



Aspen Battery Installation & Operation Manual



Aspen 48S



Aspen 48M



Aspen 24S

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Find all product documentation at <http://aquionenergy.com/support/product-documentation>.

Symbols in This Document



WARNING

WARNING indicates a hazardous situation that, if not avoided, could result in death, injury, or damage.



ATTENTION

ATTENTION indicates information that is important but not critical to safety.

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1 Introduction

1.1 About This Manual

This manual is intended to provide technical information and safe practices regarding receiving, installing, and operating the Aquion Energy Aspen battery. For complete safety information, refer to the Safety Data Sheet (SDS) included with your product shipment.



WARNING

Failure to follow the instructions in this document could result in fire, electric shock, and/or other injury or damage.

1.2 Contact Information

Mail: Aquion Energy
32 39th Street
Pittsburgh, PA 15201

Telephone: +1 412.904.6400

Web: aquionenergy.com

2 Product Information

2.1 Product Overview

Aqueous Hybrid Ion (AHI™) batteries use non-toxic, non-corrosive materials to make the world's only clean and sustainable electrochemical storage solution. Aquion Aspen 48S, 48M, and 24S batteries provide long-duration, stationary storage for residential solar, off-grid, microgrid, and energy management applications.

Aspen 48S

The Aspen 48S is the base component of Aquion Energy's scalable energy solutions. The Aspen 48S connects eight AHI battery cells in series for an unfused, 48 V product.

Aspen 48M

The Aspen 48M is a palletized, pre-wired, plug-and-play battery bank. It can serve as a stand-alone system or as a modular building block for larger systems. The Aspen 48M battery connects twelve Aspen 48S batteries in parallel, adds fusing for each 48S, and includes on-board sensing of the 48M's voltage, current, and temperature.

Aspen 24S

The Aspen 24S is a 24 V variant of the Aspen 48S battery. The Aspen 24S connects two parallel strings of four series-connected AHI battery cells for an unfused, 24 V product.

2.2 Product Specification

Voltage curves, operational efficiency, capacity by charge and discharge currents, standards compliance and certification status, and more information can be found on the Product Specification Sheet for your battery model (<http://aquionenergy.com/support/product-documentation>). The battery's model number appears on the product label.

2.3 UL

The Aspen 48S and 24S are UL recognized. The following certification tests have been completed:

- | | |
|---------------------------------------|-------------------------------------|
| + UL 1973-13 Overcharge | + UL 1973-14 Short Circuit |
| + UL 1973-15 Overdischarge Protection | + UL 1973-16 Temp and Ops |
| + UL 1973-17 Imbalanced Charging | + UL 1973-23 Vibration |
| + UL 1973-24 Shock | + UL 1973-25 Crush |
| + UL 1973-26 Static Force | + UL 1973-27 Impact |
| + UL 1973-30 Mold Stress | + UL 1973-31 Pressure Release |
| + UL 1973-32 Start-To-Discharge | + UL 1973-34 Resistance to Moisture |
| + UL 1973-35 Salt Fog | + UL 1973-36 External Fire Exposure |

2.4 CE

The Aspen 48S, 48M, and 24S batteries are CE marked. They have been assessed to meet high safety, health, and environmental protection requirements for sale in the Single Market in the European Economic Area. Contact Aquion for any of the Aspen batteries' CE Declaration of Conformity.

2.5 Cradle to Cradle Certification

The Aspen 48S and 24S batteries are Cradle to Cradle Certified™ Bronze products. Cradle to Cradle Certified™ is a certification mark licensed by the Cradle to Cradle Products Innovation Institute, which independently assesses and certifies products for material health, material reutilization, renewable energy use and carbon management, water stewardship, and social fairness.

2.6 Electromagnetic Compatibility – 48M

2.6.1 FCC

This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

Note: This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference, in which case the user will be required to correct the interference at his own expense.

2.6.2 CE

This product may cause interference if used in residential areas. Such use must be avoided unless the user takes special measures to reduce electromagnetic emissions to prevent interference to the reception of radio and television broadcasts.

3 Safety Information

Only qualified individuals are to install and service battery systems.

3.1 Electrical Hazards

Never place foreign objects or tools in or on the unit. The metal parts of the battery terminals are always live. Electrical hazards exist in the voltage and current ranges that are found in battery systems and associated electronics.



WARNING

Connecting Aspen batteries in series can lead to dangerously high voltages. Aquion must review any series configurations of Aspen 48S or 48M batteries prior to installation. Never connect Aspen 24S batteries in series. When connecting Aspen 48S or 24S batteries in parallel, Aquion recommends placing overcurrent protection devices as close as possible to the DC bus.

3.2 Electrical Safety

The batteries must be protected from overcurrent charge and discharge with appropriately rated overcurrent protection devices. If grounding is required, see Section 6.5.5.

Battery Model	Max. Recommended Charge/Discharge Current	Integrated Fusing	Notes
48S	20 A	None	
48M	240 A	Twelve 1,000 V, 20 A fuses, one per component 48S battery	Fuses are disconnected at the factory and will need to be connected (see Section 5.5).
24S	30 A	None	

3.3 Chemical Hazards

Aspen battery materials are non-toxic and present no chemical hazards. The AHI electrolyte is sodium-sulfate-based saltwater with a neutral pH. In the unlikely event that the electrolyte comes in contact with eyes or skin, thoroughly wash it out with water. Electrolyte residue on the battery terminal can be wiped away with a cloth. A collection pan under the battery stack or module is not needed as the electrolyte will not leak during normal operation, and any leaked electrolyte will not damage battery surfaces or equipment. Refer to the Safety Data Sheet (SDS) for more information.

3.4 Gas Emissions

The battery may emit trace amounts of gas H₂, O₂, CO₂, and CO during normal operation. These gases do not accumulate in hazardous quantities in typical installations when the batteries are installed and operated in accordance with the guidelines of this document (see Section 5.2.3). The battery has fully passed UL 1973 overcharge testing, an abuse test that includes monitoring for combustible vapor concentrations. Overcharging the battery (outside of specified guidelines) will result in venting of some incremental amounts of the gases listed above through the pressure relief valve.

3.5 Weight Hazards

Aspen batteries must be transported and handled with appropriate precautions. See Section 5.3 for moving and tilting restrictions.

Battery Model	Weight	Notes
48S, 24S	118 kg (260 lbs)	
48M	1,504 kg (3,315 lbs)	Forklift trucks or pallet jacks are recommended for moving and positioning 48M batteries.

3.6 Ingress Protection

The International Electrotechnical Commission publishes the International Protection (IP) Code, which classifies the degrees of protection provided by electrical equipment enclosures against ingress of solid particles and liquid.

Battery Model	Solid Particle Protection Level 2*	Liquid Ingress Protection Level 2†	IP code
48S, 24S	Confirmed	Confirmed	IP22
48M	Confirmed	Not tested	IP2X

* Protected from ingress of objects greater than 12.5 mm, such as fingers or similar objects (IP##).

† Protected against harmful effects of ingress of dripping water when tilted up to 15 degrees, for a duration of 10 minutes or less (IP#.#).

3.7 Decommissioning Hazards

AHI batteries are non-toxic and non-corrosive. Do not dump into any sewers, on the ground, or into any body of water where water runs off into open bodies of water. Dispose of according to all federal, state, and local regulations.

4 Transportation and Receipt of Product

4.1 Packaging

Battery Model	Quantity per Pallet	Packing Type	Tip-N-Tell and Drop-N-Tell Indicator Location
48S, 24S	12 or fewer	Wrapped (U.S. shipments) or crated (outside U.S.)	Affixed to outside of packaging
48M	1	Wrapped (all shipments)	Affixed to outside of wrapping

4.2 Shipping

Battery Model	Shipping Configuration Testing	State of Charge (SOC) and Voltage at Shipping
48S	Modified ISTA* 3H shipping test	<2% SOC, <45 V
48M	Pending modified ISTA 3H shipping test	<2% SOC, <45 V
24S	Modified ISTA* 3H shipping test	<2% SOC, <22.5 V

* International Safe Transit Association

4.2.1 Hazards

Aquion batteries are not hazardous and are not regulated as dangerous goods by the U.S. Department of Transportation (DOT). They do not need special transportation services. Customers shipping Aquion batteries Ex Works (EXW) should request the most recent Safety Data Sheet (SDS) from Aquion. Aquion includes a hard copy of the most recent SDS with every shipment.

4.2.2 Requirements

Aspen batteries should be shipped in an upright position and should not be tipped for extended periods. Communicate this restriction to the shipper prior to transport. The affixed Tip-N-Tell indicators trip if the package experiences extreme tilt. See Section 5.3 for moving and tilting restrictions.

4.3 Delivery Inspection

Immediately upon delivery, inspect all hard goods for signs of damage or tipping during transit before signing for the delivery. Any of the following may indicate damage during transport:

- + Damaged or torn packaging
- + Scraped or punctured product components
- + Leaking electrolyte (clear liquid)
- + Tripped Drop-N-Tell indicator
- + Tripped Tip-N-Tell indicator

If you find damage, document any signs of damage on the bill of lading before accepting the shipment. Separately document and photograph all damage, and make a claim with the carrier as soon as possible. Contact your distributor immediately.

Slight bulges or depressions in the cases of Aspen 24S or 48S batteries are normal. The battery cases are intentionally flexible to accommodate compression of the electrode stack and normal variations in internal pressure during operation. A depression or bulge of up to 10 mm in the sidewall of the battery case is not unusual, especially in new batteries, and does not present an unsafe condition. If a bulge projects more than 10 mm, do not place the battery in service, or remove it from service if already commissioned, and contact Aquion Technical Support (see Section 10).

4.4 Disassembly Hazards



WARNING

Do NOT attempt to disassemble Aspen 48S or 24S batteries. Do NOT remove the nut on the compression fixture on top of the battery.

Aspen 48S and 24S batteries have been compressed to optimize performance. Releasing this load could result in poor battery performance, permanent damage to battery components, and/or injury.

5 Installation



ATTENTION

Aspen batteries ship at low state of charge and low voltage. See Section 7.1.

Aspen 48M fuses are installed but not connected. The battery will not function until the fuses are connected. See Section 5.5.

Aspen 48M batteries and systems of sensed Aspen 48S batteries must be set up with the Aquion Battery Monitoring System (BMS-200) before operation. See Section 5.4.

Installation of Aspen batteries requires accessories not supplied by Aquion. Find the complete list of required accessories at <http://aquionenergy.com/support/product-documentation>.

5.1 Unpacking

Unpack all items carefully and note quantities received. Contact your authorized Aquion distributor if any items are missing or damaged.

Battery Model	Shipping Pallet	Included Accessories
48S, 24S	Removable	Lifting eye (one per pallet)
48M	Permanent	Amphenol DeviceNet Thick Patch Cable, 2 m, 90° (one per 48M battery, may ship separately)

5.2 Site Requirements

5.2.1 Exposure and Enclosure

Aspen batteries should be installed indoors or enclosed from the elements. A fully sealed enclosure is not recommended.

Install and operate Aspen batteries out of direct exposure to sunlight. Prolonged exposure to ultraviolet light may damage the polypropylene casing and reduce product lifetime.

5.2.2 Size and Weight

Position Aspen batteries only on surfaces appropriately rated for the product's weight. Ensure that the installation location is large enough to contain the battery product.

Battery Model	Height	Width	Depth	Weight
48S, 24S	935 mm (36.8")	330 mm (13.0")	310 mm (12.2")	118 kg (260 lbs)
48M	1,159 mm (45.6")	1,321 mm (52.0")	1,016 mm (40.0")	1,504 kg (3,315 lbs)

5.2.3 Ventilation

Aquion batteries emit trace amounts of gas during normal cycle operation. Aquion recommends installing the Aspen 48S in a non-sealed, ventilated area:

- + For installations in locations that are frequently occupied (more than 8 hours of human occupation per 24 hours), Aquion recommends continuous ventilation of 0.85 m³/hr (0.5 ft³/min) per operational battery stack.
- + For installations in locations that are infrequently occupied (less than 8 hours of human occupation per 24 hours), Aquion recommends CO detection and periodic ventilation of 0.85 m³/hr (0.5 ft³/min)

per operational battery stack or in any instance when the measured CO concentration is greater than the user's defined environmental health and safety guidelines for CO.

Alternatively, in North America, IBC and/or NFPA 1 guidelines recommend that all battery installations in enclosed spaces include ventilation equal to either six (6) air changes per hour or ventilation at 1 ft³/min per square foot of room size. In Europe and other locations, EN 50272 guidelines recommend that batteries be installed in well-ventilated rooms where ventilation corresponds to battery capacity and the exhaust air is discharged outside the building.

5.2.4 Humidity

Install Aspen batteries in clean, ordinary conditions protected from water exposure. Direct exposure of Aspen batteries to water may cause shorting. The batteries may be installed in humid or coastal regions with atmospheric salt.

5.2.5 Ambient Temperature

Aspen batteries must be operated in temperatures between -5°C and 40°C on a 24-hour average. Operation above or below these limits will cause advanced degradation of the battery chemistry. Aspen batteries must be stored in temperatures between -10°C and 40°C. Storage above or below these limits may permanently damage the batteries.

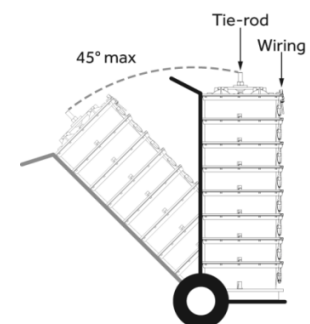
5.3 Moving

5.3.1 48S, 24S

Use proper lifting procedures and personal protective equipment when moving Aspen batteries. The Aspen 48S and 24S batteries have been designed to be moved using a lifting eye, included on each pallet of batteries, screwed onto the threaded, metal tie-rod that runs vertically through the center of the battery. No other component of the Aspen 48S and 24S is designed to support the battery's suspended weight. Use a crane, hoist, or similar device of appropriate load-bearing capacity to lift one Aspen 48S or 24S battery at a time by the lifting eye.

NEVER LIFT ASPEN 48S OR 24S PRODUCTS BY THE TERMINALS OR ANY PART OTHER THAN AN APPROPRIATELY RATED LIFTING EYE THREADED ONTO THE TIE-ROD AS THIS WILL VOID THE WARRANTY AND MAY CAUSE DAMAGE TO THE PRODUCT AND/OR SIGNIFICANT INJURY.

Alternatively, use an appropriately sized hand truck to move Aspen 48S or 24S batteries. Position the battery on the hand truck so that the wiring faces out, away from the upright frame of the hand truck. During movement to the installation site and during installation, batteries may be tilted up to forty-five (45) degrees for up to one hour. Before moving any Aspen 48S or 24S batteries, ensure that the travel path will not require tipping the battery more than forty-five (45) degrees and that the installation location is level.



5.3.2 48M

The Aspen 48M battery must be transported and handled with appropriate precaution. The use of forklift trucks and pallet jacks is recommended to move and position the battery. Before moving any Aspen 48M battery, ensure that the travel path will not require tipping the battery more than fifteen (15) degrees and that the installation location is level.

5.4 Placement



ATTENTION

Before restricting physical access to 48M or sensed 48S battery systems, such as in racking or shipping containers,

- 1. Connect Aspen 48M fuses. This requires removing and replacing the top cover. See Section 5.5.**
- 2. Set up the batteries with the Aquion BMS-200. This requires physical connection of power and communication cables. See the BMS-200 Installation & Operation Manual for instructions.**

Aspen batteries do not need any particular amount of clearance between other Aspen batteries or other architectural features, so they can be arranged in tightly packed groups. Always follow local codes for aisle and access requirements. Access and working spaces shall comply with all local codes. However, when interpreting codes, note the following points:

- + Access to the battery stack connections and lifting point for wiring and installation into the energy storage system is available at the top of the batteries.
- + When wired in parallel, Aspen batteries operate below 60 Vdc. Normal installation and operation of Aspen batteries do not require access to the sides of the batteries, including the side with cable harnesses.
- + Aquion batteries do not normally require examination, adjustment, servicing, or maintenance while energized.

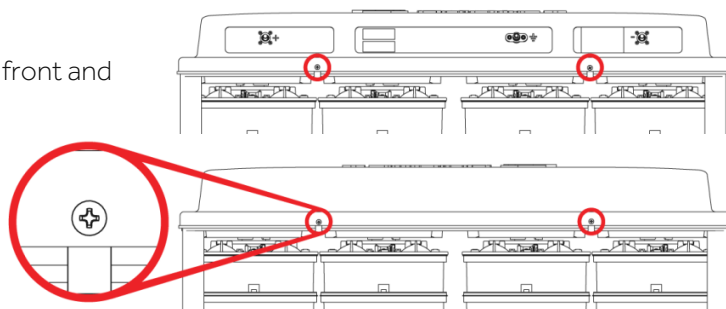
Do not stack Aspen batteries on top of each other. Do not place other items on top of the batteries. Aspen batteries are designed to be installed in an upright position (less than fifteen (15) degrees of tilt).

5.5 Fuse Connection Instructions – 48M

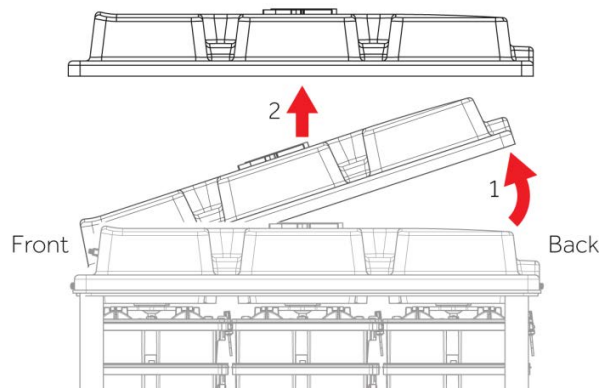
Each Aspen 48M battery ships with 12 installed, but disconnected, 20 A fuses, one for each component Aspen 48S, located beneath the battery's top cover. All 12 fuses must be connected for the battery to operate. Connect the fuses before installing the battery in your system.

1. Remove the battery's top cover.

- a. Remove the four bolts from the front and back of the battery's top cover.

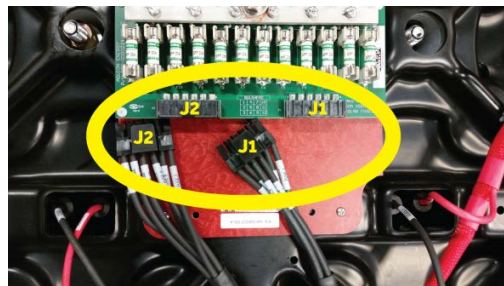


-
- b. Lift off the cover by raising the back end first, sliding the cover slightly forward to clear the terminal posts, and lifting the entire cover clear.



2. Connect the two fuse bundle connectors.

- a. Inside the top tray, locate the fuse board and the two loose fuse bundle connectors.

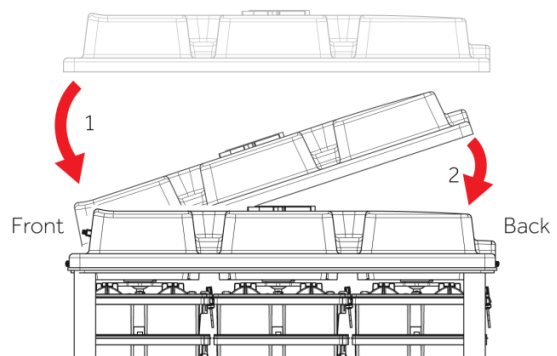


- b. Insert the J1 and J2 connector bundles into the J1 and J2 receptacles, respectively, on the fuse board until you hear a click. Check that the connectors are tightly secured.



3. Replace the top cover.

- a. Lower the front end over the terminal posts, and then lower the back end.



4. Replace the four bolts on the front and back of the top cover. For each bolt:

- a. If the clip beneath the edge of the cover has tilted, realign the clip vertically so that its hole aligns with the hole in the cover.



-
- b. Screw in the bolt through the hole in the top cover and the hole in the clip.

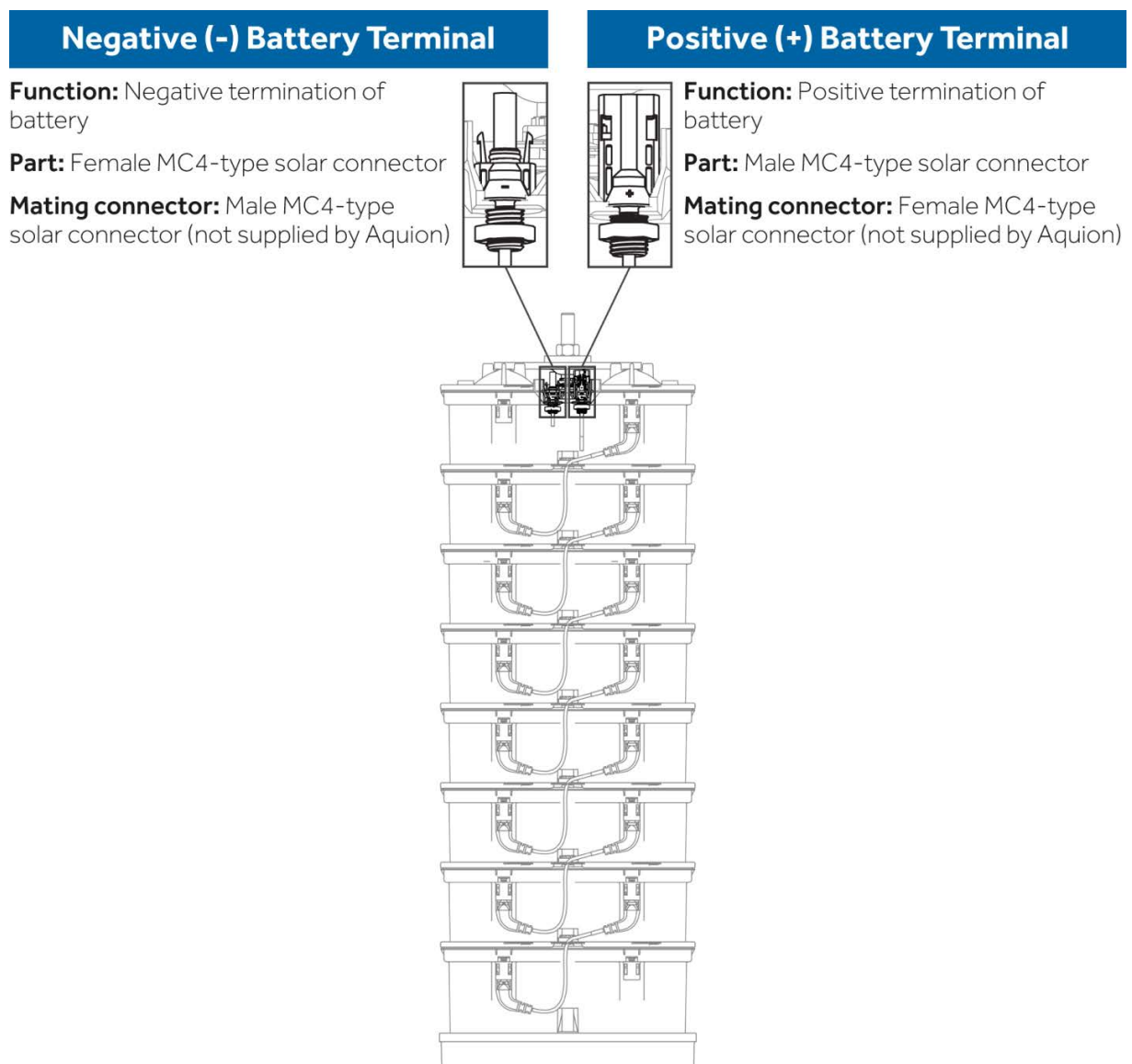


6 Electrical Integration

6.1 Electrical Interfaces and Connections

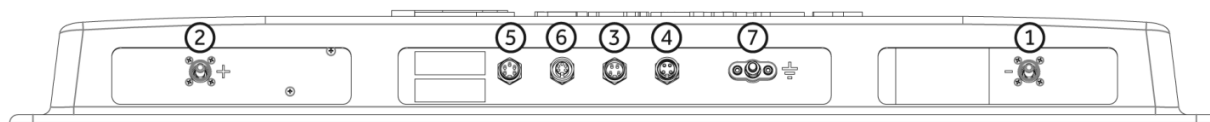
6.1.1 48S, 24S

Aspen 48S and 24S battery terminals are standard MC4-type solar connectors (48S battery pictured below). Aquion does not supply mating connectors. For optimal battery performance, Aquion recommends non-gold-plated, MC4-compatible solar connectors, such as the Amphenol H4, Flagsun FC-001, or equivalent. Find details on the battery terminal parts and the complete list of required accessories at <http://aquionenergy.com/support/product-documentation>.

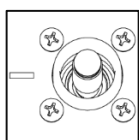


6.1.2 48M

Aspen 48M installation requires mating connectors and cables. Aquion supplies one (1) DeviceNet communications cable per 48M battery. Aquion does not supply the other accessories. Find the complete list of accessories at <http://aquionenergy.com/support/product-documentation>.



① Negative (-) Battery Terminal



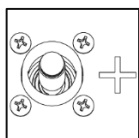
Function: Negative termination of battery

Part: Amphenol RADLOK RL9-100-101 Black

Mating connector: Amphenol RADLOK Tubular Connector Black RL0-100-1-xxBK* or equivalent. Part not supplied by Aquion.

Pin #	Name	Wire Color	Description
1	BATT-	Black	Battery Negative Terminal

② Positive (+) Battery Terminal



Function: Positive termination of battery

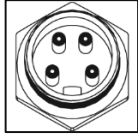
Part: Amphenol RADLOK RL9-100-101 Red

Mating connector: Amphenol RADLOK Tubular Connector Red RL0-100-1-xxRE* or equivalent. Part not supplied by Aquion.

Pin #	Name	Wire Color	Description
1	BATT+	Red	Battery Positive Terminal

* "xx" is cable size, which is determined by your installation.

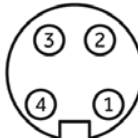
③ 24V I/O In



Function: Power input for contactor control

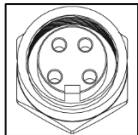
Part: Amphenol SineCo MN41PW02M005 4-pin miniBOSS, Male Receptacle, External Threads

Mating connector: Amphenol SineCo MN47[A/B]4[A/B]C01Mxxx* 4-pin miniBOSS Cordset, or equivalent, connected to a 24 V power supply (not shown; see Section 6.1.3). Parts not supplied by Aquion.



Pin #	Name	Wire Color	Description
1	24V_IO_NEG	Black	24 V I/O Negative
2	24V_IO_POS	White	24 V I/O Positive (for driving contactors)
3	INTLK_RLY_IN	Red	Interlock Relay In (normally open)
4	RLY_RTN_IN	Green	Interlock Relay Return In

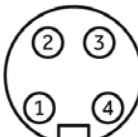
④ 24V I/O Out



Function: Power output for contactor control

Part: Amphenol SineCo MN44PW02M030 4-pin miniBOSS, Female Receptacle, Internal Threads

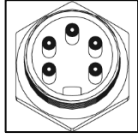
Mating connector: Amphenol SineCo MN47[A/B]4[A/B]C01Mxxx* 4-pin miniBOSS Cordset or equivalent. Part not supplied by Aquion.



Pin #	Name	Wire Color	Description
1	24V_IO_NEG	Black	24 V I/O Negative
2	24V_IO_POS	White	24 V I/O Positive (for driving contactors)
3	INTLK_RLY_IN	Red	Interlock Relay In (normally open)
4	RLY_RTN_IN	Green	Interlock Relay Return In

* "[A/B]" is connector style: A for straight, B for right-angle. The first "[A/B]" refers to the female connector, the second, the male. Choose the appropriate connector style for your installation. "xxx" refers to cable length, which is determined by your installation's requirements.

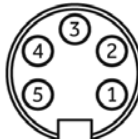
⑤ CAN In



Function: Input for sensing board power and CANbus communication

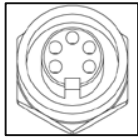
Part: Amphenol SineCo DeviceNet MN51PD01M005 Male Receptacle, External Threads

Mating connector: Amphenol SineCo DeviceNet Thick MN57[A/B]4[A/B]D01Mxxx* Patch Cable or equivalent. Aquion supplies one (1) 2-m, 90°-connector patch cable per 48M battery.



Pin #	Name	Wire Color	Description
1	CAN_GND	Bare	Isolated CAN Ground
2	24V_LOGIC_POS	Red	24 V Logic Positive
3	24V_LOGIC_NEG	Black	24 V Logic Negative
4	CAN_H	White	CAN High Signal
5	CAN_L	Blue	CAN Low Signal

⑥ CAN Out



Function: Output for sensing board power and CANbus communication

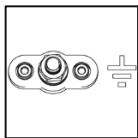
Part: Amphenol SineCo DeviceNet MN54PD01M005 Female Receptacle, Internal Threads

Mating connector: Amphenol SineCo DeviceNet Thick MN57[A/B]4[A/B]D01Mxxx* Patch Cable or equivalent. Aquion supplies one (1) 2-m, 90°-connector patch cable per 48M battery.



Pin #	Name	Wire Color	Description
1	CAN_GND	Bare	Isolated CAN Ground
2	24V_LOGIC_POS	Red	24 V Logic Positive
3	24V_LOGIC_NEG	Black	24 V Logic Negative
4	CAN_H	White	CAN High Signal
5	CAN_L	Blue	CAN Low Signal

⑦ Earth Ground Lug



Function: Battery grounding

Part: Cooper Bussmann C1938

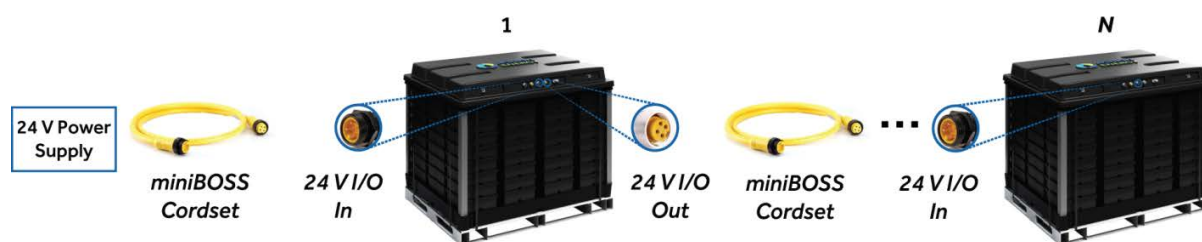
Mating connector: Ground wire with 3/8" ring terminal. Part not supplied by Aquion.

* "[A/B]" is connector style: A for straight, B for right-angle. The first "[A/B]" refers to the female connector, the second, the male. Choose the appropriate connector style for your installation. "xxx" is cable length, which is determined by your installation's requirements.

6.1.3 Contactor Control – 48M

A DC contactor (Gigavac GX11S) is installed on the positive (+) lead of each Aspen 48M battery. The DC contactor must be powered by an external 24 V power supply. Aquion does not provide this power supply.

A single 24 V power supply may be used to power the DC contactors of up to 16 Aspen 48M batteries connected by appropriate power cables (see Section 6.1.2). The power supply, connected to the first battery in the string, must be capable of supplying 100 mA to each battery in the system, plus at least 1 A of surge current. See Section 6.4 for cabling requirements.



The DC contactor operation can be easily integrated into a system-level emergency stop (ESTOP) system to break down the series voltage to <59.5 Vdc.

6.2 Product Wiring Diagrams



WARNING

Do not disconnect any cables between cells within a 48S or 24S battery at any time during installation, operation, or storage. Doing so voids the battery warranty and could lead to unsafe operation of the batteries.



6.3 Racking/Scaling Systems

Aspen 48M batteries are compatible with a variety of pallet racking solutions offered by vendors around the world. They are designed to be racked in standard pallet racking or drive-in, edge-loaded racking systems. Contact Aquion for more information.

6.4 Cabling Requirements

System Battery Model	Cabling Purpose	Cable	Max. Combined Length
48M	24 V contactor power	Amphenol SineCo 4-pin miniBOSS Cordset (MN47A4AC01Mxxx*) or equivalent	60 m (200 ft)
48M, 48S with SMI-100 Stack Monitoring Interface	CANbus communications	Amphenol SineCo DeviceNet Thick Patch Cable (MN57A4AD01Mxxx*) or equivalent	73.2 m (240 ft)

6.5 Parallel Wiring

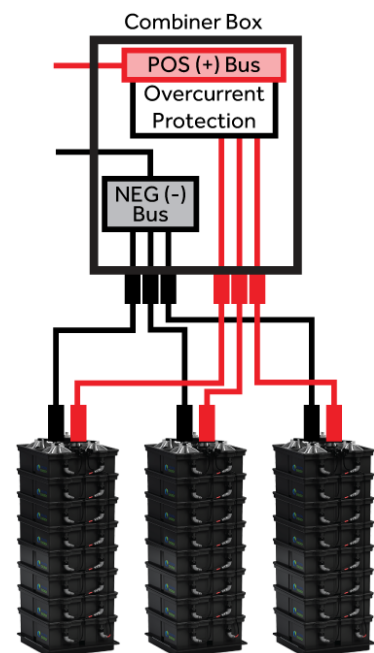
Always consult local code and regulations when wiring an electrical system. The following are only select examples of how to wire together Aspen batteries in parallel. Aquion strongly recommends fused configurations for battery products in parallel.

6.5.1 **48S, 24S**

Aspen 48S and 24S batteries are designed to be connected in parallel configurations with appropriate branch fusing. Aquion recommends monitoring for large systems of Aspen 48S batteries in parallel. Branch fuse limits may reduce the number of batteries that can be connected in parallel. Contact Aquion or your Aquion dealer for more details. Any parallel configuration should use a standard combiner box with overcurrent protection devices. Use wiring and overcurrent protection in accordance with local standards and codes and the guidance in Section 6.5.4.

6.5.2 **48M**

Up to 16 Aspen 48M batteries may be connected in parallel if monitored by a BMS-200 (see Section 6.5.3). Monitoring with the BMS-200 enables power control electronics to balance the batteries' capacities and states of charge.

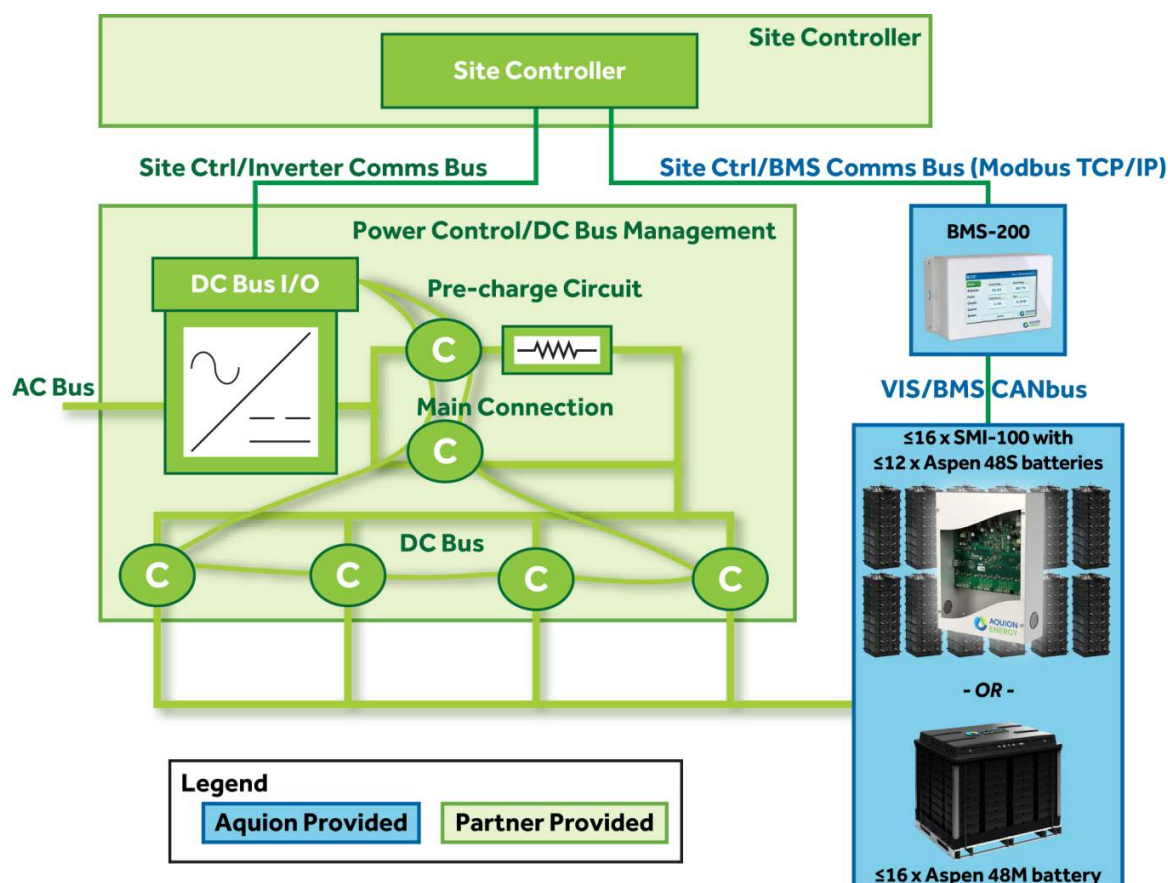


* Aquion Energy does not supply these accessories. They are available through Amphenol distributors worldwide (http://www.amphenol-sine.com/Distributors_c_108.html). Find the complete list of required accessories and parts at <http://aquionenergy.com/support/product-documentation>.

6.5.3 Monitoring

An Aquion BMS-200 can connect to as many as 16 Aquion sensing boards:

- + up to 16 Aquion SMI-100 Stack Monitoring Interfaces, each connected to as many as 12 Aspen 48S batteries - OR - + up to 16 Aspen 48M battery sensing boards daisy-chained together in a string



The BMS communicates to the site controller via Modbus TCP/IP. Contact Aquion for details of the communications protocol. Download the SMI-100 and BMS-200 specification sheets and manuals (<http://aquionenergy.com/support/product-documentation>) for more information.

If connected to an SMA Sunny Island inverter, 48S batteries may be monitored by a BMS-200 without a SMI-100. For details, see the *Aquion Battery and SMA Sunny Island Inverter Installation Manual* (<http://aquionenergy.com/support/product-documentation>).

! ATTENTION

Before restricting physical access to 48M or sensed 48S battery systems, such as in racking or shipping containers, set up the batteries with the Aquion BMS-200. This requires physical connection of power and communication cables. See the BMS-200 Installation & Operation Manual for instructions.

6.5.4 Overcurrent Protection

Systems should be protected in accordance with local codes and regulations and the parameters in the table below:

Battery Model	Continuous Current Limit	Short Circuit Current Interrupt Capability (with installation-appropriate voltage rating)
48S	<20 A	140 A
48M	<240 A	Not applicable
24S	<30 A	240 A

6.5.5 Grounding

If grounding is required, ground Aspen batteries according to local codes.

Battery Model	Grounding Point	Notes
48S, 24S	Tie rod	Recommended parts: ring terminal (Morris Products 11072), nut (McMaster 93839A832), 10 AWG wire, standard wire crimper. Attach the ring terminals to the battery, and then ground the stacks.
48M	3/8" - 16 grounding lug	A ground wire of proper size, based on local code and regulations, should be connected to the grounding lug and directly to the system DC ground.

6.6 Series Wiring



WARNING

Connecting Aspen batteries in series can lead to dangerously high voltages. Connecting Aspen 48S batteries in series is not recommended. Aquion must review any series configurations of Aspen 48S or 48M batteries prior to installation. Never connect Aspen 24S batteries in series.

Battery Model	Series Configuration	Monitoring	Notes
48S	Not recommended. Aquion must review any series configuration before installation.	Required: voltage per battery	Ensure each battery does not exceed its recommended maximum voltage. Series configurations can cause Aspen 48S batteries to exceed their voltage limit, damaging the batteries and degrading their performance and life.
48M	Aquion must review any series configuration before installation.	Required	Maximum system voltage: 1,000 Vdc
24S	Never connect 24S batteries in series.	Not applicable	Series configurations of Aspen 24S batteries can lead to dangerously high voltages.

7 Commissioning

7.1 Initial Charge

Aspen batteries are shipped at less than 2% state of charge (SOC) and less than 45 V (48S, 48M) or 22.5 V (24S). If the initial voltage is insufficient for charging power electronics, the batteries can be charged using a battery charging device set to the operating limits of the Aspen battery as defined in the latest product specification sheet (<http://aquionenergy.com/support/product-documentation>). Use only power supplies designed to charge batteries. Most DC power supplies are not designed to charge batteries and lack sufficient reverse current protection.

During its initial charge cycles, the battery may accept more energy than its nominal energy capacity before it reaches its maximum voltage. This is the normal conditioning process that occurs in the battery. A specific conditioning procedure is not required.

7.2 Voltage Matching

If Aspen batteries are to be wired in parallel, match the voltages of all batteries within the limits listed below before connecting individual batteries together:

Battery Model	Max. Recommended Voltage Difference
48S, 48M	5 Vdc
24S	2.5 Vdc

Take care when "live parallel bussing" batteries with unequal open circuit voltages (OCV). The high impedance of the Aspen battery limits its short-circuit current. However, connecting batteries with voltage differences greater than those listed above can damage the batteries and unbalance the system.

7.3 Configuring Inverters and Charge Controllers

Aspen batteries work with nearly all off-the-shelf inverters and charge controllers designed for 24 V or 48 V residential energy storage systems. To set your specific equipment, use the information provided in Section 8 of this manual and Aquion's latest operational settings for power control electronics (<http://aquionenergy.com/support/product-documentation>).

8 Operation

To maximize the performance and longevity of Aspen batteries, follow the operation guidance presented below. Failure to operate the batteries within these limits may damage the batteries, degrade their performance, shorten their life, and void the product warranty.

8.1 Operational Limits

Battery Model	Max. Recommended Charge or Discharge Current	Voltage Range (operation after initial charge)	Ambient Temperature (24-hour average)
48S	20 A	40–59.5 V	–5°C to 40°C
48M	240 A	40–59.5 V	–5°C to 40°C
24S	30 A	20–29.7 V	–5°C to 40°C

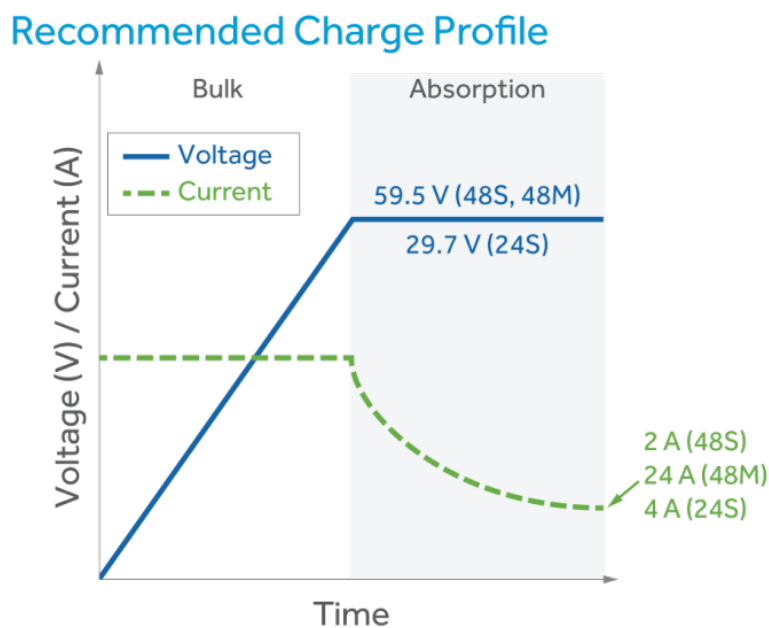
8.2 Charge Profiles

For clarity, the charge profiles include the lead acid charge terminology of *bulk*, *absorption*, and *float*, though they are not strictly correct for the AHI chemistry. Find Aquion's latest operational settings for power control electronics, available at <http://aquionenergy.com/support/product-documentation>.

8.2.1 Recommended Charge Profile

Use the recommended charge profile to obtain the energy and capacity from the Aspen battery's product specifications, which were obtained after a 10-hour charge.

Battery Model	Max. Current	Recommended Bulk Current	Max. (Absorption) Voltage	Absorption Cut-Off
48S	20 A	<10 A	59.5 V at 30°C average charge	Current <2 A
48M	240 A	<120 A	59.5 V at 30°C average charge	Current <24 A
24S	30 A	<20 A	29.7 V at 30°C average charge	Current <4 A



8.2.2 Boost Charge Profile

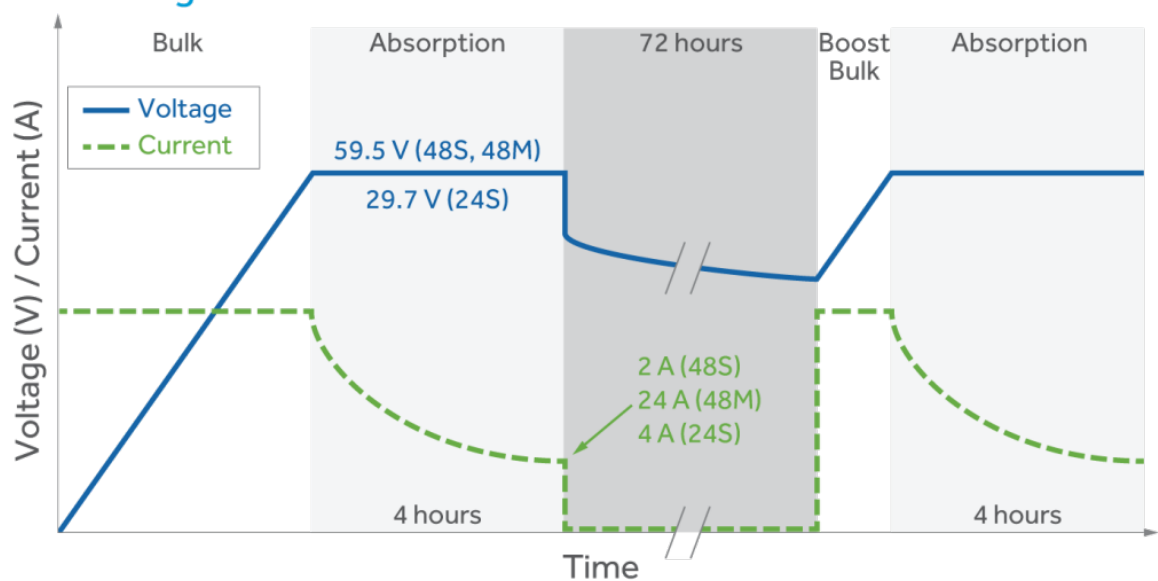
Use the boost charge profile if your Aspen battery system

- + needs to go longer than three days between discharges
AND
- + is allowed to go open circuit

This profile is for UPS and back-up applications that do not use the batteries every day.

Battery Model	Max. Current	Recommended Bulk Current	Max. (Absorption) Voltage	Absorption Cut-Off	Boost Charge
48S	20 A	<10 A	59.5 V at 30°C average charge	Time <4 hours -OR- Current <2 A	Repeat every three days between discharges
48M	240 A	<120 A	59.5 V at 30°C average charge	Time <4 hours -OR- Current <24 A	Repeat every three days between discharges
24S	30 A	<20 A	29.7 V at 30°C average charge	Time <4 hours -OR- Current <4 A	Repeat every three days between discharges

Boost Charge Profile



8.2.3 Three-Stage Charge Profile

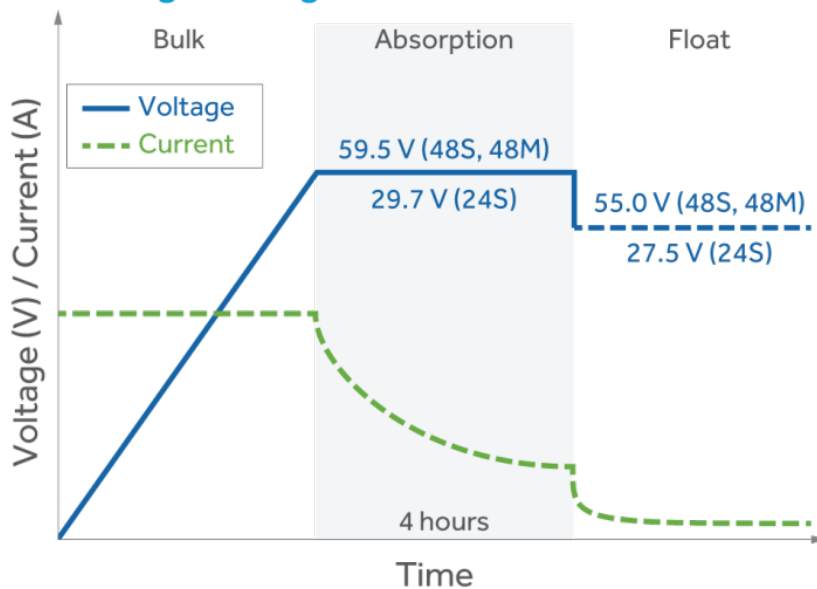
Use the three-stage charge profile if your Aspen battery system

- + needs to go longer than three days between discharges
OR
- + cannot go open circuit or requires a float setting
OR
- + does not use current termination for absorption

Aspen batteries do not require a float voltage, but one is included to maintain a full state of charge.

Battery Model	Max. Current	Recommended Bulk Current	Max. (Absorption) Voltage	Absorption Cut-Off	Float Voltage
48S	20 A	<10 A	59.5 V at 30°C average charge	Time <4 hours	55.0 V
48M	240 A	<120 A	59.5 V at 30°C average charge	Time <4 hours	55.0 V
24S	30 A	<20 A	29.7 V at 30°C average charge	Time <4 hours	27.5 V

Three-Stage Charge Profile



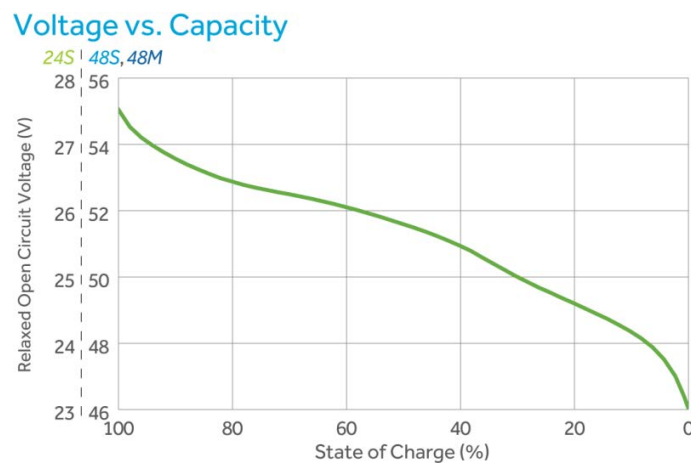
8.3 State of Charge

8.3.1 Partial State of Charge

AHI batteries can maintain a partial or low state of charge (SOC) without significant performance loss. Periodically charging the battery to 100% SOC, known as an equalization charge, is not required to maintain battery life. AHI batteries may be stored between 0% and 100% SOC for short periods. For guidance on long-term storage, see Section 8.6.

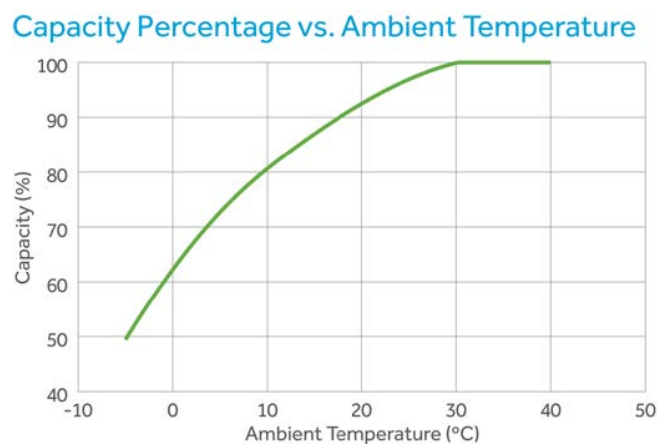
8.3.2 Determining State of Charge

The SOC of an Aquion battery can be estimated by measuring its open circuit voltage (OCV). To measure the OCV, first disconnect the battery from the DC bus by either unplugging the MC4 solar connectors or powering down the system. Let the battery sit unpowered for at least one hour (three hours recommended for full equilibrium), then measure the voltage between the positive and negative terminals.



8.4 Capacity and Ambient Temperature

The capacity of the Aquion AHI battery chemistry is closely related to the 24-hour rolling ambient temperature at which the batteries are held, as shown below.

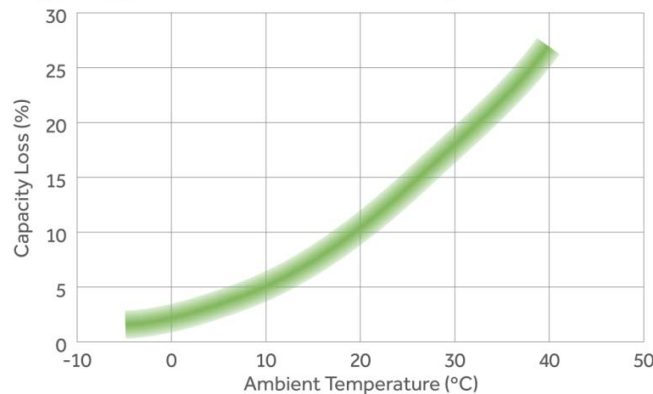


8.5 Self-Discharge

The self-discharge of the Aquion AHI battery chemistry is closely related to the ambient temperature at which the battery is held. Aspen batteries exhibit the approximate capacity losses shown below due to self-discharge over the course of one (1) month.

For the AHI battery chemistry, the capacity loss due to self-discharge is not irreversible. Capacity lost over this time can be recovered simply by recharging the battery to 100% SOC.

Capacity Loss from Self-Discharge



8.6 Long-Term Storage

If Aspen batteries are to be stored for an extended period of time, remove all signal and power connections to prevent unintended self-discharge and undetected ground faults. Keep any grounding in place. To avoid permanent damage, store products in the following conditions:

- + between -10°C and 40°C
- + indoors or protected from sun and water

8.7 Recycling and Disposal

⚠ ATTENTION

Follow all applicable recycling and disposal regulations.

AHI batteries are non-toxic and non-corrosive. Do not dump into any sewers, on the ground, or into any body of water where water runs off into open bodies of water. Dispose of according to all federal, state, and local regulations.

8.8 Record Keeping

Aquion Energy recommends maintaining proper system documentation records. These include a single-line diagram of the complete system and a log documenting system settings (inverter, charge controller, charge voltages, etc.).

Record	Description	Frequency
Single-line system diagram	Complete AC and DC system diagram	At installation or upon change
System component settings	Charge voltage and current settings	At installation or upon change

Aquion Energy recommends maintaining proper and regular operating records of battery temperatures, maximum and minimum operating voltages, and maximum currents. Sensed battery systems that include the BMS-200 log this data automatically.

Measurement	Description	Frequency
Average battery temperature	Daily average temperature	Logged every 24 hours
Minimum battery voltage	Daily minimum voltage	Logged every 24 hours
Maximum battery voltage	Daily maximum voltage	Logged every 24 hours
Maximum battery current	Daily maximum current	Logged every 24 hours

9 Warranty

Please see the Terms and Conditions and/or separate warranty documentation.

10 Technical Support

If you need technical support, visit us on our website at <http://aquionenergy.com/support>.

If you purchased your batteries from an authorized Aquion Energy dealer, please contact the dealer for assistance.

If you require immediate assistance AND if you purchased your products directly from Aquion Energy, call our support line at +1 412.904.6400. Please have your Aquion Energy order number ready.

11 Further Reading

Visit our website at <http://aquionenergy.com/support/product-documentation> for documentation on all Aquion products, as well as information on specific topics such as

- + power electronics state of charge readings and Aquion products
- + operational settings for power control electronics with Aquion batteries
- + Aquion battery and SMA Sunny Island inverter installation
- + accessories for Aquion products