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Solutions for large batteries for waterborne transport

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D6.3 Full battery system test program

Report details

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Author	Nicolas HASCOËT (CEA)	2024-05-01
WP leader	Olve Mo (SINTEF)	2024-04-30
Reviewers	Colavitto (FCSI)	2024-04-30
	Mikel Rivas (IKERLAN)	2024-04-30
Coordinator	Jeroen Stuyts (FM)	2024-05-02

Project Abstract

The goal of the SEABAT project is to develop a full-electric maritime hybrid battery concept that is based on:

- Modularly combining high-energy batteries and high-power batteries,
- novel converter concepts and
- production technology solutions derived from the automotive sector.

The modular approach will reduce component costs (battery cells, convertors) so that unique ship designs can profit from economies of scale by using standardized low-cost components. The concept will be suitable for ships requiring up to 1 MWh of storage or more.

1 Public summary

The purpose of this document is to describe a set of tests to validate that the SEABAT concept works in full scale and to make a first evaluation of hazard in case of faulty batteries. Safety tests are inspired from classical tests used in non-maritime applications. The goal is to demonstrate that the design of the module prevents propagation of a thermal event. That is an important way to validate the developed battery system concept for waterborne operations, ensuring it meets specified conditions and requirements. This involves verifying trustworthiness and effectiveness, testing the system's performance in real-world conditions, and confirming fault tolerance. A Power-HiL framework will be developed for virtual integration and testing. Specific objectives include creating a test program for operational confirmation and fault tolerance, as well as establishing a laboratory setup for virtual integration testing. The testing aim
s to demonstrate that the chosen concept functions as intended, though it does not encompass all necessary tests for full certification. Component validation occurs individually within WP4, while the entire battery system validation undergoes in a final comprehensive test.
The tasks outlined in the document include the test plan for the validation of the chosen battery system conception, testing its trustability, effectiveness, and fault-tolerance capabilities. These tasks directly contribute to the validation of the system's performance in realistic terrain and its fault-tolerance capabilities.
Then, a deliverable detailing the results of the tests proposed in this deliverable will be submitted. This will be deliverable D.6.5: Full test results.

This deliverable was delayed for multiple reasons: At submission (and original intended submission), the HESS construction was not yet completed, leading to uncertainty in the final requirements; the test setup deemed more complex than was originally intended; and finally the deliverable is not time critical for the timely execution of the project such that the priority went to getting the HESS ready, this in turn caused delays in writing and reviewing of this deliverable.

1.1 Introduction

The main idea is to validate that the developed battery system conception for waterborne operations fulfills the linked conditions and the specifications. This includes to prove trustability and effectiveness of the conception chosen to validate that the developed battery system topology works as intended in a realistic terrain and to corroborate fault- forbearance and fault lift- through capabilities of the advanced system topology and control system, considering both electric and electromechanical faults. Also, a Power-hardware- In- the- Loop (P- HiL) frame for virtual integration and testing is going to be developed. Specific objects are to:

- give a test program for confirmation of willed operation, fault forbearance and fault lift- through capabilities in realistic terrain.

- establish a laboratory Power- tackle- In- the- Loop test set- up including digital halves of the colorful subsystems for state- of- the- art virtual integration and confirmation testing.

The compass of the testing conditioning is to prove that the chosen concept works as intended. The compass doesn't include all tests demanded for a full type blessing or bracket blessing.
Components are individually validated within WP4 and the whole battery system will be validated following the proposed test program of this 6.3 deliverable in a final full test. Results of these test will be shown in the deliverable 6.5

1.1.1 Purpose of the document

The purpose of this document is to describe a set of tests to validate that the concept works in full scale and to make a first evaluation of hazard in case of faulty batteries.

For achieving that purpose, tests will be performed at three batteries scales:

- At cell scale: abuse test will be performed on both HE and HP cells in order to generate thermal runaways. The goal is to provide input data such as released energy and gases flow to feed WP4 in order to design safety elements such as cooling system or vents. The more efficient thermal runaway method will be re-used for the abuse test at module level. Furthermore, gas sampling will be done to identify and quantify toxic and hazardous gases.
- At module scale a propagation test will be performed on both HE and HP modules. They consist in generating a thermal runaway on a trigger cell and observing the propagation to the neighboring cells. The aim is to test the whole safety chain (sensors, vents, thermal architecture…).
- At HESS scale: we will not carry out abusive tests on the battery pack scale. We will simply check the correct execution of the security measures in the event of a failure. For example, we will check that the communications from the battery pack will be effective in activating the safety device via the contactors. The details of the tests will be developed later in this document.

1.1.2 Document structure

Chapter 2.1 and 2.2 deal with security issues and associated tests. First of all on the Cell scale for the first part and other hand-scaled modules. The methodology for evaluating the security of the system will be presented. Particularly with regard to thermal runaway problems.

Chapter 2.3 evaluates the complete system scale and the evaluation of its proper functioning. We will detail the means implemented and the tests planned. Here we will assess the proper functioning and robustness of the system. This is with the aim of continuing the system validation process with respect to the work already carried out on the sub-components (controller, converter, battery, etc.)

1.2 References

- Deliverable 6.1 Report of the Integration and validation test program
- Deliverable 6.4: Virtual integration and validation test results
- IEC 62660-2: Secondary lithium-ion cells for the propulsion of electric road vehicles - Part 2: Reliability and abuse testing
- IEC 61508:2010 Functional safety of electrical/electronic/programmable electronic safety-related systems
- IEC 61508:2005Functional safety of electrical/electronic/programmable electronic safety-related systems
- IEC 61511: 2003 Functional safety - Safety instrumented systems for the process industry sector
- ISO 12405-1:2011 specifies test procedures for lithium-ion battery packs and systems for use in electrically propelled road vehicles.
- IEC 62660-1:2018: Secondary lithium-ion cells for the propulsion of electric road vehicles - Part 1: Performance testing

2 Acknowledgements and disclaimer

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Project partners:

#	Partner	Partner Full Name
1	FM	FLANDERS MAKE
2	DAMEN	SCHEEPSWERF DAMEN GORINCHEM BV
3	FCSI	FINCANTIERI SI SPA
4	RINA	RINA SERVICES SPA
5	SOERMAR	FUNDACION CENTRO TECNOLOGICO SOERMAR
6	VARD	VARD ELECTRO AS
7	ABEE	AVESTA BATTERY & ENERGY ENGINEERING
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11	Fraunhofer	FRAUNHOFER GESELLSCHAFT ZUR FOERDERUNG DER ANGEWANDTEN FORSCHUNG E.V.
12	IKERLAN	IKERLAN S. COOP
13	MGEP	MONDRAGON GOI ESKOLA POLITEKNIKOA JOSE MARIA ARIZMENDIARRIETA S COOP
14	SINTEF	SINTEF ENERGI AS
15	POLITO	POLITECNICO DI TORINO

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3 Appendix A - Table of Abbreviations

Abbreviation	
A	Amperes
Ah	Ampere-hours
BEV	Battery electric vehicle
BMS	Battery Management System
C	C rate (referring to charge/discharge speed)
CU	Control unit
DoD	Depth of discharge
HD	High definition
HE	High energy (battery pack) referring to NMC technology
HF	Hydrogen fluoride
HP	High power (battery pack), referring to LTO technology
HESS	Hybrid energy storage system
Li	Lithium (cell technology)
LTO	Lithium Titanium Oxide
NMC	Nickel manganese cobalt
OCV	Open circuit voltage
PHIL	Power hardware in the loop
PMS	Power management System
Tsensor or Tc	Temperature sensor
TRA	Thermal runaway
V	Volts
Vsensor	Voltage sensor
WP	Work package (within SEABAT project)