Product Specification

Rechargeable Lithium Ion Battery

PN: EC-AU228-NAH3L4

Approved by PM	Approved by RD	Approved by M&S	Approved by PE	Approved by QA

Client Approval	**Signature:**	**Company Stamp:**
	Date:	
	Company Code:	

AMENDMENT RECORDS

Revision	Description	Date	Approval

Client's Requirement

Model: **NAH3L4**
Version: A

The Client is requested to write down your information and contact with ECO POWER GROUP in advance, if and when the Client needs applications or operating conditions other than those described in this document. ECO POWER GROUP could design and build such products according to client's special request.

	Special Request	**Criteria**
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Company code : _____ **Signature :** _____ **Date :** _____

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Definitions

Terms	Definition
Product	means the same as set out on the Scope;
Client	means purchaser of ECO POWER GROUP sales agreement;;
ECO POWER	means the same as set out in the Contract;
ECO POWER Part Number	means the unique part number provided by ECO POWER GROUP to identify the Product to be supplied to Client;
Ambient Temperature	means the ambient air temperature of the environment to which the Products are exposed and the temperature tolerance is no more than or no less than 2℃;
Battery Management System or BMS	means an active tracking and control system to be developed and implemented by client to monitor and record the operating parameters, including but not limited to voltage, current and temperature, of each product in its entire service life, and to control the operation of each product to ensure a safe operation of Product including but not limited to in accordance to Application Conditions and Safety Precautions set out on paragraph 6 and 7;
Cell Temperature	means the temperature of Product as measured by a thermal sensors to be selected and installed by Client in close proximity of Product in use
Charge C-Rate	means the ratio of charging current to the latest cell capacity as frequently measured by the Battery Management System, where such cell capacity measurement shall be carried out at least once every six (6) months, with a unit of measure denoted by “C”. For example, the initial cell capacity is 228Ah and a Charge C-Rate of 1/3C equals to a charge current of 76.0A; when the capacity dropped to 182.4Ah, a Charge C-Rate of 1/3C equals to a charge current of 60.8A.
Cycle	means a state reached when a total of 228Ah charge is discharged from a cell as recorded by BMS and it may consist of a summation of a few segments of partial discharges;
Production Date	Means the date when the Product is produced and printed on the top of the Product
Open circuit voltage(OCV)	means the cell voltage when no load or circuit is connected;
Recoverable Capacity	means capacity of a cell measured in accordance with paragraphs 2.2.3, 2.3.1 and 2.3.5 after storage, the measurement of which can be taken after repeating the Standard Charge and the Standard Discharge as set out in paragraphs 2.2.3, 2.3.1 and 2.3.5, respectively, for a maximum of three times;
Contract	means the Supply Contract in which this specification is attached as Exhibit B

Standard Charge	means the default charging method set out in paragraph 2.2.3 titled “Standard Charging Method”;
Standard Discharge	means a discharge current of 68.67A as set out in paragraph 2.3.1 with a discharge cut-off voltage of 2.0V as set out in paragraph 2.3.5;
State of Charge or SOC (SOC)	means the linear scale of charge held by a cell as measured by capacity either in Ah or Wh. 100% SOC means a cell is fully charged at 3.65V, while 0% SOC means a cell is fully discharged down to 2.0V. The SOC should indicate a no load situation
Temperature Rise	means the increase of cell temperature from one state to another in certain event such as charging or discharging;
Units of Measure	“V” (Volt) means unit of measure for electrical voltage; “A” (Ampere) means unit of measure for electrical current; “Ah” (Ampere-Hour) means unit of measure for electrical charge; “Wh” (Watt-Hour) means unit of measure for electrical energy; “Ω” (Ohm) means unit of measure for electrical resistance; “mΩ” (MilliOhm) means unit of measure for electrical resistance; “°C” (degree Celsius) means unit of measure for temperature; “mm” (millimetre) means unit of measure for length; “s” (second) means unit of measure for time; “Hz” (Hertz) means unit of measure for frequency.

1. Scope

The purpose of this document is to specify the specifications of 228Ah 3.22V rechargeable lithium ion iron phosphate cells with ECO POWER GROUP Part Number EC-AU228-NAH3L4 (“Product”) to be supplied by ECO POWER GROUP to Client. This Product is designed and intended to be exclusively used by Client and/or its customers within Target Application Zone. Any intended or unintended usage of the Product by Client and/or its customers outside the Target Application Zone constitutes a material breach of the Contract by Client and hereby releases ECO POWER GROUP from any and all obligations and/or liabilities.

This document can only be used for the cell with ECO POWER GROUP Part Number EC-AU228-NAH3L4 (“Product”)

2. Electrical specification

2.1 General

No.	Parameter	Specification	Condition
2.1.1	Typical capacity	228Ah	At 228A discharge current (25±2℃)

2.1.2	Minimum capacity	228Ah	At a 76.0A discharge current (25±2℃)
2.1.3	Operating voltage	2.0V-3.65V	N.A.
2.1.4	Impedance (1KHz)	≤0.40 mΩ	At a fresh state
2.1.5	Shipping capacity	20~50% SOC	N.A.
2.1.6	Operating temperature (charging)	0–55℃	See paragraph 2.2
2.1.7	Operating temperature (discharge)	-20–55℃	See paragraph 2.3
2.1.8	Weight	4.2±0.21 kg	N.A.
2.1.9	Size	See paragraph 9	N.A.

2.2 Charging

No.	Parameter	Specification	Condition
2.2.1	Standard charge current	76.0A	25±2℃
2.2.2	Standard charge voltage	3.65V	N.A.
2.2.3	Standard charge method	76.0A constant current charge to 3.65V for cell, then switch to constant voltage charge until charge current declines to ≤11.4±0.50A	
2.2.4	Standard charge temperature	25±2℃	Cell temperature
2.2.5	Absolute charge temperature	0 – 55°C	Stop charging once cell temperature is outside this range regardless of the charging mode adopted
2.2.6	Absolute charge voltage	3.65V max.	Stop charging once voltage exceeds this voltage regardless of the charging mode (including regeneration) adopted

2.2.1 Maximum continuous charge current (C)

T℃/SOC	0%	(0~10%]	(10~20%]	(20~30%]	(30~40%]	(40~50%]	(50~60%]	(60~70%]	(70~80%]	(80~95%]	(95~100%]
≤0	0	0	0	0	0	0	0	0	0	0	0
[0~2)	5A	5A	5A	5A	5A	5A	5A	5A	5A	5A	5A
[2~7)	0.12C	0.12C	0.12C	0.12C	0.12C	0.12C	0.12C	0.12C	0.12C	0.12C	0.12C
[7~15)	0.30C	0.30C	0.30C	0.30C	0.30C	0.30C	0.30C	0.30C	0.30C	0.20C	0.20C
[15~20)	0.50C	0.50C	0.50C	0.50C	0.50C	0.50C	0.50C	0.50C	0.50C	0.40C	0.40C
[20~45)	1.0C	1.0C	1.0C	1.0C	1.0C	1.0C	1.0C	1.0C	1.0C	0.80C	0.80C
[45~50)	0.50C	0.50C	0.50C	0.50C	0.50C	0.50C	0.50C	0.50C	0.50C	0.40C	0.40C
[50~55)	0.30C	0.30C	0.30C	0.30C	0.30C	0.30C	0.30C	0.30C	0.30C	0.20C	0.20C
≥55	0	0	0	0	0	0	0	0	0	0	0

2.3 Discharging

No.	Parameter	Specification	Condition
2.3.1	Standard discharge current	76.0C	25±2℃
2.3.2	Maximum discharge current (continuous)	228A	N.A.
2.3.3	Maximum discharge current (long pulse)	456A	2 minute duration maximum followed by a “zero current rest period” of same duration
2.3.4	Discharge cut-off voltage	2.0V minimum	-20–55°C
2.3.5	Standard discharge temperature	25±2℃	Cell temperature
2.3.6	Absolute temperature discharge	-20– 55°C	Stop discharging once cell Temperature is outside this range regardless of whether continuous or pulse current is adopted

2.3.1 Maximum continuous Discharge current (C)

T℃/SOC	0%	(0~10%]	(10~20%]	(20~30%]	(30~40%]	(40~50%]	(50~60%]	(60~70%]	(70~80%]	(80~95%]	(95~100%]
＜-20	0	0	0	0	0	0	0	0	0	0	0
[-20~0)	0	0.03C	0.05C	0.10C	0.20C	0.30C	0.30C	0.30C	0.30C	0.30C	0.30C
[0~10)	0	0.15C	0.30C	0.50C	0.60C	0.80C	0.80C	0.80C	0.80C	0.80C	0.80C
[10~15)	0	0.20C	0.40C	0.60C	0.70C	0.90C	0.90C	0.90C	0.90C	0.90C	0.90C
[15~20)	0	0.30C	0.50C	0.70C	0.80C	1.00C	1.00C	1.00C	1.00C	1.00C	1.00C
[20~45)	0	0.30C	0.50C	0.70C	0.80C	1.00C	1.00C	1.00C	1.00C	1.00C	1.00C
[45~50)	0	0.15C	0.30C	0.50C	0.60C	0.80C	0.80C	0.80C	0.80C	0.80C	0.80C
[50~55)	0	0.03C	0.05C	0.10C	0.20C	0.30C	0.30C	0.30C	0.30C	0.30C	0.30C
≥55	0	0	0	0	0	0	0	0	0	0	0

2.3.2 Maximum pulse discharge current in 30s

Temp. (℃)	0%	(0~10%]	(10~20%]	(20~30%]	(30~40%]	(40~50%]	(50~60%]	(60~70%]	(70~80%]	(80~95%]	(95~100%]
＜-20	0	0	0	0	0	0	0	0	0	0	0
[-20~-10)	0	0.13C	0.25C	0.50C	0.50C	0.50C	0.50C	0.50C	0.50C	0.50C	0.50C
[-10~-5)	0	0.30C	0.60C	1.0C	1.0C	1.20C	1.20C	1.20C	1.20C	1.20C	1.20C
[-5~0)	0	0.50C	1.0C	1.4C	1.4C	2.13C	2.13C	2.13C	2.13C	2.13C	2.13C

[0~5)	0	0.56C	1.0C	1.5C	1.5C	2.18C	2.18C	2.18C	2.18C	2.18C	2.18C
[5~10)	0	0.63C	1.13C	1.70C	1.70C	2.25C	2.25C	2.25C	2.25C	2.25C	2.25C
[10~20)	0	0.66C	1.22C	2.0C	2.0C	2.43C	2.43C	2.43C	2.43C	2.43C	2.43C
[20~45)	0	0.75C	1.5C	2.1C	2.1C	3C	3C	3C	3C	3C	3C
[45~50)	0	0.75C	1.5C	2.1C	2.1C	3C	3C	3C	3C	3C	3C
[50~55)	0	0.63C	1.13C	1.70C	1.70C	2.25C	2.25C	2.25C	2.25C	2.25C	2.25C
⩾55	0	0	0	0	0	0	0	0	0	0	0

Note: After each regeneration pulse, there should be a “rest period” with duration equal to or long than the relevant regeneration pulse. A “rest period” can either be discharging or zero current state. No regeneration is allowed within a “rest period”.

2.4 Regeneration

Regeneration means a cell is charged by pulse current regenerated during application. The regenerated voltage should be strictly regulated at all SOC and Cell Temperature. The magnitude and duration of pulse charging current should be strictly regulated according to the SOC and Cell Temperature listed on the table below. Regeneration charging of the cell outside this allowable condition may cause permanent internal damage to the Product and shall render ECO POWER GROUP’s warranties under the Contract inapplicable, thereby releasing ECO POWER GROUP from any liability in connection therewith.

2.4.1 Maximum regenerative pulse charging voltage 3.65V

2.4.2 Allowable regeneration current in 30s

Temp. (℃)	0%	(0~10%]	(10~20%]	(20~30%]	(30~40%]	(40~50%]	(50~60%]	(60~70%]	(70~80%]	(80~95%]	(95~100%]
≤0	0	0	0	0	0	0	0	0	0	0	0
(0~5]	0.12C	0.12C	0.12C	0.12C	0.12C	0.12C	0.12C	0.12C	0.12C	0.10C	0
(5~10]	0.42C	0.42C	0.42C	0.42C	0.42C	0.42C	0.30C	0.30C	0.30C	0.20C	0
(10~15]	0.50C	0.50C	0.50C	0.50C	0.50C	0.50C	0.40C	0.40C	0.40C	0.30C	0
(15~20]	0.80C	0.80C	0.80C	0.80C	0.80C	0.80C	0.50C	0.50C	0.50C	0.40C	0
(20~25]	1.20C	1.20C	1.20C	1.20C	1.20C	1.20C	1.20C	1.20C	1.20C	1.00C	0
(25~45]	1.50C	1.50C	1.50C	1.50C	1.50C	1.50C	1.50C	1.50C	1.50C	1.00C	0
(45~50]	0.80C	0.80C	0.80C	0.80C	0.80C	0.80C	0.80C	0.80C	0.80C	0.40C	0
(50~55)	0.42C	0.42C	0.42C	0.42C	0.42C	0.42C	0.42C	0.42C	0.42C	0.30C	0
⩾55	0	0	0	0	0	0	0	0	0	0	0

Note: After each regeneration pulse, there should be a “rest period” with duration equal to or long than the relevant regeneration pulse. A “rest period” can either be discharging or zero current state. No regeneration is allowed within a “rest period”.

2.5 High and Low Temperature Discharge Capacity

No.	Parameter	Specification	Condition
2.5.1	Capacity at 25℃	≥228.0Ah	Standard Charge at 25±2°C, Standard Discharge at 25°±2C (Cell Temperature in both cases)
2.5.2	Capacity at 55℃	≥205.2Ah	Standard Charge at 25±2°C, Standard Discharge at 55°±2C (Cell Temperature in both cases)
2.5.3	Capacity at -20℃	≥159.6Ah	Standard Charge at 25±2°C, Standard Discharge at -20°±2C (Cell Temperature in both cases)

2.6 Safety and Reliability

This Product is in full compliance with requirement under the Chinese Coercive Certification (GBT 31485-2015) and the transport certification (UN38.3).

2.7 Self-discharge

No.	Parameter	Specification	Condition
2.7.1	Unrecoverable self-discharge rate	≤3%/month	At a fresh state, 25±2℃, storage at 50% SOC (After 180 days)

3. Temperature Rise

The cells shall be allowed to cool down by unrestricted natural convection in a reasonably large room with stable Ambient Temperature. The temperature of each shall be measured with calibrated thermal couple sensor(s) capable of capturing data logging with respect to time. The temperature should be measured at the center of cell surface. Temperature rise is defined as temperature after discharge minus temperature just before discharge.

No.	Parameter	Specification	Condition
3.1	Temperature Rise (continuous)	≤10℃	When a cell is discharged at a 0.5C current for a period of 2 hour
3.2	Temperature Rise (pulse)	≤5℃	When a cell is discharged at a 2C current for a period of 10s at any SOC

4. Cell Life

No.	Parameter	Specification	Condition
4.1	Capacity loss	≥97%	Standard Charge to 50% SOC, storage at 25±2°C for 30 days
4.2	Cycled Capacity	≥80%	25±5℃，1C/1C，2000cycles

5. Product End of Life Management

This cell is designed to service with a finite life time. Client shall develop and implement an active tracking system to monitor and record impedance of each Product in its entire service life. Client and/or its customer shall stop using any of the Products when its impendence exceeds 250% of the value when it was fresh. Failure to comply with this requirement shall render ECO POWER GROUP's warranties under the Contract inapplicable, thereby releasing ECO POWER GROUP from any liability in connection therewith

6. Application Condition

Client shall ensure that the following application conditions in connection with the Products are strictly observed:

6.1 Client shall procure that each Product shall be used under the strict monitor, control and protection by the Battery Management System to be incorporated by Client.

6.2 Client shall provide detailed information of the BMS, including but not limited to its design, features, setting, and data file format to ECO POWER GROUP for design review and record keeping.

6.3 Once the detailed information of the BMS has been reviewed and agreed by ECO POWER GROUP, Client shall not modify or change the design, features, setting or data file format of the BMS without the prior written agreement by Client.

6.4 Client shall keep complete records of the BMS monitoring data throughout the entire service life of each Product, including keeping record of number of occurrence of Rush Charge, which will be used in the determination and judgment of any product warranty and liability claim entitlement. No warranty or liability claim will be considered without a complete set of BMS monitoring records capturing the entire service life of the relevant Product.

6.5 The BMS shall include the following monitoring and control features as a minimum requirement:

No.	Parameter	Specification	Action
6.5.1	Stop charging	3.65V maximum	Stop charging when cell voltage reaches 3.65V
6.5.2	First overcharge protection	⩾3.80V	Stop charging when cell voltage reaches 3.80V
6.5.3	Second overcharge protection	⩾4.0V	Stop charging when cell voltage reaches higher than 4.0V and lock up BMS until technical trouble shooting.
6.5.4	Stop discharge	⩽2.50V	Stop discharging when cell voltage reaches 2.50V.
6.5.5	First over discharge protection	⩽2.00V	Stop discharging when cell voltage reaches 2.00V
6.5.6	Second over discharge	⩽1.8V	Stop discharging when cell voltage falls lower

	protection		than 1.8V and lock up BMS until technical trouble shooting.
6.5.7	Short circuit protection	No short circuit allowed	Disconnect cell terminals by contactor when short circuit occurs
6.5.8	Over current protection	See paragraph 2.3	Control discharge current by BMS to values within specification
6.5.9	Over temperature protection	See paragraphs 2.2 and 2.3	Stop charging and discharging when temperature exceeds specification
6.5.10	Charging time out limit	Set up charging time limits to 8h	Stop charging if changing time exceeds 8h

6.6 Prevent draining any Product down to over discharge state. A Product may be permanently damaged internally when the cell voltage is lower than 2.0V and therefore should be strictly prohibited, failing which ECO POWER GROUP's warranties under the Contract shall cease to apply, thereby releasing the ECO POWER GROUP from any liability in connection therewith. After discharge cut-off in accordance with paragraph 2.3.5, internal power consumption of the system should be reduced to a minimum to prolong the idle time before recharge. Client undertakes to educate the users of the Products or other parties who may come to handle the Products to recharge the cells at minimum time intervals to prevent reaching the over discharge state.

6.7 Adjust SOC between 20% and 50%, when storage cell for more than 30 days.

6.8 Avoid charge (including standard charge, fast charge and regeneration) in low temperature, otherwise capacity loss may present. BMS should control cell in accordance with minimum charge temperature and regeneration temperature. Forbid to charge cell in a temperature lower than specification, or ECO POWER GROUP will not warranty any elements damaged in this manner.

6.9 Heat dissipation should be fully considered in the design of electric box. No warranty or liability claim will be considered if overheating occurred by heat dissipation design problem of electric box.

6.10 Waterproof and dustproof should be fully considered in the design of electric box. The electric box must meet the Waterproof and dustproof requirements if relevant national standards and provision. No warranty or liability claim will be considered if cell damage (corrosion and rusting) occurred by waterproof or dustproof problem.

7. Safety Precautions

Client shall ensure that the following safety precautions in connection with the Products are strictly observed:

7.1 Do not immerse cells into water.

7.2 Do not drop cells into fire or expose them to any high temperature environment exceeding

operation temperature as set out in paragraphs 2.1.7 and 2.1.8, otherwise fire hazards may present. At all time, Cell Temperature should not exceed 55°C, shut down system by BMS when it occurs.

7.3 Do not short circuit cell terminals, otherwise high current and temperature may cause body injury or fire hazards. Metallic cell terminals are exposed from plastic packaging and ample safety precautions should be implemented to avoid short circuiting them during system integration or connections.

7.4 Always connect cell terminals according to its label(s) in right polarity. Reverse charging is strictly prohibited.

7.5 It is extremely dangerous to overcharge a cell which may cause overheating and fire hazards. Multiple level of fail-safe overcharge protection should be implemented by hardware and software. See paragraph 6.6.3 for minimum requirement to be adopted by the BMS for protection. See also paragraph 7.11.

7.6 Normal charging should finish within a charging time out limit as set out in paragraph 6.6.10 when charging continues longer than charging time out limit, it tends to overheat the cells which may cause overheating and fire hazards. A timer should be implemented in the charger circuit and set up properly. In case charging does not terminate normally within charging time out limit, ensure that the timer will intervene and stop the charging. See also paragraph 7.11.

7.7 Products should be securely fixed to solid platform, and power cables should be securely attached by fastener to avoid intermittent contact which may cause arcing and sparks.

7.8 Do not service cells and electrical connections within plastic package of cell. Improper electrical connection within a cell may cause overheating in service.

7.9 In the event of electrolyte leakage, avoid contacting electrolyte with skin or eyes. In case come into contact, wash affected area with large amount of water and seek medical help. Do not swallow any parts or substances within a cell.

7.10 Protect cells from mechanical shock, impact and pressure. Internal electrical circuit may short circuit to generate high temperature and fire hazards.

7.11 When cells charging is terminated improperly for reasons such as exceeding allowable charging time, cut-off due to exceeding charging voltage or cut-off due to exceeding charging current, all these events are defined as “improper charge termination”. Such event may indicate that there is current leaking within a cell system or some components have started to malfunction and subsequent charging of such cell system without finding and fixing root cause of problem may cause potential overheat or fire hazards. When such event occurs, the BMS should lock itself up to prevent subsequent charging and notice should be given to the user to return the vehicle to dealer for servicing. Subsequent charging should only be resumed after the system has been thoroughly checked by

qualified technician who can identify and fix root cause attributed to the “improper charge termination”.

7.12 Performing tests may result in fire or explosion of the Products. Such tests shall only be performed in qualified laboratories by qualified personnel with proper safety precautions taken. Running these tests in an improper way may result in severe personal body injury or property damages.

8. Hazard Warning

8.1 Warning statement

WARNING

CELLS ARE POTENTIALLY DANGEROUS AND PROPER PRECAUTIONS MUST BE OBSERVED IN HANDLING AND MAINTENANCE.

RUNNING TESTS ON THE CELLS IMPROPERLY MAY RESULT IN SEVERE PERSONAL BODY INJURY OR PROPERTY DAMAGES.

WORK ON CELLS MUST BE PERFORMED ONLY WITH PROPER TOOLS AND PROTECTIVE EQUIPMENT MUST BE USED.

CELL MAINTENANCE MUST BE CARRIED OUT BY PERSONNEL KNOWLEDGEABLE OF CELLS AND TRAINED IN THE SAFETY PRECAUTIONS INVOLVED.

FAILURE TO OBSERVE THE ABOVE MAY CAUSE VARIOUS HAZARDS.

8.2 Client acknowledges the following potential hazards in connection with the usage and handling of the Products:

8.2.1 Working with battery can expose the handler to chemical, shock and/or arcing hazards. Although a person’s body might react to contact with direct current voltage differently than from contact with alternate current voltage, Client shall take a conservative position and consider the risk of shock or electrocution to be the same for both alternate current and direct current exposures greater than 50 volts.

8.2.2 Cells expose its handler to chemical hazards associated with the electrolyte used in the cell.

8.2.3 When selecting work practices and personal protective equipment, Client and its employees shall consider potential exposure to these hazards and therefore prevent accidental short-circuit that can result in electrical arcing, explosion, and/or “thermal runaway” of the cells.

9. Mechanical Drawing