weight (maximum)	25 kg	
Accommodation	Free standing or cabinet	
Voltage:		
<i>Nominal voltage</i>	110V DC	
<i>Float voltage</i>	125V DC	
<i>Boost voltage</i>	135V DC	
Nominal capacity	300 Ah ¹	200 Ah ²

¹ 300 Ah batteries should be used in all transmission substations and 132kV zone substations that exceed a firm rating of 20 MVA

² 200 Ah batteries should be used in zone substations; excluding 132kV zone substations that exceed a firm rating of 20 MVA

6.2 Battery Charger

Description	110V 300Ah Batteries	110V 200Ah Batteries
Applicable standard	AS 4044, AS/NZS 3000 and AS 4506	
Location	Indoor	
Mounting	Free standing or cabinet	
Type	SCR or SM	
Input voltage	Single phase voltage range: 207 – 264 V AC Three phase voltage range: 358 – 457 V AC	
Input frequency	50 Hz	
Output voltage (nominal)	120V DC	
Output current rating	35A DC	25A DC
Output type	Constant voltage	
Output compensation	Temperature compensated	
Output ripple voltage with battery connected	1% maximum	
Test facilities	Self-testing	
	Battery monitoring	
Input protection	Surge protection	
Meters, output	Voltage	
	Current	

6.3 DC-DC Converter

Description	Requirement
Applicable standard	AS/NZS 3000
Location	Indoor
Mounting	Within battery charger cabinet
Input voltage (nominal)	120V DC
Output voltage (nominal)	48V DC
Power rating	500W
Output type	Constant voltage
Output ripple voltage with battery connected	1% maximum

7 Appendix 2 - Testing Requirements

Item	No.	Tests	Test method reference	Acceptable value	Testing		
					Type Test	Factory Acceptance Test	Commissioning Test
Battery	1.	Capacity test	AS/NZS 4029.2 Clause 5.1	$C_{actual} \geq 95\% C_{rated}$ (1 st cycle) $C_{actual} \geq 100\% C_{rated}$ (by 5 th cycle)	✓		
Battery	2.	Test of suitability for floating battery operation (capacity and voltage)	AS/NZS 4029.2 Clause 5.2	Voltage within guaranteed range throughout duration	✓		
Battery	3.	Test for charge retention	AS/NZS 4029.2 Clause 5.4	$C_{retained} \geq 95\%$ at 24 hours $C_{retained} \geq 80\%$ at 90 days	✓		
Battery	4.	Test for short-circuit current and internal resistance	AS/NZS 4029.2 Clause 3.5 and Clause 5.5	Internal resistance and short circuit current determined and suitable for use in protection design calculations	✓		
Battery charger	5.	Power factor measurement (not applicable to DC -DC converter)	AS 4044 Appendix C Appendix L	$\cos \delta > 0.8$	✓		
Battery charger	6.	Voltage adjustment test (not applicable to DC -DC converter)	AS 4044 Appendix D	Output voltage as per cl 6.2 of this specification $\pm 0.2\%$ for input voltage of 207V to 264.V single phase or 358Vac to 457Vac three phase as applicable.	✓		

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Item	No.	Tests	Test method reference	Acceptable value	Testing		
					Type Test	Factory Acceptance Test	Commissioning Test
Battery charger	7.	Voltage regulation test (not applicable to DC -DC converter)	AS 4044 Appendix E	$V_{\max} = \text{cl 6.2 of this specification} \pm 1\%$ (no current 264V input) $V_{\min} = \text{cl 6.2 of this specification} \pm 1\%$ (rated current 207V input)	✓		
Battery charger & DC to DC converter	8.	Short-circuit test	AS 4044 Appendix G	Battery charger internal protection scheme performed correctly i.e. supplied rated current successfully and protection operated successfully on short circuit.	✓		
Battery charger	9.	Alternating current power restoration test (not applicable to DC -DC converter)	AS 4044 Appendix H	Operates in accordance with AS 4044 Annexure H – i.e. protection scheme suitable for supply of discharged battery.	✓		
Battery charger & DC to DC converter	10.	Start-up test	AS 4044 Appendix I	$V_{\text{peak}} < 110\%$ of preset voltage rating $\pm 1\%$ settle time to $\pm 1\% < 2$ sec (as per AS 4044 clause 6.8)	✓		
Battery charger & DC to DC converter	11.	Dynamic response test	AS 4044 Appendix J	20 to 100% response: $V_{\text{peak}} < \pm 10\%$ of voltage levels as specified in clause 5.3.2 of this specification, settle time to $\pm 2\% < 4$ sec (as per AS 4044 clause 6.9)	✓		
Battery charger & DC to DC converter	12.	Ripple voltage test	AS 4044 Appendix K	2% maximum	✓		

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Item	No.	Tests	Test method reference	Acceptable value	Testing		
					Type Test	Factory Acceptance Test	Commissioning Test
Battery	13.	Performance test	AS 2676.2 Clause 7.4 / Appendix H	$C_{actual} \geq 100\% C_{rated}$ Voltage (cells and battery) within guaranteed range throughout duration. Surface temperature and inter-cell connector heating within guaranteed rating for duration		✓	✓
Battery	14.	Individual cell impedance (typically calculated using voltage readings during discharge test)	As specified by manufacturer / supplier	Proven suitable for protection design		✓	✓
Charger	15.	Operational check	As specified by manufacturer / supplier	Meets the requirements of this specification (ETS 0085)		✓	✓
DC to DC converter	16.	Operational check	As specified by manufacturer / supplier	Meets the requirements of this specification (ETS 0085)		✓	✓
Battery System	17.	Operational tests of all alarm and control circuits	As specified by manufacturer / supplier	Meets the requirements of this specification (ETS 0085)		✓	✓
Backup supply	18.	Operational test of parallel connection between charger no. 1 and charger no. 2	As specified by manufacturer / supplier	Meets the requirements of this specification (ETS 0085)			✓

Produced by Asset Planning and Performance Branch

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