Appendix A

TACOMA Datalog
Appendix B

Spear Power Systems Brochure (SMAR-11N and SMAR-3T)

PBES Power 65 Brochure

PBES DNV Type Approval Certificate

Corvus Orca Energy Brochure

Corvus DNV Type Approval Certificate

Leclanché TiRack Brochure (partial)

EP Systems EPiC-t32 Brochure
Trident® Solutions

OPTIMIZE YOUR APPLICATION WITH THE MOST VERSATILE SERIES OF MARINE ENERGY STORAGE

Spear Power Systems’ Trident® family of marine battery solutions offer end users the ability to integrate the optimal lithium-ion chemistry for their application while leveraging the same BMS control interface. Trident® energy storage systems lead the charge in performance, safety, reliability, flexibility, and value.

With over a decade of experience developing next generation lithium-ion battery solutions, including the first large format lithium-ion cell used in commercial marine propulsion applications, Spear Power Systems delivers unmatched value to ship builders, owners, operators, and designers. Spear’s solutions are based on knowledge from designing and manufacturing lithium-ion packs for markets that demand quality and performance.

As a chemistry and cell agnostic integrator, Spear selects the most appropriate cell for a given application, balancing performance, cost, and quality.

TRIDENT® ADVANTAGES

+ **Exceptional Value** – cost competitive
+ **Industry-Leading Energy Density** – 20% system-level energy-density improvement compared to competition
+ **Industry-Leading Power Density** – reduce weight with high power cells capable of 30C pulse discharge rates
+ **Safety Oriented** – thermal propagation prevention without the need for active liquid cooling, multi-level BMS protection, high voltage / current / temperature resolution, redundant safety features
+ **Sophisticated Thermal Management** – keeps cells cool and extends battery life, all systems support forced air or liquid cooling
+ **Best-In-Class Cell Technologies** – safety and performance starts with a high-quality cell, flexible BMS configuration allows the customer to pick the optimal lithium-ion chemistry for their application
+ **Scalable Architecture** – technology supports voltages up to 1250 VDC and installations beyond 10 MWh
+ **Longer Life** – variety of solutions that support 5,000 to over 20,000 cycles at high depths of discharge
Trident® Solutions

**ROBUST, RELIABLE SOLUTIONS FOR EVERY APPLICATION**

Trident® modules integrate Spear’s proven SMOD technology and is designed with a rugged marine-grade enclosure to protect it from the harsh environment. All Trident® systems are feature propagation prevention and are monitored with Spear’s internally developed battery management system (BMS), ensuring a high degree of safety and accuracy.

## Technical Specifications

<table>
<thead>
<tr>
<th>Trident® System</th>
<th>SMAR-11N</th>
<th>SMAR-3T</th>
<th>SMAR-2P</th>
<th>SMAR-6A</th>
<th>SMAR-2F</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cell Chemistry</strong></td>
<td>NMC</td>
<td>LTO</td>
<td>NMC</td>
<td>NANO</td>
<td>LFP</td>
</tr>
<tr>
<td><strong>Embedded Energy</strong></td>
<td>11.3 kWh</td>
<td>3.4 kWh</td>
<td>2.7 kWh</td>
<td>6.2 kWh</td>
<td>2.4 kWh</td>
</tr>
<tr>
<td><strong>Nominal Capacity</strong></td>
<td>128 Ah</td>
<td>65 Ah</td>
<td>30 Ah</td>
<td>70 Ah</td>
<td>39 Ah</td>
</tr>
<tr>
<td><strong>Maximum Continuous Discharge Rate</strong></td>
<td>2.0 C</td>
<td>5.0 C</td>
<td>20.0 C</td>
<td>8.0 C</td>
<td>6.0 C</td>
</tr>
<tr>
<td><strong>Pulse Discharge Rate</strong></td>
<td>4.0 C</td>
<td>8.0 C</td>
<td>30.0 C</td>
<td>15.0 C</td>
<td>20.0 C</td>
</tr>
<tr>
<td><strong>Maximum Continuous Charge Rate</strong></td>
<td>2.0 C</td>
<td>5.0 C</td>
<td>3.0 C</td>
<td>4.0 C</td>
<td>3.0 C</td>
</tr>
<tr>
<td><strong>Energy Density (system-level)</strong></td>
<td>91 Wh/L</td>
<td>34 Wh/L</td>
<td>38 Wh/L</td>
<td>61 Wh/L</td>
<td>34 Wh/L</td>
</tr>
<tr>
<td><strong>Specific Energy (system-level)</strong></td>
<td>108 Wh/kg</td>
<td>49 Wh/kg</td>
<td>60 Wh/kg</td>
<td>88 Wh/kg</td>
<td>52 Wh/kg</td>
</tr>
<tr>
<td><strong>Specific Power (system-level)</strong></td>
<td>215 W/kg</td>
<td>247 W/kg</td>
<td>1196 W/kg</td>
<td>703 W/kg</td>
<td>309 W/kg</td>
</tr>
<tr>
<td><strong>System Scalability</strong></td>
<td>2.0 kWh — 10 MWh+</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>System Voltage Range</strong></td>
<td>48 VDC — 1250 VDC</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Battery Management System</strong></td>
<td>Spear Scalable Battery Management System (SBMS)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Cooling Method</strong></td>
<td>Forced Air / Liquid Cooling</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
PBES Power and Energy Industrial Lithium Batteries:

Power 65 (P65) is designed for high discharge power applications requiring high C-rates and faster cycling, the system provides 15,000 charge/discharge cycles at 80% DoD.

ROI focussed Energy 100 (E100) has been designed for applications requiring lower discharge rates and greater energy density. A 35% decrease in cost and weight provides the end user with a faster path to ROI and decreased footprint and weight.

Both systems use the same PBES form factor and are backed by industry leading safety, performance, and recycling systems. CellCool™, ThermalStop™ and CellSwap™ provide ideal operating conditions, thermal runaway prevention and best industry value.

PBES batteries are manufactured in Norway and exceed NMA flag approval and DNV Type Approval criteria (DNV Type Approval pending).

PBES proudly uses the highest quality lithium-ion NMC cells from XALT Energy in USA.

<table>
<thead>
<tr>
<th>General PBES Features</th>
<th>PBES System Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>BMS (Battery Management System)</td>
<td>MegaWatt ++</td>
</tr>
<tr>
<td>IMS (Information Management System)</td>
<td>API Interface</td>
</tr>
<tr>
<td>Engineered Design Life</td>
<td>5/10 year</td>
</tr>
<tr>
<td>CellCool™ Liquid Cooling</td>
<td>Yes - Patent Pending</td>
</tr>
<tr>
<td>Cell Partner</td>
<td>XALT Energy (USA)</td>
</tr>
<tr>
<td>TCP Ultra Fast Internal Comms</td>
<td>Yes</td>
</tr>
<tr>
<td>Thermal-Stop™ Thermal Runaway Protection</td>
<td>Yes - Patent Pending</td>
</tr>
<tr>
<td>E-Vent™ Safety Venting System</td>
<td>Yes - Patent Pending</td>
</tr>
<tr>
<td>Operating Temperature (active heating/cooling)</td>
<td>15°C to 30°C</td>
</tr>
<tr>
<td>Series Configurable</td>
<td>Yes</td>
</tr>
<tr>
<td>OnPoint™ Remote Active Monitoring</td>
<td>Yes</td>
</tr>
<tr>
<td>OnPoint™ Remote Active Programming</td>
<td>Yes</td>
</tr>
<tr>
<td>Parallel Configurable (capacity scalable)</td>
<td>Unlimited</td>
</tr>
</tbody>
</table>

*Specifications subject to change*
# PBES Specification Sheet

System Specifications for the PBES Power & Energy Systems

<table>
<thead>
<tr>
<th>Single Module (BBU)</th>
<th>Power 65</th>
<th>Energy 100</th>
</tr>
</thead>
<tbody>
<tr>
<td>C Rate RMS (Continuous)</td>
<td>3C</td>
<td>1.4C</td>
</tr>
<tr>
<td>Cycle Life @ 80% DoD</td>
<td>15000 cycles</td>
<td>TBF</td>
</tr>
<tr>
<td>Cell Chemistry</td>
<td>NMC</td>
<td>NMC</td>
</tr>
<tr>
<td>Dimensions</td>
<td>L 580mm, H 380mm, W 320mm</td>
<td>L 580mm, H 380mm, W 320mm</td>
</tr>
<tr>
<td>Weight</td>
<td>90kg</td>
<td>90kg</td>
</tr>
<tr>
<td>Energy</td>
<td>6.5kWh</td>
<td>10kWh</td>
</tr>
<tr>
<td>Capacity</td>
<td>75Ah</td>
<td>112Ah</td>
</tr>
<tr>
<td>Voltage Range</td>
<td>77-100VDC</td>
<td>77-100VDC</td>
</tr>
<tr>
<td>Nominal Voltage</td>
<td>88.8VDC</td>
<td>88.8VDC</td>
</tr>
<tr>
<td>RMS Continuous Current</td>
<td>225A</td>
<td>160A</td>
</tr>
<tr>
<td>Max Discharge Current</td>
<td>450A</td>
<td>336A</td>
</tr>
<tr>
<td>Max Charge Current</td>
<td>225A</td>
<td>112A</td>
</tr>
<tr>
<td>Connectors</td>
<td>IP67</td>
<td>IP67</td>
</tr>
<tr>
<td>Terminal Isolation at Module</td>
<td>Contactor</td>
<td>Contactor</td>
</tr>
<tr>
<td>Thermal-Stop™ Thermal Runaway Protection</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Self Discharge Rate/month</td>
<td>&lt;2%</td>
<td>&lt;2%</td>
</tr>
<tr>
<td>Internal resistance</td>
<td>17mΩ</td>
<td>20mΩ</td>
</tr>
<tr>
<td>Efficiency (at 1C)</td>
<td>&gt;98%</td>
<td>&gt;97%</td>
</tr>
<tr>
<td>Electrical Isolation</td>
<td>Open circuit when not in operation</td>
<td>Open circuit when not in operation</td>
</tr>
<tr>
<td>Communication interface</td>
<td>UDP</td>
<td>UDP</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Series String (1000V)</th>
<th>Power 65</th>
<th>Energy 100</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dimensions (including racking, venting and lifting apparatus)</td>
<td>W 896mm, H 2550mm, D 632mm</td>
<td>W 896mm, H 2550mm, D 632mm</td>
</tr>
<tr>
<td>Weight 10BBUs +1 MBU</td>
<td>950 kg</td>
<td>950 kg</td>
</tr>
<tr>
<td>Energy</td>
<td>65kWh</td>
<td>100kWh</td>
</tr>
<tr>
<td>Capacity</td>
<td>75Ah</td>
<td>112Ah</td>
</tr>
<tr>
<td>Voltage Range</td>
<td>770-1000VDC</td>
<td>770-1000VDC</td>
</tr>
<tr>
<td>Nominal Voltage</td>
<td>888VDC</td>
<td>888VDC</td>
</tr>
<tr>
<td>RMS Continuous Current</td>
<td>225A</td>
<td>160A</td>
</tr>
<tr>
<td>Max Discharge Current</td>
<td>450A</td>
<td>336A</td>
</tr>
<tr>
<td>Max Charge Current</td>
<td>225A</td>
<td>112A</td>
</tr>
<tr>
<td>Internal Resistance</td>
<td>180mΩ</td>
<td>200mΩ</td>
</tr>
<tr>
<td>Electrical Isolation at DC Bus</td>
<td>Breaker</td>
<td>Breaker</td>
</tr>
<tr>
<td>Integrated Racking System</td>
<td>Included</td>
<td>Included</td>
</tr>
<tr>
<td>Communication to Higher Level System</td>
<td>Modbus/TCP</td>
<td>Modbus/TCP</td>
</tr>
</tbody>
</table>

*Specifications subject to change
This is to certify:

That the Battery (Accumulator)

with type designation(s)

Basic Battery Unit (BBU), Main Battery Unit (MBU), Parallel Battery Unit (PBU)

Issued to

PBES Ltd.
Vancouver BC, Canada

is found to comply with

DNV GL rules for classification – Ships, offshore units, and high speed and light craft

Application:

Product(s) approved by this certificate is/are accepted for installation on all vessels classed by DNV GL.

Issued at Høvik on 2017-10-12

This Certificate is valid until 2022-10-11.

DNV GL local station: Trondheim

Approval Engineer: Sverre Eriksen

Andreas Kristoffersen
Head of Section

This Certificate is subject to terms and conditions overleaf. Any significant change in design or construction may render this Certificate invalid. The validity date relates to the Type Approval Certificate and not to the approval of equipment/systems installed.
**Product description**

Liquid cooled lithium-ion battery based energy storage system (EES) for use in battery-powered or hybrid vessels and off-shore units.

The system consists of basic battery units (BBU) connected in series to form a string and achieve the needed system voltage. The string is controlled by a main battery unit (MBU) that includes a breaker. The strings can be installed in parallel in order to provide the required energy capacity. The parallel strings are controlled by a separate controller, Parallel Battery Unit (PBU).

The liquid cooled [CellCool™] BBU is designed with thermal runaway protection [Thermal-Stop™] and the battery units BBU and MBU are housed within a dedicated racking system with an integrated off-gas exhaust duct [E-Vent™].

**Battery Module Unit**

*Type:* BBU  
*Cell Type:* XALT 75 HP  
*Chemistry:* Lithium ion NMC  
*Number of cells:* 24  
*Cell configuration:* 1p24s  
*Max Voltage:* 100.8 V  
*Min Voltage:* 76.8 V  
*Capacity:* 75 Ah  
*Energy:* 6,5 kWh  
*Cooling:* Liquid

**Main Battery Unit**

*Type:* MBU

**Parallel Battery Unit**

*Type:* PBU

**String**

*Max Number of modules:* 10  
*Max Voltage:* 1008 V  
*Max Energy:* 65 kWh

**Battery Management system**

Functionality of BMS is distributed between BBU and MBU. The software is identified by the following versions:

BBU sw: 0.1.x.x  
MBU sw: 0.1.x.x

**Application/Limitation**

The type approval covers hardware and software listed under Product description.

**Software versions**

Software versions are declared in PBES document TN-0018. BMS software version is a common identifier for software in BBU, MBU and PBU. Identifiers in the software version denoted as “x” may vary and are covered by the type approval.

Modifications to software resulting in a new version (identified by the 2nd number in the version string) shall be informed to DNV GL by forwarding updated software version documentation and updated version of TN-0018. Such modifications may require witnessing of type testing and will require that the certificate is renewed to identify the new software version.

**Ventilation fans**

The capacity and speed of the ventilation fans for the integrated exhaust duct are to be submitted for each product certification individually.
Cable protection
The power cables between the battery modules must be overload protected by the charger. Documentation of the chargers cable protection functionality are to be submitted for each product certification individually.

Environmental temperature control
To avoid condensation inside the liquid cooled battery modules the modules must be located in an environmental controlled room where the temperature and/or humidity of the room is controlled so that the room temperature is at all time above the dewpoint temperature of the cooling water.

Alarms
All alarms required by the rules shall be “latching” (i.e. use of non-latching warnings/alarms shall be limited to abnormal conditions which are not safety-related and which are not required alarmed).

Network storm on external network
External network storm testing shall be done onboard after the MBUs/PBUs are commissioned and connected to the external system.

Documentation for product certification
For each delivery to DNV GL class the following documentation of the battery system is to be submitted for approval:

- Reference to this type approval certificate
- Copy of the approved Safety description
- I130 Project-specific Battery System Block Diagram
- E120 Technical specification of the battery system that is subject for product certification
- E170 Electric schematic diagram of the battery system showing internal arrangement of battery modules, battery strings, switch unit and emergency stop
- Z060 Functional description, including
  o Project-specific overall description of the battery management system
  o Software and hardware versions of BBU, MBU and PBU
  o capacity calculations for the gas extract ventilation fan
  o description of the cable protection (overload) functionality of the charger
  o other relevant information not covered by the safety description.
- Z252 Test program for product certification, including routine tests specified in applicable rules

Product certificate
Each delivery of the application system is to be certified according to Pt.6, Ch.2, Sec. 1. The certification test is to be performed at the manufacturer of the application system before the system is shipped to the yard. After certification, all changes in software/configuration are to be recorded as long as the system is in use on board. Documentation of major changes is to be forwarded to DNV GL for evaluation and approval before implemented on board.

Type Approval documentation

Tests carried out
Tests according to DNVGL-CP-0418, DNVGL-CG-0339

Marking of product
PBES-BBU
PBES-MBU
PBES-PBU

Periodical assessment
The scope of the periodical assessment is to verify that the conditions stipulated for the Type approval are complied with and that no alterations are made to the product design or choice of materials.

The main elements of the assessment are:

- Inspection on factory samples, selected at random from the production line (where practicable)
- Results from Routine Tests (RT) checked (if not available tests according to RT to be carried out)
- Review of type approval documentation
- Review of possible change in design, materials and performance
- Ensuring traceability between manufacturer’s product type marking and Type Approval Certificate.

Periodical assessment is to be performed after 2 years and after 3.5 years. A renewal assessment will be performed at renewal of the certificate.

END OF CERTIFICATE
Orca ESS Solutions

THE WORLD’S MOST ADVANCED MARITIME ESS (ENERGY STORAGE SYSTEMS). Designed and built specifically for the maritime industry, the Orca ESS product line from Corvus Energy represents the future of maritime ESS solutions. Corvus combined its industry leading research & development capabilities and knowledge gained from having the largest global installed base of ESS solutions, to build the industry’s safest, most reliable, highest-performing and most cost-effective maritime ESS product line, which includes: Orca Energy and Orca Power.

Orca Energy

Orca Energy is ideal for applications that are primarily energy capacity driven, moving large amounts of energy at an inexpensive lifetime cost per kWh. Specifically designed to meet the operational requirements of:

- HYBRID FERRIES
- CRUISE SHIPS
- ALL-ELECTRIC FERRIES
- SUPER YACHTS
- TUG BOATS
- CARGO VESSELS

THE ORCA ENERGY DIFFERENCE

- Price per kWh reduced by 50%
- Highest C-Rates in the industry – up to a 6C peak C-rate
- Increased cycle life – lowering total system cost and extending ESS Lifespan
- Unparalleled energy density – 50% volume & 35% weight reductions
- Connection & commissioning time reduced by 80%
- Enhanced EMI immunity design for maritime environments
- Economical upfront & through-life costs = lower total cost of ownership
- Power connections contained within rack – no manual connections, enhanced reliability, increased safety
- Designed for pack voltages up to 1200VDC
- Scalable beyond 10MWh
- Industry-proven 4th generation BMS
- Easily monitored through the Watchman™ ESS Advisory Portal

ORCA SAFETY INNOVATIONS

Cell-level Thermal Runaway (TR) Isolation
- True cell-level thermal runaway isolation – TR does not propagate to neighbouring cells
- Isolation NOT dependant on active cooling
- Exceeds Class and Flag standards

TR Gas venting
- Integrated thermal runaway gas exhaust system
- Easily vented to external atmosphere rather than the battery room
- Additional fire suppression system not required

CONTACT
Toll Free: +1 (888) 390-7239 | sales@corvusenergy.com | www.corvusenergy.com
The Narled Ampere — powered by a Corvus ESS; the world’s first all-electric car and passenger ferry.

CONTACT
Toll Free: +1 (888) 390-7239 | sales@corvusenergy.com || www.corvusenergy.com
HEAD OFFICE  #220-13155 Delf Place, Richmond, BC  V6V 2A2, Canada || NORWAY  Nagelgården 6, 5004 Bergen | +47 918 25 618 | sales@corvusenergy.com

Technical Specifications*

<table>
<thead>
<tr>
<th>PERFORMANCE SPECIFICATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>C-Rate – Peak</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>OPERATIONAL SPECIFICATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pack Sizing</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>1100V STANDARD BATTERY PACK EXAMPLE ¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy</td>
</tr>
<tr>
<td>Voltage</td>
</tr>
<tr>
<td>Cooling</td>
</tr>
<tr>
<td>Dimensions (vertical arrangement)</td>
</tr>
<tr>
<td>Dimensions (horizontal arrangement)</td>
</tr>
<tr>
<td>Weight</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>GENERAL SPECIFICATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>EMC</td>
</tr>
<tr>
<td>Ingress Protection</td>
</tr>
<tr>
<td>Vibration &amp; Shock</td>
</tr>
<tr>
<td>Class compliance</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SAFETY SPECIFICATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voltage Isolation</td>
</tr>
<tr>
<td>Thermal runaway anti-propagation</td>
</tr>
<tr>
<td>Fire suppression recommended</td>
</tr>
<tr>
<td>Disconnect circuit</td>
</tr>
<tr>
<td>Maximum current parameter</td>
</tr>
<tr>
<td>Faults communicated</td>
</tr>
<tr>
<td>Short circuit protection</td>
</tr>
<tr>
<td>Disconnect switchgear rating</td>
</tr>
<tr>
<td>Emergency stop circuit</td>
</tr>
<tr>
<td>Ground fault detection</td>
</tr>
</tbody>
</table>

* Subject to change without notice ¹ Values shown are for reference only and should not be used for system design. Please contact Corvus Energy for complete system design solutions.
This is to certify:
That the Battery (Accumulator)
with type designation(s)
ORCA Energy

Issued to
Corvus Energy Inc.
Richmond BC, Canada

is found to comply with
DNV GL rules for classification – Ships, offshore units, and high speed and light craft

Application:
Product(s) approved by this certificate is/are accepted for installation on all vessels classed by DNV GL.

Issued at Høvik on 2017-08-14
This Certificate is valid until 2022-08-13. for DNV GL
DNV GL local station: Vancouver

Approval Engineer: Marta Alonso Pontes
Andreas Kristoffersen
Head of Section

This Certificate is subject to terms and conditions overleaf. Any significant change in design or construction may render this Certificate invalid. The validity date relates to the Type Approval Certificate and not to the approval of equipment/systems installed.
Name and place of manufacture
Corvus Energy
Richmond BC
Canada

Product description
Air cooled lithium-ion battery based energy storage system (EES) for use in battery-powered or hybrid vessels and off-shore units.
The system consists of battery modules connected in series to form a pack and achieve the required system voltage. Packs are installed in parallel in order to provide the required energy capacity. Each battery module contains a module control board (MCB) which monitors and communicates voltage, temperature and diagnostic information to the pack controller. The pack controller consists of pack disconnection module (PDM) and master control module (MCM). PDM is the electrical interface between the load and the battery pack. The MCM communicates with the pack modules, other packs, and external systems.
The battery modules, PDM, MCM and all other pack components are housed within a dedicated racking systems which provides: all module and pack electrical interconnection, pack communication, module cooling, and an integrated thermal runaway exhaust duct.

Module including cells and MCB
Type: ME1(G)-(VVV)V-AR*
Chemistry: Lithium ion NMC
Number of cells: 24
Cell configuration: 2P12S
Max Voltage: 50 V
Min Voltage: 36 V
Capacity: 128 Ah
Energy: 5.7 kWh
Cooling: Forced air

MCM
Type: MCM10(G)-(EE)*

PDM
Type: PDM100-(AAA)A-(PS)-(F)-(RR)R-(BS)*

Pack
Type: E(NN)(VVV)(C)-AR-(EE)-(PS)-ST-(Core)*
Max No. of modules: 24
Max Voltage: 1200V
Max Energy: 137 kWh

* The values in parenthesis may vary from one configuration to another. Refer to CORVUS document "Configurations for DNVGL TAC Rev2" dated 18 July 2017 for possible configurations.

Battery Management system
Functionality of BMS is distributed between MCB, MCM and PDM. Independent overtemperature protection according to DNV GL Pt.6 Ch.2 Sec.1 [4.1.5.2] is arranged as hardwired signal tripping high voltage interlock loop (HVIL).

The software is identified by the following versions:

Modules
SW: v1.3.2 Build# 359

MCM
SW: v.1.3.18 Build # 449
Application/Limitation
1. When installed on a ship or offshore unit, the DNV GL class rules for battery installation must be followed (DNV GL Pt.6 Ch.2 Sec.1).
2. The piping system venting the exhaust gases from the rack to open air/safe location shall be verified onboard in each case. Requirements in DNV GL rules Pt.6 Ch.2 Sec.1 shall be fulfilled.
3. Communication interface between battery arrays / banks is not covered by this Type Approval and if installed it shall be approved and tested on case by case basis.
4. The Type Approval covers hardware and software listed under Product description.
5. The Type Approval is valid for systems made by production facilities listed under Place of Manufacture.

Product certification:
A DNV GL product certificate according to DNV GL Pt.6 Ch.2 Sec.1 Table 2 is required for each delivery. The following documents shall be submitted for approval:
- Reference to this type approval certificate
- Copy of the approved Safety description
- (E120) Technical specification of the battery system that is subject for product certification
- (I030) Project-specific Battery System Block Diagram
- (I020) Project-specific functional description
- Information on software versions applicable for the particular delivery
- (Z252) Test procedure at manufacturer

Location classes (DNVGL-CG-0339)
- Temperature: Class A
- Humidity: Class B
- Vibration: Class A
- EMC: Class A
- Enclosure: IP44

Software update notification
When the type approved software is revised (affecting all future deliveries) DNV GL is to be informed by forwarding updated software version documentation. If the changes are judged to affect functionality for which rule requirements apply a new functional type test may be required and the certificate may have to be renewed to identify the new software version.

Type Approval documentation

Tests carried out
Tests according to DNVGL-CP-0418, DNVGL-CG-0339 and pack level safety function tests, DOC#: 1009814 rev.C

Marking of product
Manufacturer name, and battery system type designation.

Periodical assessment
The scope of the periodical assessment is to verify that the conditions stipulated for the Type approval are complied with and that no alterations are made to the product design or choice of materials.

The main elements of the assessment are:
- Inspection on factory samples, selected at random from the production line (where practicable)
- Results from Routine Tests (RT) checked (if not available tests according to RT to be carried out)
- Review of type approval documentation
- Review of possible change in design, materials and performance
- Ensuring traceability between manufacturer’s product type marking and Type Approval Certificate.

Periodical assessment is to be performed after 2 years and after 3.5 years. A renewal assessment will be performed at renewal of the certificate.

END OF CERTIFICATE
The heart of any storage device is the cell. Its quality determines the performance of the entire storage system. Cells provided with a lithium-titanate anode are vastly superior to conventional lithium-ions with regard to capacity, service life and load cycles.

15,000 full cycles
With 15,000 charging and discharging cycles the lithium-titanate cell LecCell is particularly suitable for long-term investment and low-maintenance storage systems. The costs for maintenance and exchange are minimal and shorten the return on investment period.

Permanent charging/discharging rate of up to 4C
The quality of the cell permits a stable current of 4C. Thus a cell is charged or discharged within 15 min.

100% DoD (= Depth of Discharge)
The possible Depth of Discharge of LecCell of 100% considerably increases the efficiency of the storage system. The depth of discharge persists over the 15,000 charge/discharge life of the cells.

Stable operating range on any SOC level
The service life of the cell is not influenced by the operation of the cell in a specific SOC (= State Of Charge) range. Whether primarily in a range of 30% SOC or 60% SOC: The service life is entirely independent of the SOC.

Water-based cell manufacturing
As the only manufacturer worldwide Leclanché avoids using ecologically damaging solvents in electrode manufacturing and using water based method. This method is environmentally friendly and prolongs the service life of the cell.

- Wide temperature range for operating the cell
- CE and UN 38.8 tested by TÜV Rheinland
- Individual ID for each cell for tracking the manufacturing process
- Continued internal and external tests
Innovative Technology – quantifiable added value in the field
Profit from our sound partnership with ads-tec

The heart of any storage device is the cell. Its quality determines the performance of the entire storage system. Cells provided with a lithium-titanate anode are vastly superior to conventional lithium-ions with regard to capacity, service life and load cycles.

Flexibility
Leclanché energy storage systems are individually designed, developed and produced according to the customers’ requirements. Depending on the specific demand and application alternative cell technologies are used. The integration of the storage system into existing systems is possible without problems owing to the use of prevailing industry standards.

100 % depth of development – the expertise in detail
- Development of everything from electronics, mechanics and software to complete systems takes place in-house
- Years of research and development work lead to special results in important points such as cell bonding and cooling
- Multi-stage and redundant monitoring equipment ensures safe shutdown and monitored operation on module and system level

Final assembly, logistics and service
Under one roof
- Based on highly integrated, IT-driven processes, material flow, final assembly, tests and services take place in a modern and optimised infrastructure
- Key process steps of module assembly take place on automation lines developed by ads-tec for this purpose
- Final assembly and testing are monitored and documented with the aid of » in-line « measurement methods and processes

- Flexible and demand-based warranty for up to 10 years
- 19” industry standard mounting
- International certifications
- In-house laboratory and testing facilities
- Free from maintenance
- Quality “Made in Germany”
**Example of product: TiRack 63**

**Unbeatable facts of technology**

<table>
<thead>
<tr>
<th>Security</th>
<th>Embedded String-Controller</th>
<th>Integrated String-Controller</th>
</tr>
</thead>
<tbody>
<tr>
<td>External / internal interfaces</td>
<td>Ethernet / CAN</td>
<td>Master or slave</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>String configuration</th>
<th>String format</th>
<th>19° triple rack</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of battery modules connected in series</td>
<td>15</td>
<td>-</td>
</tr>
<tr>
<td>Number of string controllers per triple rack</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>Number of string controllers per double rack</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Number of string shutoff modules »bipolar«</td>
<td>1</td>
<td>-</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Connection values</th>
<th>Battery voltage »empty«</th>
<th>510V DC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Battery voltage »full«</td>
<td>810V DC</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Currents</th>
<th>Operating current</th>
<th>180A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum string current</td>
<td>300A</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Battery system</th>
<th>Cell chemistry</th>
<th>Lithium-titanate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cell capacity</td>
<td>30Ah</td>
<td></td>
</tr>
<tr>
<td>Nominal system capacity</td>
<td>63kWh</td>
<td></td>
</tr>
<tr>
<td>Specified cycles 1C/1C @23°C at 100% DOD</td>
<td>15,000</td>
<td></td>
</tr>
<tr>
<td>Expected calendar lifespan</td>
<td>20 years</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Environmental conditions</th>
<th>Temperature range (long life &lt; 2C)</th>
<th>10 to 30 °C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protection class</td>
<td>IP20</td>
<td></td>
</tr>
<tr>
<td>Humidity</td>
<td>&lt; 90%, non-condensing</td>
<td></td>
</tr>
</tbody>
</table>

| Guarantee                 | Limitation period for claims due to defects | 24 months   |

| Function and durability   | In combination with a Big-LinX service contract | Up to 10 years |

<table>
<thead>
<tr>
<th>Standards</th>
<th>EMV:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Transport: UN38.3 Transport directive for lithium batteries</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Isolation and fire protection: DIN EN 60664-1, VDE 0110-1, DIN VDE 0298-4, VDE 0471 DIN EN 60695-11-10 und -20</td>
<td></td>
</tr>
</tbody>
</table>
**EPiC t32 Liquid Cooled Lithium Titanate Battery**

**Features**
- Integrated liquid cooling system
- Scalable in series and parallel
- Lightweight (75 Wh/kg)
- Compact (79 Wh/l)
- High power (1,000W/l)
- 15,000+ Cycles (100% DOD)
- Isolated CANbus interface
- Isolated discrete control and sense I/O

**Specifications**

<table>
<thead>
<tr>
<th>Electrical</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Voltage @ Charge:</td>
<td>31 - 32 V</td>
</tr>
<tr>
<td>Nominal Discharge Voltage:</td>
<td>27.6 V</td>
</tr>
<tr>
<td>Voltage @ Discharge Termination:</td>
<td>24 V</td>
</tr>
<tr>
<td>Nominal Capacity (C/2):</td>
<td>23 Ah</td>
</tr>
<tr>
<td>Standard Discharge:</td>
<td>23 A (C)</td>
</tr>
<tr>
<td>Max Cont. Charge:</td>
<td>184 A (8C)</td>
</tr>
<tr>
<td>Max Cont. Discharge:</td>
<td>184 A (8C)</td>
</tr>
<tr>
<td>Peak Discharge:</td>
<td>460 A (20C, &lt;10s)</td>
</tr>
</tbody>
</table>

**Mechanical**
- Dimensions: 13.5" x 6.0"W x 6.0"H
- Mass: 8.5 Kg / 18.7 lbs
- Cooling: 50/50 glycol mix, ~1 gpm

**Temperature**
- Discharge: -30°C to +70°C
- Charge: 0°C to +60°C
- Storage: -20°C to +35°C

**Interfaces**
- Module: Isolated Serial x1
- Controller COM: Isolate CANbus x2
- Controller Discrete Out: Isolated <60V, x4
- Controller Discrete In: Isolated <60V, x4

**Life Data**
- Cycle Life: 15,000 cycles > 80% BoL
- 100% DOD
- Shelf-Life: 60 months

EPS introduces the t32 advanced lithium-ion battery offering very high power, long life rechargeable energy in an extremely lightweight compact package. The chemistry uses high power lithium titanate (LTO) chemistry, capable of very high symmetrical discharge and charge rates, very high cycle life and very long calendar life. A proprietary cooling system allows the t32 to operate at very high discharge and charge rates continuously without impacting the cycle life of the cells.

The design also allows the t32 to be assembled into parallel and series strings up to 1kV to construct larger battery systems. The t32’s integrated battery management system (BMS) communicates to a central controller that manages the complete system, balances the lithium cells, controls charge and discharge operations, measures current, and provided state-of-charge information over the integrated CANbus interface.

Contact EPS to discuss incorporation of this advanced technology into your application.

---

Contact EPS
Electric Power Systems
16125 East Gale Ave.
City of Industry CA 91745
www.ep-sys.net + sales@ep-sys.net
(714) 200-3209