



Certificate No:
TAE00004C5

TYPE APPROVAL CERTIFICATE

This is to certify:

That the Li-Ion Battery System

with type designation(s)
LS-M-LFP-X-Y-Z

Issued to

Lithium System AG
Illnau, ZH, Switzerland

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 **Hamburg** on **2021-11-11**

This Certificate is valid until **2026-11-10**.

DNV local station: **Augsburg**

for **DNV**

Approval Engineer: **Uwe Supke**

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Arne Schaarmann
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.

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

Lithium-ion battery system for use in battery powered vessels / off-shore platforms and hybrid applications.

The battery system consists of one or more pack units, connected in series to one PDU-switchbox.

Numerous systems can be set up in parallel to gain more capacity and redundancy.

Packs up to a voltage limit of 1000V can be connected in series. Three pack-sizes are defined. One battery-pack consists of LiFePo4-cell-modules, MMU-slave, MSD-Fuse, HV-sockets, LV-sockets, and the 2nd level temperature protection. The PDU consists of BMU-master, HV-contactors, HV-sockets, LV-sockets, MSD-Fuse. Internal communication between packs and PDU is solved by a Master-Slave concept.

The size of the battery system is limited by the number of all cells in the system. The maximum configuration is 240 cells in series. Mix of A-, B- and C-packs, increases the system voltage from 77V up to 768V nominal.

Type Designation for Type Approval LS-M-LFP-X-Y-Z

LS -> Lithium System AG

M -> Maritime Application

LFP -> LiFePO4 chemistry

X -> X - Placeholder for Capacity [Ah] (176Ah or 277Ah)

Y -> Y - Placeholder for Cell Configuration

Z -> Z - Placeholder for Pack Arrangement (Numbers + Pack size)

Attribute	176Ah	277Ah
Chemistry	LiFePO4	
System Voltage nominal	96V up to 768V	77 - 772V
System Capacity	176Ah	277Ah
System Energy	16.9kWh – 135.2kWh	21.4kWh – 214.1kWh
System Continuous charge current	1C, 176A	277A
System Continuous discharge current	1C, 176A	277A
Temperature range charge	0°C – 55°C	
Temperature range discharge	-20°C – 55°C	
Heating System	PTC Heater inside each pack	
Ingress protection Pack	IP67	
Ingress protection PDU	IP67	
Communication protocol	CAN 2.0A/B , SAEJ1939	

Three packs are designed with different number of cells. Each pack is available with two different cell types. 176Ah or 277Ah cells. Pack Type:

		Type - LS-M-LFP-176		
Pack size	A	B	C	
Capacity [Ah]		176Ah		
Voltage [V]	96	192	211.2	
Cell config.	30	60	66	
Modul config.	3x (1p10s)	6x (1p10s)	6x (1p11s)	
Energy [kWh]	16.9	33.8	37.2	
Weight [kg]	161.5	302	328	
Width [mm]		630		
Height [mm]		240		
Length [mm]	797	1496	1630	
Fuse		400A		

		Type - LS-M-LFP-277		
Pack size	A	B	C	
Capacity [Ah]		277Ah		
Voltage [V]	77.28	154.56	173.88	
Cell config.	24	48	54	
Modul config.	3x (1p8s)	6x (1p8s)	6x (1p9s)	
Energy [kWh]	21.2	42.5	47.9	
Weight [kg]	172.4	321.8	355.9	
Width [mm]		630		
Height [mm]		240		
Length [mm]	867	1552	1697	
Fuse		630A		

Examples of pack arrangements.

System name 176Ah for Type Approval	Nbr. LS-M-LFP-176-A	Nbr. LS-M-LFP-176-B	Nbr. LS-M-LFP-176-C	System Nominal Voltage [V]	System Max Voltage [V]	System Energy [kWh]	Total Weight [Kg]	Cell Configuration
LS-M-LFP-176-30-1A	1			96,0	109,5	16,9	161,50	30
LS-M-LFP-176-60-1B		1		192,0	219,0	33,8	302,00	60
LS-M-LFP-176-66-1C			1	211,2	240,9	37,2	328,00	66
LS-M-LFP-176-60-1A1B	1	1		288,0	328,5	50,7	463,50	90
LS-M-LFP-176-96-1A1C	1		1	307,2	350,4	54,1	489,50	96
LS-M-LFP-176-120-2B		2		384,0	438,0	67,6	604,00	120
LS-M-LFP-176-126-1B1C		1	1	403,2	459,9	71,0	630,00	126
LS-M-LFP-176-132-2C			2	422,4	481,8	74,3	656,00	132
LS-M-LFP-176-150-1A2B	1	2		480,0	547,5	84,5	765,50	150
LS-M-LFP-176-156-1A1B1C	1	1	1	499,2	569,4	87,9	791,50	156
LS-M-LFP-176-162-1A2C	1		2	518,4	591,3	91,2	817,50	162
LS-M-LFP-176-180-3B		3		576,0	657,0	101,4	906,00	180
LS-M-LFP-176-186-2B1A		2	1	595,2	678,9	104,8	932,00	186
LS-M-LFP-176-192-1B2A		1	2	614,4	700,8	108,1	958,00	192
LS-M-LFP-176-198-3C			3	633,6	722,7	111,5	984,00	198
LS-M-LFP-176-210-1A3B	1	3		672,0	766,5	118,3	1.067,50	210
LS-M-LFP-176-216-1A2B1C	1	2	1	691,2	788,4	121,7	1.093,50	216
LS-M-LFP-176-222-1A1B2C	1	1	2	710,4	810,3	125,0	1.119,50	222
LS-M-LFP-176-228-1A3C	1		3	729,6	832,2	128,4	1.145,50	228
LS-M-LFP-176-240-4B		4		768,0	876,0	135,2	1.208,00	240
System name 277Ah for Type Approval	Nbr. LS-LFP277-A	Nbr. LS-LFP277-B	Nbr. LS-LFP277-C	System Nominal Voltage [V]	System Max Voltage [V]	System Energy [kWh]	Total Weight [Kg]	Cell Configuration
LS-M-LFP-277-24-1A	1			77,3	87,6	21,4	172,40	24
LS-M-LFP-277-48-1B		1		154,6	175,2	42,8	321,80	48
LS-M-LFP-277-54-1C			1	173,9	197,1	48,2	355,90	54
LS-M-LFP-277-72-1A1B	1	1		231,8	262,8	64,2	494,20	72
LS-M-LFP-277-78-1A1C	1		1	251,2	284,7	69,6	528,30	78
LS-M-LFP-277-96-2B		2		309,1	350,4	85,6	643,60	96
LS-M-LFP-277-102-1B1C		1	1	328,4	372,3	91,0	677,70	102
LS-M-LFP-277-108-2C			2	347,8	394,2	96,3	711,80	108
LS-M-LFP-277-120-1A2B	1	2		386,4	438,0	107,0	816,00	120
LS-M-LFP-277-126-1A1B1C	1	1	1	405,7	459,9	112,4	850,10	126
LS-M-LFP-277-132-1A2C	1		2	425,0	481,8	117,7	884,20	132
LS-M-LFP-277-144-3B		3		463,7	525,6	128,4	965,40	144
LS-M-LFP-277-150-2B1C		2	1	483,0	547,5	133,8	999,50	150
LS-M-LFP-277-156-1B2C		1	2	502,3	569,4	139,1	1.033,60	156
LS-M-LFP-277-162-3C			3	521,6	591,3	144,5	1.067,70	162
LS-M-LFP-277-168-1A3B	1	3		541,0	613,2	149,8	1.137,80	168
LS-M-LFP-277-174-1A2B1C	1	2	1	560,3	635,1	155,2	1.171,90	174
LS-M-LFP-277-180-1A1B2C	1	1	2	579,6	657,0	160,5	1.206,00	180
LS-M-LFP-277-186-1A3C	1		3	598,9	678,9	165,9	1.240,10	186
LS-M-LFP-277-192-4B		4		618,2	700,8	171,3	1.287,20	192
LS-M-LFP-277-198-3B1C		3	1	637,6	722,7	176,6	1.321,30	198
LS-M-LFP-277-204-2B2C		2	2	656,9	744,6	182,0	1.355,40	204
LS-M-LFP-277-210-1B3C		1	3	676,2	766,5	187,3	1.389,50	210
LS-M-LFP-277-216-4C			4	695,5	788,4	192,7	1.423,60	216
LS-M-LFP-277-222-1A3B1C	1	3	1	714,8	810,3	198,0	1.493,70	222
LS-M-LFP-277-228-1A2B2C	1	2	2	734,2	832,2	203,4	1.527,80	228
LS-M-LFP-277-234-1A1B3C	1	1	3	753,5	854,1	208,7	1.561,90	234
LS-M-LFP-277-240-5B		5		772,8	876,0	214,1	1.609,00	240

PDU Specification

Power distribution unit connects a pack-string to the DC-Link. It has a communication interface and contains main fuse, contactors, main BMS, main HV-connectors, auxiliary power supply connector. Each pack-string is equipped with its own PDU and operates as a standalone battery system.

BMS Specification

The BMS is designed as a Master – Slave - System. Master (BMU) is located in the PDU and sensors system values like system current, system voltage, temperature. The Master calculates all relevant data like SOC, SOH and communicates with the vessel controller. A Slave (MMU) is located in each pack and sensors connect to it and collect all relevant pack data like cell voltage and cell temperature. BMU and MMU are connected via CAN bus.

For device information see document I020 V1.2.

Type	HW-version	SW-version
BMU	JKY70001A	1.218.6.2
MMU	JKY20310	4.x.218.1 (x: 1 .. n MMU-units, depending on configuration)

Place of manufacturer:

Modules/Pack + PDU: see document E120 V1.5 for details
BMS: see document I020 V1.2 for details

Location classes

Temperature:	Class C
Humidity:	Class B
Vibration:	Class A
EMC:	Class A
Enclosure:	Class C (IP 67)

Application/Limitation

A DNV GL product certificate according to DNV GL-RU-SHIP Pt.6 Ch.2 Sec.1 Table 2 is required for each delivery of a battery system.

The following documentation shall be submitted for approval:

- Reference to this type approval certificate
- Copy of the safety description
- E120 Technical specification of the battery system that is subject for vessel certification
- E170 Electric schematic diagram of the battery system showing internal arrangement of battery modules, battery strings, including switch gear and control gear
- I030 Project-specific Battery System Block Diagram
- I020 Functional description, including
 - Project-specific overall description of the battery management system
 - Software and hardware versions of BMS and MCR
 - Other relevant information not covered by the safety description
- Z252 Test procedure at manufacturer (routine tests)

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

When the type approved software is revised (affecting all future deliveries) DNV GL is to be informed by forwarding updated software version documentation and updated BMS release note. 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 the certification the clause for application software control will be put into force.

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 is to be forwarded to DNV GL for evaluation and approval before implemented on board.

Type Approval documentation

Tests carried out

Type tests according to applicable DNV rules and standards as listed below have been carried out.
DNVGL-RU-SHIP Pt.6 Ch.2 Sec.1 (07-2020), DNVGL-RU-SHIP Pt.4 Ch.8, DNVGL-RU-SHIP Pt.4 Ch.9, DNVGL-CG-0339 Sec.3 Items 6–9,12,14 (12-2019), DNVGL-CP-0418 (09-2018).
Propagation testing acc. DNVGL-RU-SHIP Pt.6 Ch.2 Sec.1 [4.2.2.1] (opt.1: no propagation between cells)
Test Report of Propagation Test V1.1 dated 06.08.2021.
Safety Function and Sensor Failure Test acc. DNVGL-RU-SHIP Pt.6 Ch.2 Sec.1 [4.1.5.2]

Marking of product

The products to be marked with:

- manufacturer name
- model name
- serial number
- power supply ratings

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 of factory samples, selected at random from 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 of the 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