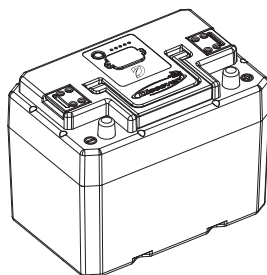


Discover[®]

ADVANCED ENERGY

Lithium Ion Battery

Operating Manual



15-24-1000
15-36-1000

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1. SAFETY

1.1 Warnings, Cautions, Notes and Symbols

▲ WARNING
Important information regarding possible personal injury.

▲ CAUTION
Important information regarding possible equipment damage.

▲ NOTE
Additional information concerning important procedures and features of the battery.

1.2 General Warning

▲ CAUTION
It is important to operate the device with care to avoid undesirable consequences.



Do not throw in the garbage. Do not dispose in fire.



Use personal protective equipment when working with batteries.



Additional information concerning important procedures and features of the battery. Read all the instructions before installation, operation and maintenance.



This product must be recycled and is made of recycled products.

▲ CAUTION
Do not disassemble or modify the battery. If the battery housing is damaged, do not touch exposed contents.

1.3 Fire Risk

▲ WARNING
Risk of fire - No user serviceable parts.

- Battery has a battery management system with integrated solid state relay to reduce fire risk.
- Primary suppression for lithium battery fires is water. Secondary suppression is CO₂, powder and halon.

1.4 Electric Shock Risk

▲ WARNING
For wet and electrically uninsulated working conditions, electric shock risk is high, and can cause injury and death.

Model	Nominal System Voltage	Maximum System Voltage
15-24-1000	24 V	29.6 V
15-36-1000	36V	38.4V

1.5 Chemical Risk

▲ WARNING

Lithium batteries are a chemical risk if misoperated, mishandled or abused.

1.6 Do's

- Do protect terminals from short circuit before, during, and after installation
- Do wear electrically insulated gloves
- Do use electrically insulated tools
- Do wear eye protection
- Do wear safety toe boots / shoes
- Do handle battery carefully
- Do secure battery safely
- Do always assume battery terminals are energized

1.7 Do Not's

- Do not immerse battery in water
- Do not lift or carry the battery during usage or operation
- Do not operate or store battery outside of operating limits
- Do not short circuit battery
- Do not puncture battery
- Do not expose battery to flames, or incinerate
- Do not open battery case or disassemble battery
- Do not wear rings, watches, bracelets or necklaces when handling or working near battery
- Do not drop or crush battery
- Do not lift battery by the terminal cables
- Do not vibrate battery
- Do not expose battery to water or other fluids
- Do not expose battery to direct sunlight
- Do not dispose of battery
- Do not connect with other types of batteries
- Do not expose battery to high temperatures
- Do not install with other battery types or brands

1.8 DC Motor Connection

Direct connection to DC motors without proper safety protection, motor controllers, and external motor voltage clamping systems (such as high power anti-parallel diodes or braking resistor systems) may result in damage to the internal pack protection system which may result in unsafe situations. Please consult Discover technical support before directly connecting any motor loads.

1.9 Transportation

If the battery is not installed in equipment, it must be transported in the original package or equivalent. Batteries are tested according to UN Handbook of Tests and Criteria, part III, sub section 38.3 (ST/SG/AC. 10/11/Rev.5). For transport the batteries belong to category UN3480, Class 9, Packaging Group II.

2. Maximum Operating Limits

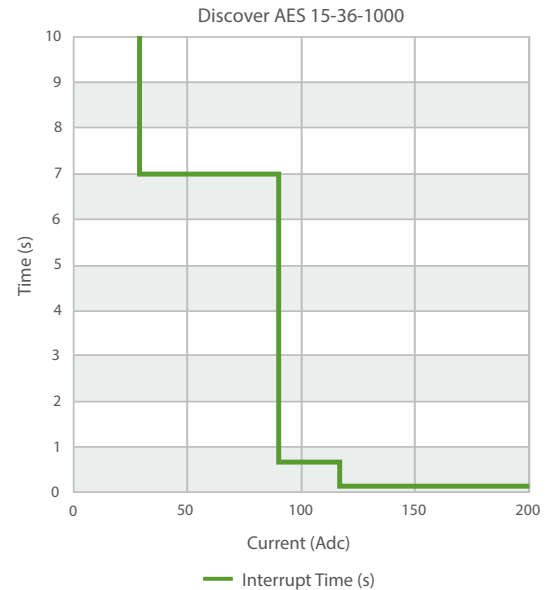
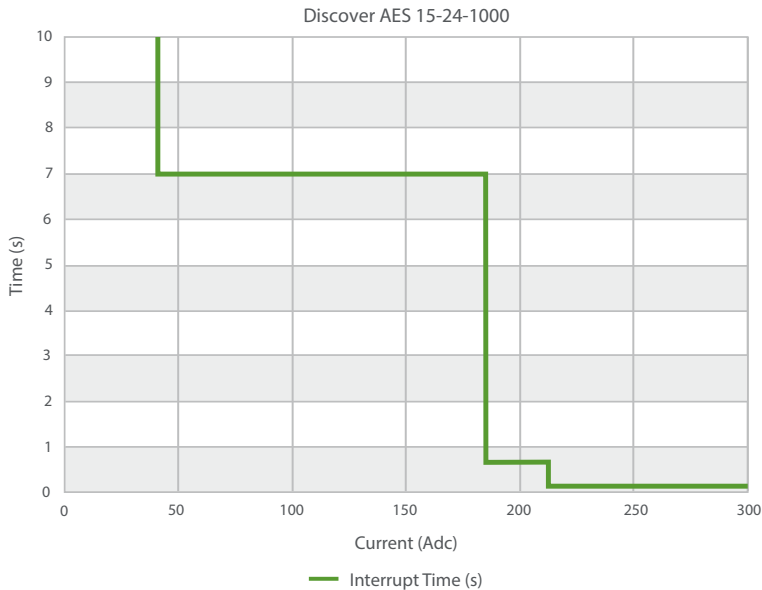
2.1 Battery Operating Limits

The battery should not be operated outside these operating limits.

Operating Limits	15-24-1000	15-36-1000
Discharge and Charge Current*	40 Adc	25 Adc
Charge Voltage	27.2 V	40.8 V
Operating Voltage (Min / Max)	22.4 V / 29.6 V	33.6 V / 44.4 V
Charge Temperature (Min / Max)	0°C / 45°C (32°F / 113°F)	
Discharge Temperature (Min / Max)	-20°C / 50°C (-4°F / 122°F)	
Storage Temperature (Min / Max)	-20°C / 45°C (-4°F / 113°F)	

* Effects of AC Ripple must be taken into consideration when sizing and configuring your system.

Nominal BMS Interrupt Chart



▲ NOTE!

Intentional bypassing of BMS to operate battery outside maximum and minimum limits voids warranty.

When installing batteries in parallel, the total charge and discharge current can not exceed the operating limits of a single battery.

3. Design Features & Components

3.1 Battery Management System (BMS)

Monitoring

BMS monitors:

- Cell module voltage
- Battery voltage
- Battery current
- Battery temperature
- Battery state of charge (SOC)

Module Balancing

- BMS performs balancing of cell modules.

Protection & Fault Management

- BMS sounds buzzer when fault limits are reached
- BMS generates fault when maximum operating limits are reached
- Fault events cause switch to open and battery to shut down after a 120s delay

Communication Ports

BMS has an isolated RS232 communication port (for service technician use only). Use accessory harness 790-0018 to connect battery to computer with AES Dashboard Software.

3.2 Fuse

Fuse provides back-up over-current protection.

Fuse Replacement

A blown fuse requires service from a qualified technician. Contact your Discover supplier for more information.

3.3 Terminals

Terminals are post-type, M6 female.

Terminal Torque	7.0-7.7 Nm / 5.1-5.7 Ft-lb
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4. Handling

▲ WARNING!
Read Safety Section before installing the battery.

- Battery should be off
- Battery cables should be disconnected
- Battery terminals should be protected
- Battery handle should be used to lift battery
- Do not lift or carry the battery during usage or operation

5. Installation - Single Battery

▲ WARNING!
Read Safety Section before installing the battery.
▲ CAUTION!
Do not install batteries in series. Select the appropriate AES battery model for the voltage of your system.
▲ NOTE!
The battery is IP55 rated. If the installation can be exposed to water consider using an external battery enclosure.

5.1 Tools

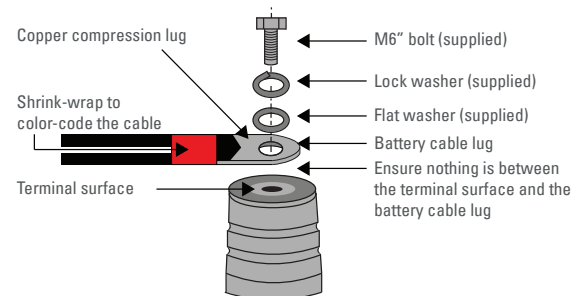
- Insulated tools sized to match nuts, bolts and cables in use
- Voltmeter
- Post cleaner and wire brush
- Personal protective equipment

5.2 Securing Battery

- Battery can be strapped in place with non-conductive nylon straps

5.3 Installation

- Check that battery is switched off
- If the battery circuit has a disconnect, open disconnect to isolate the battery
- Clean cable connections. Broken, frayed, brittle, kinked or cut cables should be replaced
- Install and secure new battery. Be careful not to ground the terminals to any metal mounting, fixture, or body part
- Connect battery cables. Connect ground cable last to avoid sparks
- Recommended terminal torque is 7.0 – 7.7 Nm (5.1 – 5.7 ft-lb)
- Close circuit disconnect (if open)
- Turn battery switch on



▲ NOTE!
All cable ends must be connected to battery terminals without any washers between terminal bushings and cable ends.

Terminal burnout is caused by:

- Discharge currents exceeding allowable limits
- Improper cable installation
- Improper cable sizing
- Improper terminal torque

▲ NOTE!

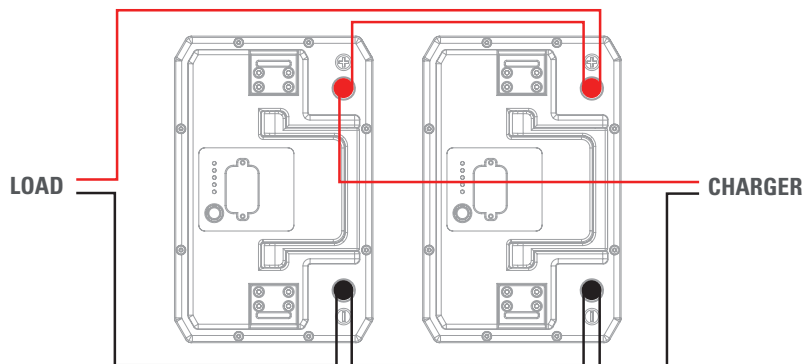
Without exception, product experiencing terminal burn out will not be warranted.

5.4 Parallel Battery Wiring

Parallel wiring example. Consult with your local authority having jurisdiction.

▲ NOTE!

If installing in parallel, the energy (capacity) increases but the power must not exceed the operating specifications of a single battery.



6. Operation

▲ NOTE!

Review operating limits.

6.1 On–Off

- To turn the battery on press and hold switch for 2-3 seconds
- To turn the battery off press and hold switch for 2-3 seconds



6.2 Power Modes

The battery is on and ready to discharge or charge in all ON power modes. The battery will however change the rate it communicates and reduce the LED on time to conserve power when not in use.

6.2.1 Battery ON – Full Operation

- Battery relay closed
- One solid LED light indicates State of Charge (Figure 1)
- Communications transmit once every one second

6.2.2 Battery ON – Low Power Operation

After one hour of 0 current:

- Battery relay closed
- One solid LED light indicates State of Charge (Figure 1)
- Communications transmits 30 seconds every 90 seconds

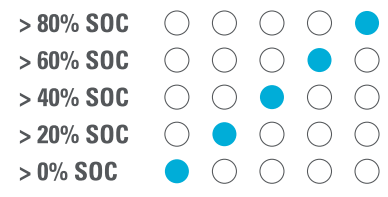


Figure 1

6.2.3 Battery ON – Stand by

After 17 hours of no current:

- Battery relay closed
- 500 ms LED light pulse every 10 seconds used to indicate State of Charge (Figure 2)
- Communications transmits 30 seconds every 10 minutes

6.2.4 Battery OFF

- Battery relay opened
- No communications transmitted
- NO LED lights in use

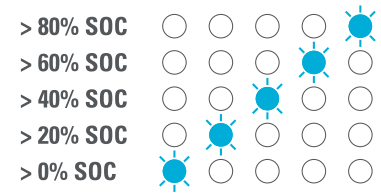


Figure 2

6.2 Charging

Before operating the charger make sure to read and understand the instructions that come with the charger. Never attempt to charge a battery without first reviewing and understanding the instructions for the charger being used.

▲ CAUTION!

Always make sure the chargers charging curve meets the battery's charging requirement; never charge a visibly damaged battery; never charge a frozen battery.

1. Connect the charger leads to the battery.
2. Make sure that the charger lead, both at the charger and the battery side, connections are tight.
3. Turn the charger on.
4. Turn the battery on (if required).

▲ CAUTION!

NOT ALL CHARGERS ARE CAPABLE OF CHARGING LITHIUM BATTERIES!

During system design CONFIRM that your chosen charger is not capable of transient spikes that exceed the published MAXIMUM TERMINAL RATINGS of the battery

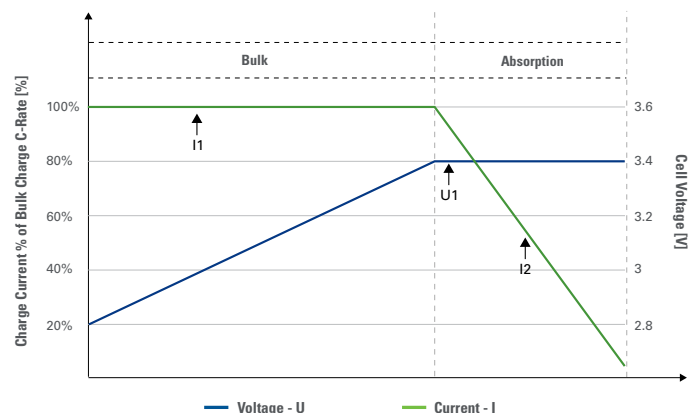
Spikes are fast, short duration electrical transients in voltage (voltage spikes), current (current spikes), or transferred energy (energy spikes) in an electrical circuit. Voltage spikes usually happen when the AC/DC adaptor is plugged in, or charge current is cut off quickly. Multi voltage chargers are made using transformers that may be capable of producing spikes that exceed the maximum ratings of the Discover AES. You must confirm with the charger supplier that the chargers being supplied:

- meet Discover's recommended charge curve, and
- are not capable of exceeding Discover's maximum terminal voltages.

6.3 Charge Curve

Charge sequence

5. Use Qualification phase for auto-on feature (optional).
6. Charge at constant current to 3.4V per cell module (Bulk).
7. Maintain constant voltage 3.4V per cell module (Absorption).
8. Terminate when charge current drops below 2A.



▲ CAUTION!

Do not charge battery higher than 3.4 V per cell module.

▲ NOTE!

Recommended charge current is 0.5C or below.

▲ NOTE!

If the temperature of the battery is below 0°C, the battery will not allow charge.

Model	Cell Modules in Series	I1	U1	Termination Charge Current
15-24-1000	8S	40 A maximum	27.2 V	$I_2 \leq 2 \text{ A}$
15-36-1000	12S	25 A maximum	40.8 V	

6.4 Discharging

- Turn on battery
- Turn on load

▲ NOTE!

Recharge battery immediately after every use.

▲ NOTE!

Do not discharge battery below recommended minimum operating voltages.

▲ NOTE!

Do not discharge battery at rates greater than recommended operating currents.

6.5 Storage

Systems should be stored out of direct sunlight under the following temperature conditions:

Minimum Storage Temperature	-20°C / -4°F
Maximum Storage Temperature	45°C / 113°F

Systems should be put into storage at > 80% SOC and checked monthly to ensure the system SOC does not fall below 20%. At 20% SOC the battery will self discharge in approximately 2 months.

▲ CAUTION!

Do not store a discharged battery. Recharge battery after every use. Batteries that have self-discharged to a severely discharge state are not recoverable.

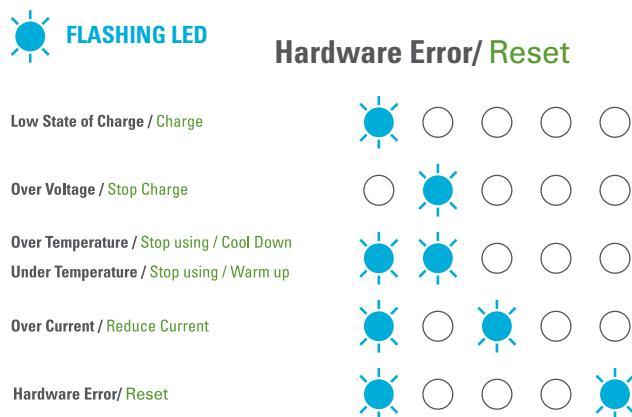
To improve the accuracy of the State of Charge indicator after the battery has been in storage, the battery should be cycled (charged and discharged) for proper calibration.

7. Protection & Faults

- BMS generates faults when maximum operating limits are reached.
- BMS sounds a buzzer when fault limits are triggered.
- BMS monitors the following information for faults and warning:
 1. Cell module voltage
 2. Battery current
 3. Battery temperature

7.1 Faults

In the event of a fault the BMS will sound an audible buzzer warning and the system will shut off after a 120 second delay. When the operating conditions are within acceptable ranges, the battery can be recovered from Fault by pushing the ON-OFF button.\



▲ NOTE!

Refer to device technical specification tables at the end of this manual for Fault Limits.

CORRECTIVE ACTIONS

High Temperature	<ul style="list-style-type: none"> • Stop discharge or charge • Leave the battery to cool
Low Temperature	<ul style="list-style-type: none"> • Stop discharge or charge
High Voltage	<ul style="list-style-type: none"> • If charging stop the charge • Confirm proper charge algorithm is being used
Low Voltage	<ul style="list-style-type: none"> • Do not discharge the battery. Any discharge current detected will force the battery into Low Voltage Fault • The user can charge the battery in Low Voltage Recovery • If no charge current is detected within 2 minutes the BMS will turn off the battery
Over Current	<ul style="list-style-type: none"> • Reduce current
Low SOC	<ul style="list-style-type: none"> • Stop discharge • Charge the battery
Hardware Error	<ul style="list-style-type: none"> • Cycle battery Off/On, if problem persists contact Discover Retailer

8. Service & Maintenance

Batteries should be carefully inspected on a regular basis in order to detect and correct potential problems before they can do harm. This routine should be started when the batteries are first received.

8.1 Inspection

- Look for cracks in the case
- Check the battery, terminals and connections to make sure they are clean, free of dirt, fluids and corrosion
- All battery cables and their connections should be tight, intact, and NOT broken or frayed
- Replace any damaged batteries
- Replace any damaged cables
- Check torque on terminal bolts

9. Troubleshooting

9.1 Battery Won't Turn On

Symptom	Does the battery turn on for a short time then turns itself off?
Description	The battery is likely in a low voltage or low SOC state. Check to see if the blue light is blinking. This indicates a low voltage or low SOC condition.
Action	Connect to charger and turn on the battery.

Symptom	Was the battery left on or stored for extended periods of time?
Description	The battery will turn itself off at 5% SOC. If left sitting at a low SOC, the battery may have discharged itself completely.
Action	Do not use. Replace and recycle.

10. Recycling and Disposal

Batteries must not be mixed with domestic or industrial waste. Discover's Advanced Energy Systems are recyclable and must be processed through a recognized recycling agency or dealer. Please contact Discover[®] or your servicing dealer for details.



11. 15-24-1000 TECHNICAL SPECIFICATIONS

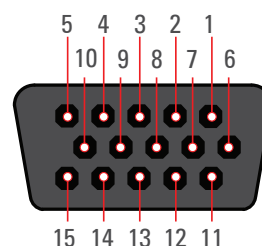
Electrical Specifications	
Nominal Voltage	25.6 V
Charge Voltage	27.2 V
Maximum Voltage	29.6 V
Minimum Voltage	22.4 V
Nominal Capacity	40 Ah
Nominal Energy	1024 Wh
Max Continuous Current	40 Adc
Fuse	80 A Internal Fuse - provides backup over-current protection
Cell Chemistry	LiFePO ₄
Cell Modules	8S 8P
Self-Discharge 25°C / 77°F	< 5% per month (battery off)
	< 30% per month (battery on)

Fault Limits	
OverTemperature - Discharge Protection	> 60°C/140°F for 2s
OverTemperature - Charge Protection	> 45°C/113°F for 2s
LowTemperature - Discharge Protection	< -20°C/-4°F for 2s
Low Temperature - Charge Protection	< -1°C/30°F for 2s
Over Voltage Protection	> 3.8 V in any cell module for 2s
Under Voltage Protection	< 2.5 V in any cell module for 2s
Over Current Protection	45 to 166 A for 6s
In-Rush Current Protection	166 to 222 A for 640ms

Mechanical Specifications	
Battery Dimensions (HxWxD)	198 x 258 x 167 mm
Battery Weight	12.4 kg
Shipping Dimensions (HxWxD)	255 x 340 x 255 mm
Shipping Weight	13 kg
Terminal	A2 - M6
Terminal Hardware	M6 Stainless Steel Bolt, Flat Washer, Lock Washer (Supplied)
Terminal Torque	7.0 - 7.7 Nm
Case Material	PC-ABS UL 94 V0 Compliant
Enclosure IP Rating	IP 55
Charge Temperature Range	0°C/45°C (32°F/113°F)
Discharge Temperature Range	-20°C/50°C (-4°F/122°F)
Storage Temperature Range	-20°C/45°C (-4°F/113°F)

Operational Specifications	
Battery Management System (BMS)	Integrated, with Solid State Relay (SSR)
Cell Balancing	Passive balancing during charge when Cell Voltage > 3.35 V
Non-Volatile Memory	Yes
Lifetime Logged Data	Charge Amp-Hours, Discharge Amp-Hours (lifetime)
State of Charge Battery Meter	5 LEDs (> 80%, 60%, 40%, 20%, 5%)
Communication Ports	Isolated RS232 communication port
Communication Connector	DE-15 Female

FEMALE



Pin 3	RS232 GND	Isolated RS232 Ground
Pin 4	RS232 TX	Isolated RS232 Transmit
Pin 5	RS232 RX	Isolated RS232 Receive

Regulatory Approvals	UN 38.3, Designed to: IEC 62133, UL 2271
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UN38.3 PASSED
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12. 15-36-1000 TECHNICAL SPECIFICATIONS

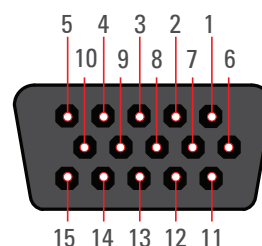
Electrical Specifications	
Nominal Voltage	38.4 V
Charge Voltage	40.8 V
Maximum Voltage	44.4 V
Minimum Voltage	33.6 V
Nominal Capacity	25 Ah
Nominal Energy	960 Wh
Max Continuous Current	25 A
Fuse	50 A Internal Fuse - provides backup over-current protection
Cell Chemistry	LiFePO ₄
Cell Modules	12S 5P
Self-Discharge 25°C / 77°F	<5% per month (battery off)
	<30% per month (battery off)

Fault Limits	
OverTemperature - Discharge Protection	> 60°C/140°F for 2s
OverTemperature - Charge Protection	> 45°C/113°F for 2s
LowTemperature - Discharge Protection	< -20°C/-4°F for 2s
Low Temperature - Charge Protection	< -1°C/30°F for 2s
Over Voltage Protection	>3.8V in any cell module for 2s
Under Voltage Protection	<2.5V in any cell module for 2s
Over Current Protection	28 to 88 A for 6s
In-Rush Current Protection	88 to 134 A for 640ms

Mechanical Specifications	
Battery Dimensions (HxWxD)	198 x 258 x 167 mm
Battery Weight	12.4 kg
Shipping Dimensions (HxWxD)	255 x 340 x 255 mm
Shipping Weight	13 kg
Terminal	A2 - M6
Terminal Hardware	M6 Stainless Steel Bolt, Flat Washer, Lock Washer (Supplied)
Terminal Torque	7.0 - 7.7 Nm
Case Material	PC-ABS UL 94 V0 Compliant
Enclosure IP Rating	IP 55
Charge Temperature Range	0°C/45°C (32°F/113°F)
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UN38.3 PASSED
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