

## PRODUCT SPECIFICATION

### Rechargeable Lithium Ion Battery Model : INR18650MH1

#### [Approval table]

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|  |  |  |  |  |

#### [Notice]

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4. LGC strongly prohibits this product to be applied to any application other than as specified in this product specification section 1.2, and shall not be liable for any loss, damage, or liability resulting from any misapplication.



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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 Highpower by LG Chem. All conditions and criteria written in this document are defined and resulted from fresh cell (ex-factory) state.

1.2 Product classification: Cylindrical rechargeable lithium ion battery

1.3 Model name: INR18650MH1

## 2. Nominal Specification

| Item                                                            | Condition / Note                                                                                                                  | Specification                         |
|-----------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------|---------------------------------------|
| 2.1 Capacity                                                    | By Std. charge/discharge                                                                                                          | Nom. 3200mAh<br>Min. 3100 mAh         |
| 2.2 Nominal Voltage                                             | Average by Std. charge/discharge                                                                                                  | 3.70V                                 |
| 2.3 Shipping Cell Voltage*                                      | At ex-factory state.                                                                                                              | Approx. SOC30%                        |
| 2.4 Standard charge<br>(Refer to 4.1.1)                         | Constant current (1C=3100mA)<br>Constant voltage<br>End condition(Cut off)<br>Charging time <sup>1)</sup>                         | 0.5C (1,550mA)<br>4.20V<br>50mA<br>3h |
| 2.5 Max. Charge Voltage                                         | In all measurements and operations of the cell, the minimum allowable closed circuit voltage shall not exceed the following value | 4.20V                                 |
| 2.6 Max. Charge Current<br>(complete full charge) <sup>2)</sup> | 0 ~ 50°C (Atmosphere)                                                                                                             | 1.0C (3,100mA)                        |
| 2.7 Standard Discharge<br>(Refer to 4.1.2)                      | Constant current<br>End voltage(Cut off)                                                                                          | 0.2C (620mA)<br>2.50V                 |
| 2.8 Min. Discharge Voltage                                      | In all measurements and operations of the cell, the minimum allowable closed                                                      | 2.50V                                 |

|                                                                                 |                                                                                                                                                                  |                                              |
|---------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------|
|                                                                                 | circuit voltage shall not be below the following value                                                                                                           |                                              |
| 2.9 Max. Discharge Current <sup>2)</sup>                                        | -20 ~ 10°C                                                                                                                                                       | 0.5C (1,550mA)                               |
|                                                                                 | 10 ~ 25°C                                                                                                                                                        | 6.0A(6,000mA)                                |
|                                                                                 | 25 ~ 60°C                                                                                                                                                        | 1.5C(4,650mA)                                |
|                                                                                 | 0 ~ 60°C                                                                                                                                                         | 10A(10,000mA)<br>(Peak current under 10 sec) |
| 2.10 Over Voltage Protection                                                    | Cell voltage shall not exceed the following value to prevent any safety events. And cell performance can't be guaranteed between 4.20V and 4.25V                 | 4.25V                                        |
| 2.11 Under Voltage Protection                                                   | Cell voltage shall not drop below the following value to prevent any safety events. And cell performance can't be guaranteed between 2.50V and 2.00V             | 2.00V                                        |
| 2.12 Weight                                                                     | Tubing cell                                                                                                                                                      | 44.5 ± 1.0g                                  |
| 2.13 Operating Temperature <sup>3)</sup><br>(Atmosphere or Chamber Temperature) | Charge                                                                                                                                                           | 0 ~ 50°C                                     |
|                                                                                 | Discharge                                                                                                                                                        | -20 ~ 60°C                                   |
|                                                                                 | * Max. cell surface temperature should be below 70°C for discharging.<br>(Temperature cut-off function is needed on BMU under 70°C of cell surface temperature.) |                                              |
| 2.14 Storage Temperature <sup>4)</sup><br>(for shipping state <sup>i*)</sup> )  | 1 month                                                                                                                                                          | -20 ~ 60°C                                   |
|                                                                                 | 3 month                                                                                                                                                          | -20 ~ 45°C                                   |
|                                                                                 | 1 year                                                                                                                                                           | -20 ~ 25°C                                   |
|                                                                                 | Recovery capacity <sup>5)</sup> after the storage ≥ 80% of minimum energy(or capacity)                                                                           |                                              |
| 2.15 Storage Temperature <sup>4)</sup><br>(for fully charged state)             | 1 month                                                                                                                                                          | -20 ~ 45°C                                   |
|                                                                                 | 6 month                                                                                                                                                          | -20 ~ 25°C                                   |
|                                                                                 | Recovery capacity <sup>5)</sup> after the storage ≥ 80% of minimum energy(or capacity)                                                                           |                                              |
|                                                                                 |                                                                                                                                                                  |                                              |
| 2.16 Storage Humidity                                                           |                                                                                                                                                                  | 25~50%                                       |

\* Shipping state : About 30% capacity of fully charged state

- 1) Charging time is based on one complete charge from the 0~100% SOC. contact and discuss with LG chem, if trickle charging is required to maintain fully charged state (ex. Trickle or floating charge)
- 2) The maximum continuous charge or discharge current herein is the allowable current to operate cell without possibility of dramatic degradation of the cell. (Max. cell surface temperature should be controlled by BMU protection unit below 55°C for charging and 70°C for discharging). "Complete full charge" means that cell is charged from the minimum discharge voltage (refer to 2.8) to the max charge voltage (refer to 2.5) without stopping for 1 cycle. The charge and discharge current herein doesn't have an effect on the safety, but this has nothing to do with guarantee of cycle performance and/or single cell degradation speed. For detailed Criteria for Cell basic properties (such as cycle life and capacity, etc), please refer to the explicit current conditions in each sections of this document.
- 3) The operating temperature range defined in this section (2.13) is not for defining safety window, but it is the maximum allowable range in which the battery cell can perform normal charge/discharge without sudden internal changes such as CID activation. However, even if the cell is charged / discharged within the above (2.13) operating temperature range, characteristics of the cell such as capacity / voltage / internal resistance may be deteriorated depending on factors such as the accumulated number of charge / discharge cycles, usage time and diverse charge/discharge current profiles. For detailed Criteria for Cell basic properties (such as cycle life and capacity, etc), please refer to the explicit temperature conditions in each sections of this document.
- 4) The storage temperature and period range defined in this section (2.14 and 2.15) is not for defining safety window, but it is the maximum allowable range in which the battery cell can perform normal charge/discharge without sudden internal changes such as CID activation. However, even if the cell storage (including the cell storage after assembled inside the final application in the field) is within the above (2.14 and 2.15) temperature and range, characteristics of the cell such as capacity / voltage / internal resistance may be deteriorated when compared to the fresh cell state (ex-factory state). It is highly recommended that the cell should be stored (including the cell storage after assembled inside the final application in the field) in the room temperature (25°C) and under the shipping SOC. For detailed Criteria for Cell basic properties (such as cycle life and capacity, etc), please refer to the explicit temperature conditions in each sections of this document.
- 5) Recovery Capacity: After storage, cells shall be discharged with Std. discharge condition per 4.1.2, and then cells shall be charged with Std. charge condition per 4.1.1, and then discharged with Std. discharge condition per 4.1.2.

### 3. Appearance and Dimension

#### 3.1 Appearance

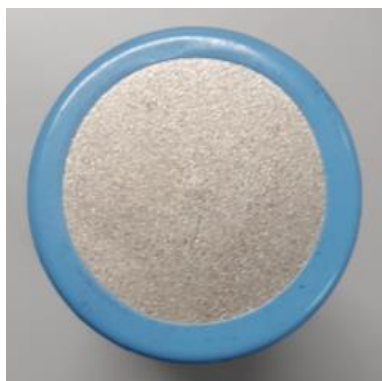
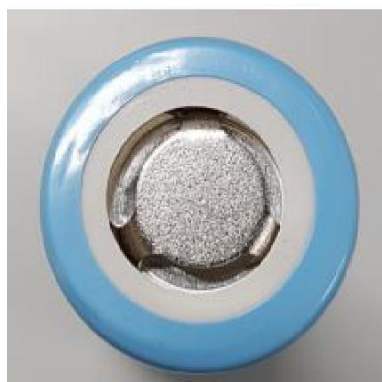
There shall be no such defects as severe scratch, crack, rust, discoloration or leakage, which may adversely affect the commercial value of the cell.

#### 3.2 Dimension

Diameter :  $\leq 18.4$  mm

Diameter is defined as the largest data value measured on the "A" area (4mm from the top) of a cylindrical cell, measured by Vernier Calipers (Mitsutoyo (500-182-20)).

Height :  $\leq 65.2$  mm



## 4. Performance Specification

### 4.1 Test condition

#### 4.1.1 Standard Charge

Unless otherwise specified, "Rated Charge" shall consist of charging at constant current of 0.5C(1550mA). 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 25°C.

#### 4.1.2 Standard Discharge

"Standard Discharge" shall consist of discharging at a constant current of 0.2C(620mA) to 2.50V. Discharging is to be performed at 25°C unless otherwise noted (such as capacity versus temperature).

### 4.2 Electrical Specification

| Item                           | Condition                                                                                                                                                                                                                   | Specification                                 |
|--------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------|
| 4.2.1<br>Initial AC Impedance  | Cell shall be measured at 1kHz after charge per 4.1.1                                                                                                                                                                       | $\leq 40 \text{ m}\Omega$                     |
| 4.2.2<br>Initial DC Impedance  | Cell shall be charged per 4.1.1 and discharged to the SOC (states of charge) 50%.<br>Measurement of internal impedance under DC loads at constant current of 0.5C for 10 sec at 25°C without any attachment of metal leads. | $48 \pm 6 \text{ m}\Omega$                    |
| 4.2.3<br>Initial Capacity      | Cells shall be charged per 4.1.1 and discharged per 4.1.2 within 1h after full charge.                                                                                                                                      | $\geq 3,100 \text{ mAh}$                      |
| 4.2.4<br>Cycle Life(0.5C/0.5C) | Charge(CC/CV) : 0.5C(1550mA), 4.2V, 50mA cut-off, rest time 10min. at 25°C<br>Discharge(CC) : 0.5C(1550mA), 2.75V cut-off, rest time 20min. at 25°C                                                                         | $\geq 70\%$ of initial capacity at 500cycles  |
| 4.2.5<br>Cycle Life(0.3C/0.5C) | Charge(CC/CV) : 0.3C(930mA), 4.1V, 155mA cut-off, rest time 10min. at 25°C<br>Discharge(CC) : 0.5C(1550mA), 3.0V cut-off, rest time 20min. at 25°C                                                                          | $\geq 80\%$ of initial capacity at 1000cycles |



#### 4.3 Environmental specification.

| Item                                              | Condition                                                                                                                                                                                                                              | Specification                                         |               |
|---------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------|---------------|
| 4.3.1<br>Storage Characteristics                  | Cells shall be charged per 4.1.1 and stored in a temperature-controlled environment at 25°C for 30 days. After storage, cells shall be discharged per 4.1.2 to obtain the remaining capacity*.                                         | Capacity ≥ 2,790 mAh<br>(90% of 4.2.3)                |               |
| 4.3.2<br>High Temperature<br>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 4.1.1 and 4.1.2 for 3 cycles to obtain recovered capacity* . | No leakage,<br>Capacity ≥ 2,480 mAh<br>(80% of 4.2.3) |               |
| 4.3.3<br>Temperature<br>Dependency of<br>Capacity | Cells shall be charged per 4.1.1 at 25°C and discharged per 4.1.2 at the following temperatures.                                                                                                                                       |                                                       |               |
|                                                   | Charge                                                                                                                                                                                                                                 | Discharge                                             |               |
|                                                   | 25°C                                                                                                                                                                                                                                   | -10°C                                                 | 70% of 4.2.3  |
|                                                   |                                                                                                                                                                                                                                        | 0°C                                                   | 85% of 4.2.3  |
|                                                   |                                                                                                                                                                                                                                        | 25°C                                                  | 100% of 4.2.3 |
| 45°C                                              |                                                                                                                                                                                                                                        | 95% of 4.2.3                                          |               |
|                                                   | 60°C                                                                                                                                                                                                                                   | 95% of 4.2.3                                          |               |

#### 4.4 Mechanical / Safety Specification

- Cell satisfies UN38.3 regulation

\* 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 Std condition(4.1.2), 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.

## 5. Warranty

Warranty period of the battery cell is 12 months from the date of Cell manufacture. This warranty becomes void when the cells are used in ways that deviate from this specification or handled improperly. This warranty holds only when the cells are used under conditions specified in this document.

## 6. Cautions and Prohibitions in Handling

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.

### 6.1 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(atmosphere) temperature range 0 ~ 50°C
- Battery must be discharged at operating(atmosphere) temperature range -20 ~ 60°C.  
(Cell surface temperature -20 ~ 70°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 (3 months or more) 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.
- Do insulate between the metal plate and cell or other components not to make a electrical short.
- The cells should be handled and used in Pack/System manufacturing companies only.
- The cells should be sold only to Battery Pack Maker(s) or System Integrator(s). The cells should not be handled by individual consumers and should not be sold to individual consumers by individual markets. (especially, the cells are strictly prohibited to be used for any kinds of E-cigarette devices)
- Be sure to request and confirm the most current product specifications in advance which explain the specifications in detail, before the final stage of your design, purchasing or use for any application.

## 6.2 Prohibitions

- Do not connect battery directly to cigarette/aux jack in automobiles. Use only approved chargers.
- Do not charge with constant current more than maximum charge current.
- Do not charge the cell, which was discharged equal to 1V or under..
- 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.
- Do not give immoderate heat and force to battery cell during a welding process of metal plates on it.

## 6.3 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.

### 6.3.1 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.

### 6.3.2 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 circuit easily.
- The design of battery pack and its structure should be reviewed physically, mechanically and electrically not to cause cell imbalance.
- The battery pack for multiple cells should be designed to monitor the voltage of each bank.
- To prevent the deterioration of battery (cell imbalance, cycle degradation, etc) by heat, the battery (cells) should be positioned/ installed as far as possible from the area where heat is generated in the application or system.

### 6.3.3 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. 2.5, 2.6)
- The battery should be charged under operating temperature specified in product specification. (Article. 2.13)

### 6.3.4 Discharge

- Discharging method is Constant Current (CC).
- Discharging should be operating under maximum discharge current which is specified in the product specification. (Article. 2.9)
- Discharging should be done by cut off voltage which is specified in the product specification. (Article. 2.7)
- The battery should be discharged under operating temperature specified in product specification. (Article. 2.13)

### 6.3.5 Protection Circuit

- The protection circuit should be installed in the battery pack, charger.
- The system should have voltage sensing to prevent over charge or over discharge in order to maintain the battery's normal operating mode and protect against cell imbalance.
- The system should have protection against over temperature, over voltage and over current
- When battery packs for any applications are assembled with cells, following functions must be designed into the battery packs and/or in the charger or charging adapter. The detailed levels, values, conditions for each following functions should be referring to the contents specified in this Product Specification. If one or more than one function is/are to be omitted, the Packer Company (and/or System integration company) must be informing to LG Chem's or to LG Chem's sales Agent company. Without informing to LGC, LGC will not be liable for any field quality issues happened due to exclusion of following functions.

- (1) Over voltage protection circuit
- (2) Under voltage protection circuit
- (3) Over Charge current protection circuit
- (4) Over Discharge current protection circuit
- (5) Short circuit protection
- (6) Over Temperature protection circuit

- (7) 2nd over voltage protection
- (8) FET failure protection (in case FET is out of order)
- (9) Cell imbalance protection circuit (only for battery packs assembled with more than one cell)
- (10) Cell Voltage balancing function (only for battery packs assembled with more than one cell)

※ If the customer or user doesn't comply with this item(6. Caution and Prohibition in Handling), LG Chem is not responsible for any problems

## 7. Compliance details of buyer

- The Buyer shall read, understand, and comply with all the conditions set forth in this Contract and the PRODUCT SPECIFICATION provided by the Seller, in particular the section(s) related to the cautions and prohibitions of the Products.
- The Buyer shall not make any use of the Products without obtaining and fully understanding the PRODUCT SPECIFICATION.
- The Buyer or buyer's customer shall not make different product or set up the different equipment, with the product ,which is not following the PRODUCT SPECIFICATION
- The Buyer fully understands and agrees that the Products should be sold to and handled only by battery pack makers, system integrators or other entity expressly authorized by the Seller. The Products can be used solely for the application(s) set forth in the PRODUCT SPECIFICATION and no other application is permitted for use without obtaining the express prior written consent/confirmation as well as the most current PRODUCT SPECIFICATION from the Seller.
- The Buyer shall provide (a) the most recent PRODUCT SPECIFICATION, (b) the terms of this Special Responsibilities of the Buyer and (c) the terms of the Prohibited Sales of the Buyer under this Contract to its customers, have them acknowledge the contents and require that the Buyer's customers be bound by the terms and conditions set forth therein.
- During the Effective Period of this Contract and for three (3) years thereafter, the Seller may, at any time with fourteen (14) days' prior notice, audit the Buyer's information, records and data (which may include battery pack and system application data) to validate Buyer's compliance with the terms contained in this Special Responsibilities of the Buyer and the Prohibited Sales of the Buyer.

In the event that the Buyer (or the Buyer's customer) violates the terms and conditions of the PRODUCT SPECIFICATION, the Special Responsibilities of the Buyer or the Prohibited Sales of the Buyer of this Contract, the

Seller shall bear no liability for any losses or damages incurred by any party arising out of or resulting from any such violation. The Buyer shall be solely liable for such violation and shall indemnify, defend, and hold the Seller and its affiliates, officers, directors, agents and employees harmless from and against any and all losses, damages, liabilities, settlements, penalties, fines, costs and expenses (including, without limitation, costs of suit, attorney's fees, other professional fees and expenses), which may at any time be suffered by or incurred by, or be asserted against Seller, directly or indirectly, and which are attributable to any and all allegations, claims, or suits arising out of or in connection with any such violation, or any breach of Buyer's obligations under this Contract. Furthermore, such violation of the Buyer (or such violation of the Buyer's customer) shall cause this Contract to be immediately terminated.

The Seller shall cooperate with the Buyer and its legal representatives in the investigation and defense of any claim, lawsuit or other action covered by this indemnification, all at the reasonable expense of the Buyer. The Seller shall have the right to be represented by counsel of its own selection and expense.

※ **If the customer or user doesn't comply with this item(6. Caution and Prohibition in Handling), LG Chem is not responsible for any problems**

## 8. 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.)

There are no warranties-implied or express-other than those stipulated herein. In the event the battery pack and/or cells have been used in accordance with this product specification and the defect is found to be attributable to LGC, LGC shall replace the defective battery pack and/or cell with a new battery pack and/or cell that is free of any defects. In such circumstances, replacement of the battery pack and/or cell shall be the sole remedy available to the customer.