Certificate no.:
TAE00004X3

TYPE APPROVAL CERTIFICATE

This is to certify:

that the Li-Ion Battery System

with type designation(s)
CUBE Battery System

issued to
Lehmann Marine GmbH
Seevetal, **Germany**

is found to comply with
DNV 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.

Issued at **Høvik** on **2024-08-30**
This Certificate is valid until **2029-08-29**.
DNV local unit: **Hamburg – CMC North/East**

for **DNV**

Approval Engineer: **Andreas Andrecht**

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.

LEGAL DISCLAIMER: Unless otherwise stated in the applicable contract with the holder of this document, or following from mandatory law, the liability of DNV AS, its parent companies and their subsidiaries as well as their officers, directors and employees ("DNV") arising from or in connection with the services rendered for the purpose of the issuance of this document or reliance thereon, whether in contract or in tort (including negligence), shall be limited to direct losses and under any circumstance be limited to 300,000 USD.

Product description

The CUBE Battery System consists of air-cooled battery modules utilizing LFP battery cells which make the CUBE battery system inherently safe. The modules are scalable in number to reach the required battery capacity.
The Switch Unit including the master battery-management-system is part of the system. A battery string consists of a Switch Unit and up to eleven battery modules. The Control Cabinets provide the control electronics, on-site operation / visualization, and the interfaces to the energy management system. One Control Cabinet can control up to sixteen battery strings, thus forming a battery cluster.

The system consists of following parts:

Battery CUBE (BC**)** (1 – 11 per string) including:

- 24 single LFP battery cells per Module, connected in series
- Battery Management System BMS slave, Cell Monitoring Unit CMU, 2 per Module including:
  - Cell temperature sensors
  - Single cell voltage measurement
  - Ambient temperature sensor
- Independent monitoring electronics (CobraSense42S, 1 per Module) including:
  - Gas sensor
  - Pilot line (safety line)
  - Two redundant temperature fuses
  - Monitoring and control of the fan function
  - Monitoring and control of the module balancing resistor
- Power Line fuse

Switch Unit (SU) (one per string) including:

- Two fuses for all pole protection
- Two main contactors for connection to DC-bus
- Current sensor with voltage measurement
- Master BMS (MCU) per string
- Independent monitoring electronics (COBRASense42 Master)
- Precharge circuit for DC-bus

Control Cabinet (CC**)** with

- Optional 24V redundancy Module
- Control PLC for battery system operation
- Interfaces for communication to the power management system
- Emergency switch
- One battery string enable switch and two illuminated pushbuttons for each battery string
- Local/remote select switch

Software components
The software is installed in PLC, Master-BMS, CobraSense42 Slave and CobraSense42 Master.

CUBE Battery Module

Data	Value		Unit
Energy		12,5	kWh
Capacity		163	Ah
Configuration		1P24S	
Cooling		Air cooled	
Nominal voltage		77	V
Max. voltage (100% SoC)		87	V
Min. voltage (0% SoC)		60	V
Max. charge current		163	A
Max. discharge current		163	A
Max. discharge peak current (10s)		200	A
Protection class		IP65	

Switch Unit

Data	Value		Unit
Max. voltage		1000	V
Max. current		250	A
Fuse		125	A
Protection class		IP66	

Control Cabinet

Data	Value		Unit
Supply		24	V
Interface	Depends on customer need		
Protection class		IP66	

String

CUBE count	1	2	3	4	5	6	7	8	9	10	11	Unit
Nominal voltage	77	154	231	308	385	462	539	616	693	770	847	V
Max. voltage (100% SoC)	87	174	261	348	435	522	609	696	783	870	957	V
Min. voltage (0% SoC)	60	120	180	240	300	360	420	480	540	600	660	V

Hardware Versions

Control Cabinet	CC1Dxxxxxxx
Switch Unit	SU1Gxxxxxxx
Battery CUBE	BC0Bxxxxxxx
CobraSense42 Slave	V3.01
CobraSense42 Master	V2.02

Software Versions

CobraSense42 Slave Software	V2.xx
CobraSense42 Master Software	V2.xx
PLC Software	V2.xx
BMS Master Software	V2.xx

Location classes

Temperature Class B
Humidity Class A
Vibration Class A
EMC Class A
Enclosure IP65/66

Application/Limitation

Approval conditions

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

Battery system

- Reference to this type approval certificate
- Copy of the 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, emergency stop and independent safety system
- Z060 Functional description, including a project-specific overall description of the battery management system
    - software and hardware versions of components
    - capacity calculations for the gas extract ventilation fan
    - other relevant information not covered by the safety description
- Z252 Test program for product certification, including routine tests specified in applicable rules
- Z265 Calculation report, documentation of the SOC and SOH calculation

The Type Approval covers hardware and software listed under product description.

When the type approved software is revised (affecting all future deliveries) DNV 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.

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, the clause for application software control will be put into force. The independent cell voltage disconnection is integrated in the system and is not required to be tested during certification. See DNV-RU-SHIP Pt.6 Ch.2 Sec.1, Table 7 Tests of battery systems, item 10.

Application software control
All changes in software are to be recorded as long as the system is in use on board. Documentation of major changes are to be forwarded to DNV for evaluation and approval before implemented on board.

Type Approval documentation

Tests carried out

Type tests for the battery system according to applicable DNV rules and standards as listed below have been carried out. DNV-RU-SHIP Pt.6 Ch.2 Sec.1 (Edition 2023-07), DNV-RU-SHIP Pt.4 Ch.8, DNV-RU-SHIP Pt.4 Ch.9, DNV-CG-0339 (Edition: 2021-08), DNV-CP-0418 (Edition: 2021-09).

IEC 62620:2023 - 6.3.1 Discharge performance at +25 °C; 6.3.2 Discharge performance at low temperature; 6.3.3 High rate permissible current; 6.4 Charge (capacity) retention and recovery; 6.5.2 Measurement of the internal a.c. resistance; 6.5.3 Measurement of the internal d.c. resistance; 6.6.1 Endurance in cycles; 6.6.2 Endurance in storage at constant voltage.

IEC62619:2022 - 7.2.1 External short-circuit test; 7.2.2 Impact test; 7.2.3 Drop test; 7.2.4 Thermal abuse test; 7.2.5 Overcharge test; 7.2.6 Forced discharge test; 7.3.3 Propagation test (battery system); 8.2.2 Overcharge control of voltage; 8.2.3 Overcharge control of current; 8.2.4 Overheating control.

Propagation test passed in accordance with DNV-RU-SHIP Pt.6 Ch.2 Sec.1 [4.2.2] Edition July 2023 (with design option 1: No propagation between cells).

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