



E - S T R E A M

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Specification

ES18650-29MP

Lithium-Ion 18650 rechargeable battery cell

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Revision History

Version	Created by	Date of approval	Changes
V1.0	Jamshid Tavana	11/10/2020	Initial
V1.1	Jamshid Tavana	11/24/2020	Appearance
V1.2	Jamshid Tavana	01/27/2021	Cycle life, pulse charge/discharge
V1.3	Jamshid Tavana	02/03/2021	Redesign, safety notes

Specified Product

Type

Cylindrical Lithium-Ion Rechargeable Cell

Name

ES18650-29MP

Scope

This product specification has been prepared to specify the cylindrical Lithium-Ion cell to be supplied to the customer by E-Stream GmbH & Co KGaA. The cell performance on pack level needs to be evaluated individually based on actual conditions.

Safety notes

Please read this specification carefully before testing or using the cell since improper handling of a Li-ion cell may lead to loss of efficiency, heating, ignition, electrolyte leakage and explosion.

**Nominal specification**

Capacity	Nominal 2900mAh	At 0.2C discharge to 2.75V and 0.2C charge to 4.2V
	Minimum 2750mAh	
Nominal voltage [V]	3.7	
Energy [Wh]	10.545	
Discharge cut-off voltage [V]	2.75	
Maximum charge voltage [V]	4.2	
Internal Impedance ACIR [mΩ]	≤ 28	
Standard charge current [A]	1.425	0.5C
Standard charge cut-off current [mA]	142.5	0.05C
Maximum continuous charge current [A]	2.9	1C
Maximum pulse charge (< 2s) current [A]*	5.7	2C
Standard discharge current [A]	2.85	1C
Maximum continuous discharge current [A]**	10	3.5C
Maximum pulse (< 1s) discharge current [A]**	15	5.26C
Weight [g]	≤ 47	
Diameter [mm]	18.25 ± 0.2	
Height [mm]	64.95 ± 0.2	
Operating temperatures charge [°C]	0 ≤ T ≤ 50	
Operating temperatures discharge [°C]	-20 ≤ T ≤ 60	
Cut-off temperature limit discharge [°C]	60	
Cycle life (80% of initial capacity)	≥ 1000 cycles (standard charge/discharge)	
Storage temperatures with maximum 70% relative humidity	≤ 30 days	-20°C – 60°C
	> 30 ≤ 90 days	-20°C – 45°C
	> 90 ≤ 365 days	-20°C – 25°C

*Not for cycle life

**With 60°C temperature cut

Standard charge and discharge conditions

All tests need to be performed under the following conditions: Ambient temperature $T = 25^{\circ}\text{C} \pm 3^{\circ}\text{C}$ and with a relative humidity $R_h = 65\% \pm 20\%$.

Standard charge CCCV

Charge with a constant current (CC) of 1.425A (0,5C) until the voltage reaches 4.2V. Then charge with a constant voltage (CV) up to the cut-off current of 142.5mA (0.05C).

Standard discharge

Discharge with constant current of 2.85A (1C) up to the cut voltage of 2.75V.

Electrical characteristics

Parameter	Test procedure	Requirement	
Nominal voltage	The average value of working voltage during discharge with the current of 0.5C, after standard charged under the defined conditions.	3.7V	
Initial capacity	At the ambient temperature of $25 \pm 5^{\circ}\text{C}$, cells shall be discharged with a current of 1C and cut-off at 2.75V within 10 minutes after standard charging as defined.	$\geq 2750\text{mAh}$	
Cycle life	At the ambient temperature of $25 \pm 5^{\circ}\text{C}$, cell shall be standard charged under the defined conditions. Rest 10 minutes, then discharge the cell with 1C and cut-off at 2.75V. Rest 10 minutes. This is a cycle life. If discharge capacity is lower than 80% of that of the first cycle twice in series, cycle life test is over.	≥ 1000 cycles (0.5C/1C)	
Rate characteristics	At the ambient temperature of $25 \pm 5^{\circ}\text{C}$, cells shall be charged under the standard conditions. Rest 10 minutes and then discharge the cells to 2.75 V at different currents.	0.5C	= 100%
		1C	$\geq 95\%$
		2C	$\geq 90\%$
		3C	$\geq 85\%$
Temperature dependence of discharge capacity	Cells shall be charged per standard definition at $25 \pm 5^{\circ}\text{C}$ and discharged per standard definition at the following temperatures.	-20°C	$\geq 70\%$
		-10°C	$\geq 75\%$
		0°C	$\geq 80\%$
		25°C	= 100%
		55°C	$\geq 90\%$



Capacity retention at room temperature	Cells should be charged and discharge per standard definition at an ambient temperature of $25 \pm 5^{\circ}\text{C}$. Marking the discharging capacity as initial capacity. Then cells should be standard charged and stored at the ambient temperature of $25 \pm 5^{\circ}\text{C}$ for 28 days. After 28 days, cells should be standard discharged at $25 \pm 5^{\circ}\text{C}$. Marking the capacity as retention capacity. Then charging and discharging cells as defined in the standard charge and discharge. Marking the discharging capacity as the recovery capacity. The retention or recovery can be calculated by the retention capacity (recovery capacity) divides to initial capacity.	Retention $\geq 85\%$ Recovery $\geq 90\%$
Capacity retention at high temperature	Cells should be charged and discharged per standard definition at an ambient temperature of $25 \pm 5^{\circ}\text{C}$. Mark the initial discharge capacity. Then standard charge the cells at $25 \pm 5^{\circ}\text{C}$ and store them 7 days at the ambient temperature of $55 \pm 2^{\circ}\text{C}$. Standard discharge the cells after staying at $25 \pm 5^{\circ}\text{C}$ for 5 hours to achieve the retention capacity. Then charge and discharge the cells with the defined standard respectively at $25 \pm 5^{\circ}\text{C}$ to achieve the recovery capacity.	Retention $\geq 85\%$ Recovery $\geq 90\%$

Electrical tests

Short Circuit	After fully charged under the standard conditions the cell is to be short-circuited by connecting the positive and negative terminals of the cell for 10 minutes. The connection needs to be performed with a wire with less than 0.1 Ω	No explosion and no fire
Overcharge	After fully discharged under standard conditions each cell shall apply a 1C constant current 12V constant voltage charge for 1.5h.	No explosion, no leakage and no fire
Over discharge	After fully charged under the standard conditions, then discharged by 1C(2850mA) current for 90 min and observed for 1 hour.	No explosion, no leakage and no fire

Mechanical tests

Vibration	After fully charged under the standard conditions the testing cells are firmly secured to the platform of the vibration machine. The vibration shall be a sinusoidal waveform with a sweep between 10Hz and 55Hz and back to 10Hz traversed in 180-200 minutes. The amplitude is then maintained at 0.8mm (1.6mm total excursion). The cell shall be vibrated in each direction along axis of the cylinder and the vertical direction of axis of the cylinder.	No leakage, no venting, no disassembly, no rupture and no fire.
Crush	After fully charged under the standard conditions the testing cells are between two flat surfaces for a crush Test. The direction of the crushing force shall be vertical to axis of the cylinder. Using a pressure device which has a 32mm diameter Hydraulic piston with 13 KN Crushing force, Release the pressure immediately until the maximum is reached.	No explosion and no fire
Drop	After fully charged under the standard conditions, measure the initial state of the cell, then the positive and negative terminals of cell is to be dropped from a height of 150 cm to cement floor.	No explosion, no flame and no fire

Environmental tests

<p>Temperature cycling</p>	<p>After fully charged under the standard conditions the cells need to be stored at $75 \pm 2^{\circ}\text{C}$ for at least 6 hours, then followed by storing at $-40 \pm 2^{\circ}\text{C}$ for at least 6 hours. The maximum time interval between two test temperature is 30 minutes. The procedure needs to be repeated for 10 times. Then all tested cells should be stored at an ambient temperature ($20 \pm 5^{\circ}\text{C}$) for 24 hours.</p>	<p>No leakage, no venting, no disassembly, no rupture and no fire.</p>
<p>Low pressure (altitude simulation)</p>	<p>After fully charged under the standard conditions the cells need to be stored at an absolute pressure of 11.6kPa (1.68psi) and a temperature of $23 \pm 2^{\circ}\text{C}$ for 6 hours.</p>	<p>No leakage, no venting, no disassembly, no rupture and no fire.</p>
<p>Seawater Immersion</p>	<p>After fully charged under the standard conditions the cells are immersed in 3.5% NaCl solution (weight percent, this solution concentration is same to seawater) for 2 hours.</p>	<p>No leakage, no venting, no disassembly, no rupture and no fire.</p>
<p>Hot Oven</p>	<p>After fully charging the cell following the standard charge method and put it into the oven. And then the oven temperature will be ramped at 5°C per minute to $130 \pm 2^{\circ}\text{C}$ When the temperature of the cell reach $130 \pm 2^{\circ}\text{C}$, the cell is maintained in the $130 \pm 2^{\circ}\text{C}$ oven for 30 minutes or until fire or explosion is obtained and observed for 1 hour.</p>	<p>No explosion and no fire</p>

Appearance

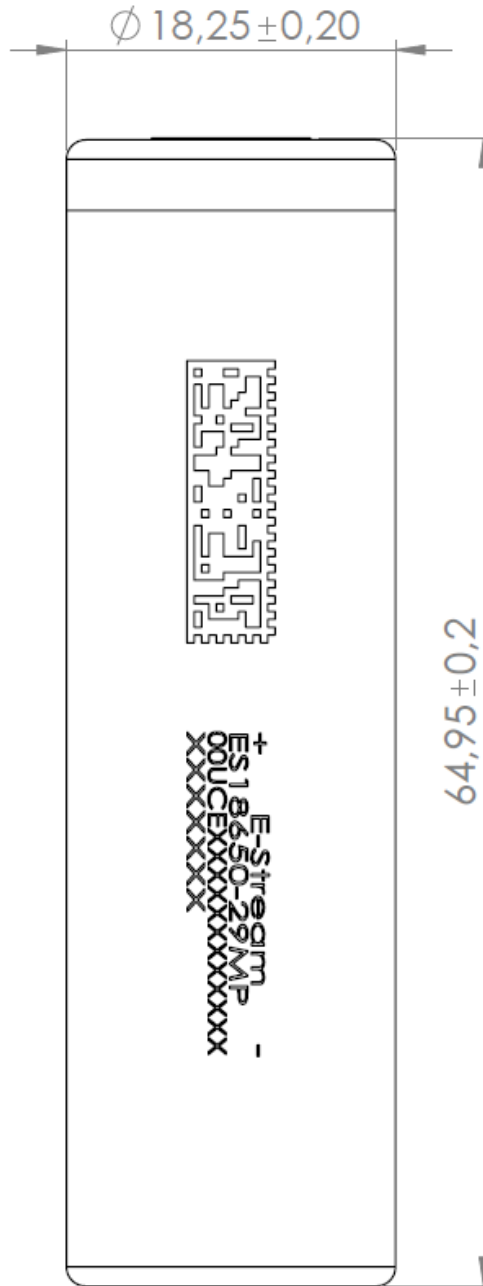
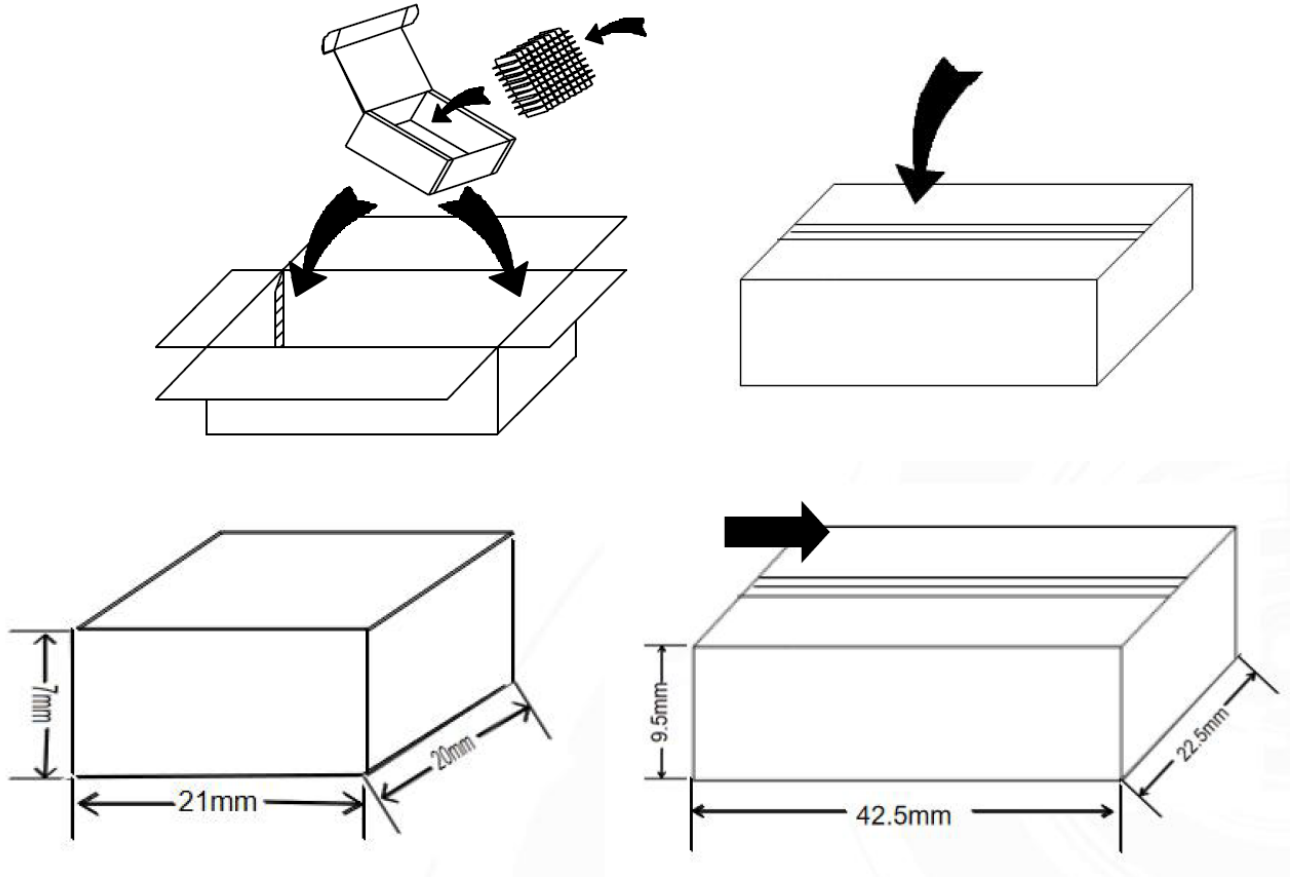


Fig. 1: The dimensions of the cell (in mm)

Packing and transport

Packing

Batteries are at half-charged state when packed. The surface of the packing boxes containing the following information: name, type, nominal voltage, quantity, gross weight, date, capacity and impedance. Cells are being packed as follows: 100 cells per box, 2 boxes into a case, totally 200 cells.



Transport

During transportation, do not subject the cell(s) or the box (es) to violent shaking, bumps, rain or direct sunlight. Keep the cell(s) at half-charged state.

Long-term Storage

When delivery, cells will be charged to the voltage of 3.60V~3.80V. Long-term storage at/more than 80% SOC will lead to capacity loss and cycle life loss, please keep cell in use when cell capacity more the 80%. Cells may be required to delivery at 30% SOC, cells may be fully discharged due to the self-discharge. Do not use or storage the cells when voltage less than 2.75V.

The storing temperature (T) for 1 month or less must be $-20^{\circ}\text{C} < T < 60^{\circ}\text{C}$.

The storing temperature (T) for 3 months or more than 1 month must be $-20^{\circ}\text{C} < T < 45^{\circ}\text{C}$.

The storing temperature (T) for 12 months or more than 3 months must be $-20^{\circ}\text{C} < T < 25^{\circ}\text{C}$.

Danger

Electrical misusage

- a) Use dedicated charger.
- b) Use or charge the battery only in the dedicated application.
- c) Do not charge the battery by an electric outlet directly or the other charger.
- d) Do not charge the battery reversely.

Environmental misusage

- a) Do not leave the battery near the fire or a heated source.
- b) Do not throw the battery into the fire.
- c) Do not leave, charge or use the battery in a car or similar place where inside of temperature may be over 60°C.
- d) Do not immerse, throw, wet the battery in water / seawater.

Others

- a) Do not fold the battery cased with laminated film such as pouch and Polymer.
- b) Do not store the battery in a pocket or a bag together with metallic objects such as keys, necklaces, hairpins, coins, or screws.
- c) Do not short circuit (+) and (-) terminals with metallic object intentionally.
- d) Do not pierce the battery with a sharp object such as a needle, screw drivers.
- e) Do not heat partial area of the battery with heated objects such as soldering iron.
- f) Do not hit with heavy objects such as a hammer, weight.
- g) Do not step on the battery and throw or drop the battery on the hard floor to avoid mechanical shock.
- h) Do not disassemble the battery or modify the battery design including electric circuit.
- i) Do not use seriously scared or deformed battery.
- j) Do not put the battery into a microwave oven, dryer, or high-pressure container.
- k) Do not use or assemble the battery with other makers' batteries, different types and/or models of batteries such as dry batteries, nickel-metal hydride batteries, or nickel-cadmium batteries.
- l) Do not use or assemble old and new batteries together.

Warning

- a) Stop charging the battery if charging is not completed within the specified time.
- b) Stop using the battery if the battery becomes abnormally hot, order, discoloration, deformation, or abnormal conditions is detected during use, charge, or storage.
- c) Keep away from fire immediately when leakage or foul odors are detected. If liquid leaks onto your skin or cloths, wash well with fresh water immediately.
- d) If liquid leaking from the battery gets into your eyes, don't rub your eyes and wash them with clean water and go to see a doctor immediately.
- e) If the terminals of the battery become dirty, wipe with a dry cloth before using the battery.
- f) Cover terminals with proper insulating tape before disposal.

Caution

Electrical misuse

- a) Charge current must be controlled by specified value in Cell specification.
- b) When the ambient temperature is lower than 15°C or higher than 40°C, charging greater than 0.2c will affect the cell cycle.
- c) Cut-off voltage of charging must be less than 4.2V, otherwise, it will affect the electrical and safety performance of the cell.
- d) Charger must stop charging battery by detecting either charging time or current specified in Cell's specification.
- e) Discharge current must be controlled by specified value in Cell's specification.
- f) Cut-off voltage of discharging must be above 2.75V, otherwise, it will affect the electrical and safety performance of the cell.
- g) The cell should be used within the specified temperature range, beyond which the electrical and safety properties of the cell will be affected.

Caution in use

- a) Abnormal operating conditions such as overcharge (voltage >4.2V), over discharge (voltage <2.75V) and overcurrent charge-discharge (maximum current allowed at current temperature) cannot occur during the operation of the cell. It is strictly prohibited to use the cell in the environment which is easy to generate static electricity and poor sealing (water and dust entering).
- b) More than 0.5C current charging, use in high-temperature/low-temperature environment, use in vibration environment, not match well cells, and use in humid environment will reduce the cycle life of the cell.

- c) The battery shall not be used in the environment of high frequency microwave and ultrasonic wave. When the battery is used in multiple S and P module, it is recommended to coat the electromagnetic insulation cover of high-voltage wire to prevent the electromagnetic wave from damaging adjacent devices and human body.
- d) There should be no overlapping or contact between the positive and negative terminal wires of the battery to reduce the risk of short circuit.
- e) The battery shall be designed for charging and discharging in strict accordance with the current specification to ensure the battery's cycle life and safety.
- f) When the battery is assembled module for use, the cells with the same capacity, internal resistance position, same batch and same charged state shall be used. The standard of the battery should be strictly in accordance with the technical agreement. The working process of the battery module, the battery pack inside temperature difference should be less than 5°C.
- g) Do not charge the cell when cell temperature less than 0°C, please standby before charging when cell exposure at under-zero environment. Time standby as follows:

Outside Temperature	$-5^{\circ}\text{C} \leq T \leq 0^{\circ}\text{C}$	$-10^{\circ}\text{C} \leq T \leq -5^{\circ}\text{C}$	$-15^{\circ}\text{C} \leq T \leq -10^{\circ}\text{C}$	$-20^{\circ}\text{C} \leq T \leq -15^{\circ}\text{C}$
Time	2 h	5 h	8 h	10 h

Others

- a) The cell should be stored in a dry area and no corrosive gas.
- b) No press on the cell.
- c) After the cell assembled in pack, the pack should be recharged to 40% SOC if the pack has never been used for one year, this will avoid the cell voltage drop too low.
- d) Keep the battery away from babies and children to avoid any accidents such as swallow.
- e) If younger children use the battery, their guardians should explain the proper handling method and precaution before using.
- f) Before using the battery, be sure to read the user's manual and precaution of its handling.
- g) Before using charger, be sure to read the user's manual of the charger.
- h) Replace the battery when using time of battery becomes much shorter than usual.
- i) Cover terminals with insulating tape before proper disposal.
- j) While the battery is charged, used and stored, keep it away from object materials with static electric chargers.

Precautions on battery pack design

- a) Do not make the shape and mechanism which static electricity and water easy go through the battery pack inside.
- b) Overcharge protection should work below 4.2V/cell by charge. Then charge current shall be shut down.
- c) Within a voltage range of 2.75V/cell, over-discharge protection should work. Then discharge current shall be shut down and consumption current is below 1 μ A.
- d) When discharge current exceeds 20A, over-discharge current protection should work. Then over discharge current shall be shut down.
- e) To avoid discharging during storage, design the low consumption current electronic circuit (e.g. Protection circuit, fuel gauge, etc) inside battery pack.

Battery pack assembly

- a) Prohibition of usage of damaged cell. Do not use abnormal cell which has been damaged by shipping stress, drop, short, twice spot or something else, and which gives off electrolyte.
- b) The cell should be inspected visually before battery assembly.
- c) Inspect voltage and internal impedance before using.
- d) Do not solder onto a cell to avoid damage on the cell. Weld spot welding lead plate onto cell, and solder lead wire or lead plate.
- e) The battery assembly must pay attention to anti-static, avoid electronic components damaged by electrostatic.
- f) Battery assembly should pay attention to prevent the short circuit.

Safety handling procedure for the transport

Quarantine

- a) Packages that are crushed, punctured, or torn open to reveal contents should not be transported. Such packages should be isolated until the shipper has been consulted, provided instructions and, if appropriate, arranged to have the product inspected and repacked.

Spilled Product

- a) In the event that damage to packaging results in the release of cells or batteries, the spilled products should be promptly collected and segregated and the shipper should be contacted for instructions.

Design of positioning the battery pack in application and charger

- a) To prevent the deterioration of the battery performance caused by heat, battery shall be positioned away from the area where heat is generated in the application and the charger.