From superior cell to one of the safest battery systems

In the construction of our batteries, we collaborate closely with Kokam, which supplies us with the best Lithium Polymer Battery Cells on the market today. This, combined with our patented safety system and unique balancing BMS, results in an extremely reliable, modular, and passive safety system, with a very high energy density that has been approved by the strictest maritime classification societies.

The technical choices for the design of the Green Orca battery system start with the cells. We then consider the module and battery management system, before examining the system as a whole and how it is integrated on board in order to guarantee the safety of the entire system.
Kokam’s Leading Cell Technology
Kokam develops and manufactures different kinds of Lithium Polymer Cells. These Lithium Polymer Cells have been proven to deliver the best performance and quality to demanding customers in the aerospace industry. Due to their patented and certified cell design and the highest energy density available on the market, a strong partnership with Kokam is the best foundation for building the safest possible maritime system.

Lithium Polymer NMC cells by Kokam
Our Green Orca Modules use Lithium Ion Polymer NMC (Lithium Nickel Manganese Cobalt Oxide). The combination of nickel, manganese and cobalt ensures the highest energy density, in combination with good overall performance compared to other lithium-based battery technologies, such as Lithium Ion Phosphate (lower energy density) or Lithium Titanate (extremely expensive).

Pouch Cells & Z-Folding
The pouch cells we use provide a flexible and lightweight solution for battery design, while delivering high load currents. Compared to prismatic cells and cylindrical cells, pouch cells make more efficient use of space and achieve 90% to 95% packaging efficiency. The cells benefit from improved thermal behaviour, as there is no heat encapsulated in the cell core, as is the case with prismatic and cylindrical cells. The Z-fold stacking method significantly reduces internal resistance (which results in less energy lost as heat as the cell charges and discharges), and increases efficiency, power, and cycle life.

Life time & Cycle Life
Our cells have Cycle Life of approx. 5,000 cycles by and DoD of 80% at an EoL of 80%. This means that the cell’s energy content and life expectancy have been decreased by 20%. There are more cycles possible in the 2nd life phase.

1) Cycle Life #: the number of complete charge-discharge cycles a battery can perform by a certain DoD (see table).
2) Depth of Discharge % (DoD): the percentage of total capacity that is discharged (see table).
3) End-of-Life % (EoL) indicates the time elapsed before a battery becomes unusable, as the capacity decreases with use and over time.
Green Orca® high energy module
Built as one of the industry’s safest modules

Green Orca® Modules
The Green Orca® High Energy module is a modular, patented system designed in accordance with the strictest safety norms required by the DNV-GL and the Norwegian Maritime Authority. The system is DNV-GL type approved and offers in combination with the Gas Exhaust System a passive protection system against thermal runaway. The Gas Exhaust System routes gasses out of the ship and reducing requirements on the battery room.

Mechanical structure
The system’s simple, but effective modular structure makes it easy to install it in accordance with the client’s wishes. The direct cell-to-cell connection makes optimal use of the system’s volume-to-energy density, low impedance and limited heat generation. Its spring-loaded system keeps the cells in position under even the most demanding circumstances. Thanks to the IP 67 watertight aluminium casing, the system is extremely robust and safe.

BMS, Redundant & Active balancing
The Battery Management System (BMS) was developed by EST-Floattech to meet the highest requirements for naval purposes. The cells are monitored and logged for voltage and current, and the redundant safety circuit constantly monitors the temperature and communicates with the BCU. It is unique in the market in that it features active cell-to-cell and battery-to-battery balancing, for optimal energy storage and battery life.

Energy Modules (C-Ratings, Capacity)
The Green Orca® High Energy has a gross power rating of 10.5kWh, in which 14 200Ah cells are connected in series to provide a nominal 52 volts. The Green Orca has a nominal C-rating of 2C discharge, and a Nominal charge rating of 1C. The 2 C rating means that the discharge current will discharge the entire battery in 30 minutes (0.5 hours) with 21kW, where 1C means that the entire battery can be charged in 1 hour with 10.5kW.

Dimensions (WxHxD)
335 mm x 541 mm x 542 mm
Battery Application
Building the system and integration

Green Orca® Energy Storage System
The EST-Floattech Energy Storage System is ideal for use in maritime applications, such as fully electric or hybrid propulsion, coupled with diesel, hydrogen or LNG power systems. It can be used for propulsion, hotel load, auxiliary equipment and during harbour stays, and for optimal engine efficiency during peak saving and peak power applications. The system is DNV-GL type approved and offers in combination with the Gas Exhaust System a passive protection system against thermal runaway. The Gas Exhaust System routes gasses out of the ship and reducing requirements on the battery room.

Battery Control Unit (BCU)
The Battery Control Unit (BCU) is responsible for communication between the battery modules and the application’s power management. The BCU transforms the separate battery modules into an Energy Storage System (ESS), and is integrated with the complete on-board power management system.

Communication
Like the BMS, the BCU features a redundant safety circuit and checks, validates and collects all of the data from BMSs, and is the data gateway to the on-board Power Management System. The maximum module power rating is 1000 volts, with 18 modules per string. One Master BCU can be connected to 3 slave BCUs.

Communication is provided by ModBus or CanBus, in accordance with NMEA 2000 standards for plug-and-play communications.

Installation and Commissioning
EST-Floattech differentiates itself from the competition by supporting the client from start to finish, from the conceptual design and detailed engineering phases, to the final installation of the system on board.

System Sizes
The batteries are delivered together with their storage racks, with makes the modules easy to assemble. These racks can be configured to customers requirements and to fit the battery compartment. The visual shows a example of a 284kWh system with Gas Exhaust System and Fire Retardant.

Dimensions (WxHxD)
3.638 mm x 1.646 mm x 611 mm
Safety and Certification
Energy Storage Systems on board are only an option when they are proven to be both reliable and safe. To that end, everything in the module is geared towards preventing a thermal runaway or thermal event from ever occurring in the first place, by means of electronic safety measures. However, in a worst-case scenario, the battery design needs to be so robust that it is capable of dealing with a thermal runaway without the need for any active systems.

Safe by design
EST-Floattech’s ‘Safe by Design’ principle served as the foundation the design of our energy storage system & modules. This principle is based on the understanding that in order to offer the maximum level of safety, thermal runaway protection should not be dependent on a system such as a Battery Management System, cooling system or external fire extinguisher, but should rather be an intrinsic element of the design itself. That way, the last line of defence in safety does not rely on an active safety system.

Unique features of the Green Orca® Safety System
The Green Orca Energy Storage System is built to withstand a full Thermal Runaway, beyond a Thermal Event such as cell venting. The unique gas exhaust system eliminates hazardous inflammable gases from the compartment via the integrated exhaust channel. And if a thermal runaway does occur, the temperature of the adjacent modules will stay well within safe limits.

DNV-GL type approval & NMA Propagation
Norway is currently at the forefront of the use of maritime battery systems. The Norwegian Maritime Authority (NMA) and the DNV-GL classification society both build on the Norwegian maritime industry’s advantage in this area in order to further develop the technology in a safe manner and to set the standard for maritime battery systems.
## Green Orca® High Energy

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capacity</td>
<td>10.5 kWh</td>
</tr>
<tr>
<td>Cycle Life at 80% D.O.D and 80% E.O.L</td>
<td>&gt;5,000 cycles</td>
</tr>
<tr>
<td>Cycle Life at 50% D.O.D and 80% E.O.L</td>
<td>&gt;20,000 cycles</td>
</tr>
<tr>
<td>Cycle Life at 20% D.O.D and 80% E.O.L</td>
<td>&gt;75,000 cycles</td>
</tr>
<tr>
<td>Nominal Charge</td>
<td>200A/1C</td>
</tr>
<tr>
<td>Nominal Discharge</td>
<td>600A/3C</td>
</tr>
<tr>
<td>Maximum Discharge &lt;10 sec. &gt; S.O.C. 50%</td>
<td>10,5kW</td>
</tr>
<tr>
<td>Volt Minimum</td>
<td>44.8V</td>
</tr>
<tr>
<td>Volt Nominal</td>
<td>52V</td>
</tr>
<tr>
<td>Volt Maximum</td>
<td>58V</td>
</tr>
<tr>
<td>BMS</td>
<td>Included</td>
</tr>
<tr>
<td>Certification</td>
<td>Required by Class</td>
</tr>
<tr>
<td>Dimensions (W x H x D)</td>
<td>335 x 542 x 541 mm</td>
</tr>
<tr>
<td>CanBus Communication</td>
<td>Included</td>
</tr>
<tr>
<td>Weight</td>
<td>82 kg.</td>
</tr>
<tr>
<td>Cooling</td>
<td>Air Cooled</td>
</tr>
<tr>
<td>Gas Exhaust System</td>
<td>Included</td>
</tr>
<tr>
<td>Racking</td>
<td>Required by Class</td>
</tr>
<tr>
<td>Dedicated Battery Room</td>
<td></td>
</tr>
</tbody>
</table>

### Battery Cell Tests
- UN38.3 T-2 Thermal abuse
- UN38.3 T-5 External Short Circuit
- UN38.3 T-6 Impact
- UN38.3 T-8 Forced Discharge
- Overcharge (by the redundant safety system)

### Battery System Tests
- Propagation Test
- Safety function test – Emergency stop function
- Capacity Validation
- Sensor Failures
- State of Charge Validation
- IEC 62619 Overcharge with Voltage
- IEC 62619 Overcharge with Current
- IEC 62619 Overheating Control

### Environmental Tests
- DNV-GL CG0339 Vibration
- DNV-GL CG0339 Dry Heat
- DNV-GL CG0339 Damp Heat
- DNV-GL CG0339 EMC