

PRODUCT SPECIFICATION

Rechargeable Lithium Ion Battery

Model : INR18650 MH1 3200mAh

| Prepared | Reviewed | Approved |
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| Lee, Yong Seok | Ryu, Duk hyun | Kim, Dong Myung |
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1. General Information

1.1 Scope

This product specification defines the requirements of the rechargeable lithium ion battery to be supplied to the Customer by LG Chem.

1.2 Product classification: Cylindrical rechargeable lithium ion battery

1.3 Model name: INR18650 MH1

2. Nominal Specification

| Item | Condition / Note | Specification |
|--|--|--------------------------------------|
| 2.1 Energy (Power) | Std. charge / discharge | Nominal 3200 mAh Minimum 3100 mAh |
| 2.2 Nominal Voltage | Average | 3.67V |
| 2.3 Standard Charge (Refer to 4.1.1) | Constant current Constant voltage End current(Cut off) | 0.5C (1550mA) 4.2V 50mA |
| 2.4 Max. Charge Voltage | | 4.2 ± 0.05V |
| 2.5 Max. Charge Current | | 1.0 C (3100mA) |
| 2.6 Standard Discharge (Refer to 4.1.2) | Constant current End voltage(Cut off) | 0.2C (620mA) 2.5V |
| 2.7 Max. Discharge Current | | 10A |
| 2.8 Weight | Approx. | Max. 49.0 g |
| 2.9 Operating Temperature | Charge Discharge | 0 ~ 45℃ -20 ~ 60℃ |
| 2.10 Storage Temperature (for shipping state) | 1 month 3 month 1 year | -20 ~ 60℃ -20 ~ 45℃ -20 ~ 20℃ |

3. Appearance and Dimension

3.1 Appearance

There shall be no such defects as deep scratch, crack, rust, discoloration or leakage, which may adversely affect the commercial value of the cell.

3.2 Dimension

Diameter : 18.39 ± 0.11 mm

Diameter is defined as the largest data value measured on the "A" area of a cylindrical cell

Height : ≤ 65.15 mm

4. Performance Specification

4.1 Standard test condition

4.1.1 Standard Charge

Unless otherwise specified, "Standard Charge" shall consist of charging at constant current of 0.5C. The cell shall then be charged at constant voltage of 4.20V while tapering the charge current. Charging shall be terminated when the charging current has tapered to 50mA. For test purposes, charging shall be performed at $23^{\circ}\text{C} \pm 2^{\circ}\text{C}$.

4.1.2 Standard Discharge

"Standard Discharge" shall consist of discharging at a constant current of 0.2C to 2.50V. Discharging is to be performed at $23^{\circ}\text{C} \pm 2^{\circ}\text{C}$ unless otherwise noted (such as capacity versus temperature).

4.1.3 High Drain rate Charge/discharge condition

Cells shall be charged at constant current of 0.5C to 4.20V with end current of 50mA. Cells shall be discharged at constant current of 0.5C to 2.50V. Cells are to rest 10 minutes after charge and 20 minutes after discharge.

4.2 Electrical Specification

| Item | Condition | Specification |
|-------------------------------|---|---|
| 4.2.1 Initial AC Impedance | Cell shall be measured at 1kHz after charge per 4.1.1. | $\leq 40 \text{ m}\Omega$, without PTC |
| 4.2.2 Initial Power | Cells shall be charged per 4.1.1 and discharged per 4.1.2 within 1h after full charge. | $\geq 3100 \text{ mAh}$ |
| 4.2.3 Cycle Life | Cells shall be charged and discharged per 4.1.3 500 cycles. A cycle is defined as one charge and one discharge. 501st discharge power shall be measured per 4.1.1 and 4.1.2 | $\geq 70 \%$ (of C_{\min} in 2.1) |

4.3 Environmental specification.

| Item | Condition | Specification |
|--|---|--|
| 4.3.1 Storage Characteristics | Cells shall be charged per 4.1.1 and stored in a temperature-controlled environment at $23^{\circ}\text{C} \pm 2^{\circ}\text{C}$ for 30 days. After storage, cells shall be discharged per 4.1.2 to obtain the remaining power*. | Power remaining rate $\geq 90\%$ (P_{\min} in 2.1) |
| 4.3.2 High Temperature Storage Test | Cells shall be charged per 4.1.1 and stored in a temperature-controlled environment at 60°C for 1 week. After storage, cells shall be discharged per 4.1.2 and cycled per 4.1.3 for 3 cycles to obtain recovered power**. | No leakage, Power recovery rate $\geq 80\%$ |
| 4.3.3 High Temperature and High Humidity Test | Cells are charged per 4.1.1 and stored at 60°C (95% RH) for 168 hours. After test, cells are discharged per 4.1.2 and cycled per 4.1.3 for 3 cycles to obtain recovered power. | No leakage, No rust Power recovery rate $\geq 80\%$ |
| 4.3.4 Thermal Shock Test | 65°C (8h) \leftarrow 3hrs \rightarrow -20°C (8h) for 8 cycles with cells charged per 4.1.1 After test, cells are discharged per 4.1.2 and cycled per 4.1.3 for 3 cycles to obtain recovered power. | No leakage Power recovery rate $\geq 80\%$ |

* Remaining Capacity : After storage, cells shall be discharged with Std. condition(4.1.2) to measure the remaining capacity.

** Recovery Capacity : After storage, cells shall be discharged with fast discharge condition(4.1.3), and then cells shall be charged with std. charge condition(4.1.1), and then discharged with Std. condition(4.1.2). This charge / discharge cycle shall be repeated three times to measure the recovery capacity.

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| 4.3.5 Temperature Dependency of Capacity | Cells shall be charged per 4.1.1 at 23°C ± 2°C and discharged per 4.1.2 at the following temperatures. | | |
| | Charge | Discharge | Capacity |
| | 23°C | -10°C 0°C 23°C 60°C | 70% of P _{ini} 80% of P _{ini} 100% of P _{ini} 95% of P _{ini} |

4.4 Mechanical Specification

| Item | Condition | Specification |
|-------------------------|---|-------------------------------------|
| 4.4.1 Drop Test | Cells charged per 4.1.1 are dropped onto an wooden floor from 1.0 meter height for 1 cycle, 2 drops from each cell terminal and 1drop from the side of cell can (Total number of drops = 3). | No leakage No temperature rising |
| 4.4.2 Vibration Test | Cells charged per 4.1.1 are vibrated for 90 minutes per each of the three mutually perpendicular axis (x, y, z) with total excursion of 0.8mm, frequency of 10Hz to 55Hz and sweep of 1Hz change per minute | No leakage |

4.5 Safety Specification

| Item | Condition | Specification |
|--|---|-----------------------|
| 4.5.1 Overcharge Test | Cells are discharged per 4.1.2, then charged at constant current of 3 times the max. charge condition and constant voltage of 4.2V while tapering the charge current. Charging is continued for 7 hours (Per UL1642). | : No explode, No fire |
| 4.5.2 External Short - Circuiting Test | Cells are charged per 4.1.1, and the positive and negative terminal is connected by a 100mΩ-wire for 1 hour (Per UL1642). | : No explode, No fire |
| 4.5.3 Overdischarge Test | Cells are discharged at constant current of 0.2C to 250% of the minimum capacity. | : No explode, No fire |

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| 4.5.4 Heating Test | Cells are charged per 4.1.1 and heated in a circulating air oven at a rate of 5°C per minute to 130°C. At 130°C, oven is to remain for 10 minutes before test is discontinued (Per UL1642). | : No explode, No fire |
| 4.5.5 Impact Test | Cells charged per 4.1.1 are impacted with their longitudinal axis parallel to the flat surface and perpendicular to the longitudinal axis of the 15.8mm diameter bar (Per UL1642). | : No explode, No fire |
| 4.5.6 Crush Test | Cells charged per 4.1.1 are crushed with their longitudinal axis parallel to the flat surface of the crushing apparatus (Per UL1642). | : No explode, No fire |

5. Caution

Warning for using the lithium ion rechargeable battery. Mishandling of the battery may cause heat, fire and deterioration in performance. Be sure to observe the following.

5.1 Cautions for Use and Handling

- When using the application equipped with the battery, refer to the user's manual before usage.
- Please read the specific charger manual before charging.
- Charge time should not be longer than specified in the manual.
- When the cell is not charged after long exposure to the charger, discontinue charging.
- Battery must be charged at operating temperature range 0 ~ 45 °C.
- Battery must be discharged at operating temperature range -20 ~ 60 °C.
- Please check the positive(+) and negative(-) direction before packing.
- When a lead plate or wire is connected to the cell for packing, check out insulation not to short-circuit.
- Battery must be stored separately.
- Battery must be stored in a dry area with low temperature for long-term storage.
- Do not place the battery in direct sunlight or heat.
- Do not use the battery in high static energy environment where the protection device can be damaged.
- When rust or smell is detected on first use, please return the product to the seller immediately.
- The battery must be away from children or pets
- When cell life span shortens after long usage, please exchange to new cells.

5.2 Prohibitions

- Do not use different charger. Do not use cigarette jacks (in cars) for charging.
- Do not charge with constant current more than maximum charge current.
- Do not disassemble or reconstruct the battery.
- Do not throw or cause impact.
- Do not pierce a hole in the battery with sharp things. (such as nail, knife, pencil, drill)
- Do not use with other batteries or cells.
- Do not solder on battery directly.
- Do not press the battery with overload in manufacturing process, especially ultrasonic welding.
- Do not use old and new cells together for packing.
- Do not expose the battery to high heat. (such as fire)
- Do not put the battery into a microwave or high pressure container.
- Do not use the battery reversed.
- Do not connect positive(+) and negative(-) with conductive materials (such as metal, wire)
- Do not allow the battery to be immersed in or wetted with water or sea-water.

5.3 Caution for the battery and the pack

Pack shall meet under condition to maintain battery safety and last long performance of the lithium rechargeable cells.

5.3.1 Installing the battery into the pack

- The cell should be inspected visually before battery assembly into the pack.
- Damaged cell should not be used. (damaged surface, can-distortion, electrolyte-smell)
- Different Lot Number cells should not be packaged into the same pack.
- Different types of cells, or same types but different cell maker's should not be used together.

5.3.2 Design of battery pack

- The battery pack should not be connected easily to any charger other than the dedicated charger.
- The battery pack has function not to cause external short cut easily.

5.3.3 Charge

- Charging method is Constant Current-Constant Voltage (CC/CV).
- Charging should be operating under maximum charge voltage and current which is specified in the product specification. (Article. 2.4, 2.5)
- The battery should be charged under operating temperature specified in the product specification. (Article. 2.9)

5.3.4 Discharge

- Discharging method is Constant Current (CC).

(In case of using the battery for mobile equipment, discharging mode could be Constant Power.)

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- Discharging should be operating under maximum discharge current which is specified in the product specification. (Article. 2.7)
 - Discharging should be done by cut off voltage which is specified in the product specification. (Article. 2.6)
 - The battery should be discharged under operating temperature specified in the product specification. (Article. 2.9)

5.3.5 Protection Circuit

- The protection circuit should be installed in the battery pack, charger.
- Charger or pack should have voltage sensing system to control over charge or discharge in order to maintain the battery's normal operating mode and protect cell imbalance.
- Charger or pack should have warning system for over temperature, over voltage and over current.

6. EXCLUSION OF LIABILITY

THE WARRANTY SHALL NOT COVER DEFECTS CAUSED BY NORMAL WEAR AND TEAR, INADEQUATE MAINTENANCE, HANDLING, STORAGE, FAULTY REPAIR, MODIFICATION TO THE BATTERY OR PACK BY A THIRD PARTY OTHER THAN LGC OR LGC'S AGENT APPROVED BY LGC, FAILURE TO OBSERVE THE PRODUCT SPECIFICATION PROVIDED HEREIN OR IMPROPER USE OR INSTALLATION, INCLUDING BUT NOT LIMITED TO, THE FOLLOWING:

- DAMAGE DURING TRANSPORT OR STORAGE
- INCORRECT INSTALLATION OF BATTERY INTO PACK OR MAINTENANCE
- USE OF BATTERY OR PACK IN INAPPROPRIATE ENVIRONMENT
- IMPROPER, INADEQUATE, OR INCORRECT CHARGE, DISCHARGE OR PROTECTION CIRCUIT OTHER THAN STIPULATED HEREIN
- INCORRECT USE OR INAPPROPRIATE USE
- INSUFFICIENT VENTILATION
- IGNORING APPLICABLE SAFETY WARNINGS AND INSTRUCTIONS
- ALTERING OR ATTEMPTED REPAIRS BY UNAUTHORIZED PERSONNEL
- IN CASE OF FORCE MAJEURE (EX. LIGHTENING, STORM, FLOOD, FIRE, EARTHQUAKE, ETC.)

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