

# Lithium Ion Batteries



## RECHARGEABLE, PRESSURE TOLERANT

Phoenix International Holdings, Inc (Phoenix) has developed the next generation underwater battery. Proven on multiple ROV excursions into RMS TITANIC (>12,000 fsw), these rechargeable batteries are high energy, pressure tolerant, fault

tolerant and designed for S9310 requirements. Phoenix Cells include a proprietary, networked Battery Management System (BMS) providing charge and discharge protection and more. The Modules, of 8, 12, or 13 cells in series, have a BMS header board and can be connected in series and parallel to meet the system's voltage, load, and energy needs.

## Battery Features

**Pressure Tolerant** - Designed to operate at ambient pressure or 1 atmosphere. All components tested to 10,000 psi in production. Proven in over 1000 hours under pressure.

**Battery Management System (BMS)** – Three-tier design: Cell, Module, Battery. Electronics embedded in each Phoenix Cell protect the cell during charge, discharge and handling. The networked modules and cells provide complete, real time reporting and control of the battery and each cell.

**High Energy** - State of the art chemistry is packaged to maximize energy density with high efficiency BMS.

**Easy Operation** - BMS isolates cells for storage/shipping.

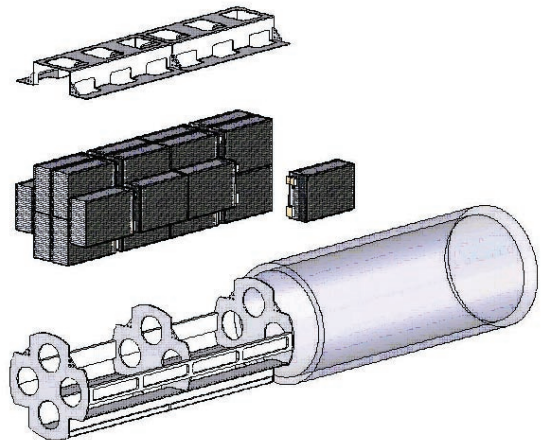
Modules stack to supply up to 275 VDC (higher voltage in development). Charge with any DC supply at nominal 48VDC or 300VDC, no equalization is required. Plug and Play cell and module replacement.

**Robust** – Modules can be stacked in parallel and series. BMS resets after faults. BMS recovers remainder of a voltage stack's energy after a single cell failure.

**Safety Approval** – Navy S9310 safety review approved a system with Phoenix batteries for submarine T&E. Transportation testing is planned.

## Standard Modules

Phoenix produces a range of modules for assembly in series and parallel to make batteries of any voltage, power, or energy. Upon request, module configurations can be optimized for specific requirements. A high energy, large 12 cell module has been developed for 21 inch and larger diameter UUVs.



The 1800 Wh Module is sized to fit efficiently in a 21-inch hull.

## Point of Contact

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## Phoenix Cell\* Characteristics

<b>Phoenix Cell BMS Functions</b>	Short/Overload Protection, High Charge and Low Discharge Protection, 1 second Auto-Reset, Cell shut off, Plug-in replacement, and voltage, current, and temperature reporting.
<b>Cell Voltage</b>	3.75 V Nominal, Max. 4.2 V, Min 2.75 V under load
<b>Cell Energy</b>	Sizes available from 15 to 50 A-hr
<b>Cell Energy Density</b>	210 Wh/Kg, 340 Wh/Liter (chemical cells)
<b>Discharge Current</b>	14 A max. (BMS limit), < 10 A (recommended continuous)
<b>Charging</b>	5 A/cell max., cells charge at 5V (large modules supply 5V)
<b>Pressure Rating</b>	0 - 10,000 psi (production test pressure)
<b>Temperature Range</b>	-25oC / +50°C (operating), -25oC / +60°C (storage)
<b>Cycle Life @ 20°C,</b>	>400 (4.2V to 2.75V @ 3.75 A charging and discharging)
<b>100% DOD to 80%Cap</b>	>1000 (4.1V to 3.0V @ 3.75 A charging and discharging)
<b>Cell Safety Features</b>	BMS in each cell for voltage and current protection. Cell separator shuts down cells at 135°C. Electrode connections are fused.

\* A Phoenix cell integrates the Phoenix BMS to a base cell that Phoenix has made pressure tolerant.

## General Module Characteristics

<b>Max. Discharge Current (BMS limit)</b>	14 A (0.8 C) per module, Parallel modules to meet load
<b>Pressure Rating</b>	10,000 psi
<b>Cell Energy</b>	Sizes available from 15 to 50 A-hr
<b>Battery Management System (BMS)</b>	Voltage, current, and temperature protection Efficiency: 98% @ 5 A, 95% @ 10 A
<b>Case Material</b>	G-10 fire resistant FRP
<b>Charge Method</b>	BMS does constant current to constant voltage charge. Input 48 or 300 VDC on large or 5 VDC on small modules



The 800 Wh module in a compensated housing fits in a small system.

## Example Module Characteristics

Module Size	1800 Wh	800 Wh	600 Wh
<b>Battery Voltage</b>	Up to 275 VDC	Up to 55 VDC	Up to 55 VDC
<b>Module Voltage</b>	45.0 V Nominal, 50.4 V to 36.0 V	48.75 V Nominal, 54.6 to 39.0 V	30.0 V Nominal, 33.6 V to 24.0 V
<b>Capacity</b>	40 A-hr	16.5 A-hr	20 A-hr
<b>Module Dimensions</b>	12.4" x 8.2" x 4.2" (Al housing)	9.25" x 5.7" x 4.25" (+ .5" flange)	11.0" x 4.0" x 2.6" (No Housing)
<b>Module Weight (flooded)</b>	27.5 lbs	13.6 lbs	7.8 lbs (No Housing)
<b>Module Configuration:</b>	12S1P	13S1P	8S1P