D3.19 HSE Workshop

Synergetics | Synergies for Green Transformation of Inland and Coastal Shipping

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Release Approval

1 | Release Approval

Name	Role	Date
P. Garcia Barrena (MARIN)	WP-Leader, Reviewer 1	23-02-2024
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Executive Summary

Within task 3.5 the risks associated with utilization of hydrogen, methanol, and batteries in drivetrains of the SYNERGETICS demonstrators were discussed in the format of a HSE partner-workshop. Presentations were held on both a theoretical approach for the implementation of a monitoring method and moreover on the view of a classification society on the topic. To prepare the participants for the open discussion in the second part of the workshop, three experts presented the risks associated with hydrogen, methanol, and battery-electric drive systems. The key takeaways from all three presentations were that the risks, that are different from those related to diesel-engines and sometimes may present a higher risk, can be safely contained on board a ship if properly addressed from the very beginning. For this, on the one hand technical measures of all kind are already available on the market; sometimes from other sectors, but always with the highest safety standards suitable for waterborne applications. On the other hand, trainings for the crew are indispensable to establish safe working routines, enabling the crew members to feel capable of acting in all situations arising around the alternative drive systems.

The special features of three demonstrator vessels were presented and the possibilities and plans for the safe integration of the new systems were discussed. The participants were also shown the vessels' general arrangement plans to have a better understanding of the situation on board. Since it is not possible to replace a diesel system one by one with an alternative system of the same power and range, the operational profiles were also presented to be considered when choosing alternative drive systems and tank size for the demonstrators.

An important outcome of the discussion was that the new energy sources for inland waterway vessels pose new challenges for the ship and the crew. Detailed monitoring, planned from the outset and continuously improved, is therefore essential. For example, additional crew training or technical measures or improvements can be introduced at an early stage. The concept of double assurance presented above, i.e. monitoring both errors and successes, appears to be a desirable monitoring method.

In contrast to other sectors, shipping is still at the beginning of widespread use of alternative technologies. For this reason, the partners at the workshop concluded that a look at other industries, such as the process industry, which has been working with complex and hazardous systems for a long time, is also very helpful for the demonstrators within the SYNERGETICS project.

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1. | Introduction

This deliverable reports the outcome of task 3.5 "Health, safety and environment (HSE) monitoring" with the following task description from the Grant Agreement:

> The purpose of this task is to properly consider the **risks associated with utilization of hydrogen, methanol, and batteries in drivetrains of the demonstrators**. Within the task, a **HSE Workshop** addressing the risks associated with utilization of hydrogen, methanol, and batteries onboard inland vessels and costal ships will be organized. Based on the outcomes of the HSE Workshop, a **methodology for monitoring** of the relevant risks will be developed and subsequently implemented throughout the Demonstration.

2. | HSE-Workshop

The HSE workshop took place at DST premises on the 9th of November 2023. Partners from ANLEG, ANZ, CRS, DST, MARIN, MER and VIA participated. In addition, Dana Meißner of the Institute for Safety Engineering, Rostock Germany, was invited for a presentation on risks associated with Lithium-ion batteries and their most relevant cell chemistries. The aim of the workshop was to achieve a general understanding of the risks associated with the new energy sources. In addition, a monitoring method was to be developed that would be used in the project for the pilots.

2 | Workshop programme

09:30-10:00	**Welcome**
10:00-10:15	**Introduction to SYNERGETICS (DST)**
10:15-10:30	**Introduction to WP3 Demonstration (MARIN)**
10:30-12:15	**First part of the Workshop: Risks and mitigation strategies** Friederike Dahlke-Wallat, DST **Basic ideas and concepts of HSE monitoring** Vedran Klisarić, Croatian Register of Shipping **General considerations on the role of classification societies on monitoring of the risks associated with utilization of new technologies** Patrick Höving, Koedood Marine Group / August Storm GmbH **Methanol applications: perspective of an engine manufacturer** Dana Meißner, Institut für Sicherheitstechnik / Schiffssicherheit e. V. **Risks and mitigation strategies for battery applications** Ria Pabst, Dirk Fischer, Argo-Anleg GmbH **Risks and mitigation strategies for hydrogen applications**
12:15-13:15	**Lunch break**
13:15–14:45	**Second part of the Workshop: Brainstorming session** **Discussion of the risks and mitigation strategies of the ships used as the demonstrators in SYNERGETICS:** Push boat BAD DEUTSCH-ALTENBURG (via donau) Cement carrier LE SANDRE (CFT/SOGESTRAN) Chemical tanker (Mercurius)
14:45–15:00	**Wrap-up and conclusions**

Also, a presentation by the partner ZES on the safety concept of the *ZESpack* was provided.

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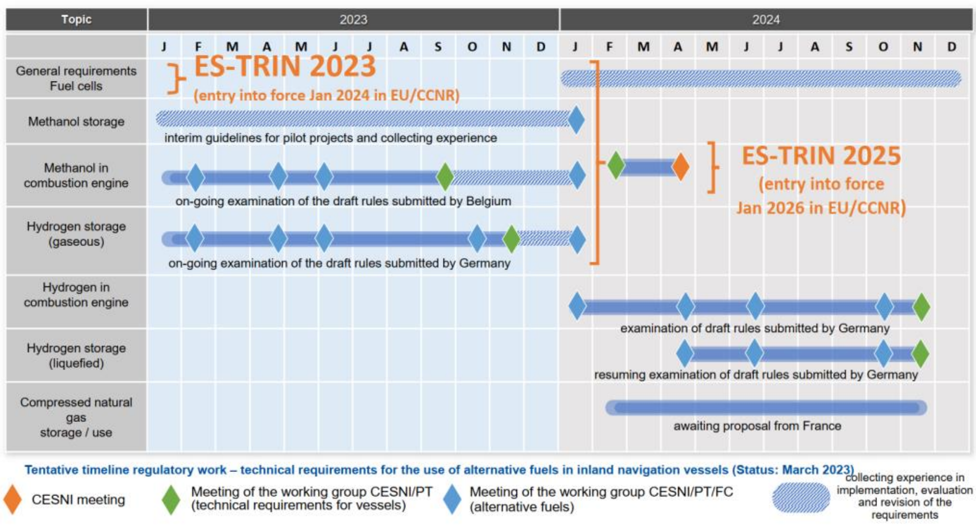
Table 3 shows the regulatory status of the technologies covered within SYNERGETICS. It is noticeable that the development of technical regulations by CESNI/PT and its working groups is almost complete. The regulations for crew competences (CESNI/QP), on the other hand, still need to be developed. This is another reason why the SYNERGETICS workshop on HSE is so important: in pilot applications, the safety of the crew must be guaranteed and monitored without the possibility of using standards. In figure 1 the CESNI/PT/FC working plan for the development of the technical rules can be seen.

3 | Regulatory status of technologies [1]

Technologies		Vessel	Crew	Police
Diesel	HVO/ advanced biofuels	In force	In force	In force
LNG	LBM	In force	In force	In force
Batteries		In force (clarifications approved on the location of swappable battery containers)	Proposal of competence standards developed in PLATINA3 To be developed by CESNI/QP	Foreseen in the work programme
Hydrogen in fuel cells or combustion engines		Fuel cells covered by ES-TRIN 2023 On-going work on the storage of compressed hydrogen		
Methanol in fuel cells or combustion engines		Fuel cells covered by ES-TRIN 2023 Draft requirements for methanol storage approved by CESNI/PT in 06/2023 On-going work on methanol engines		



1 | CESNI/PT/FC working plan

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3. | Basic ideas and concepts of HSE monitoring

The first presentation of the workshop, given by Friederike Dahlke-Wallat of DST, dealt with basic ideas and concepts of HSE monitoring. New energy carriers come with different hazards and risks. This does not necessarily imply that they are more dangerous than conventional energy carriers, but as they are new, their storage, preparation and use on board needs to be evaluated to identify and minimize the hazards they may present. Proper HSE management provides pilot projects with a comprehensive means of ensuring compliance with relevant regulations and requirements - with an assessment of all health, safety, and environment (HSE) requirements.

2 | Three fields of HSE

To facilitate entry into HSE management for new energy carriers on inland waterway vessels, it is also helpful to look at existing technologies, other sectors, and how these technologies are being applied on sea-going ships: What are similarities, what are differences between diesel-like fuels & natural gas and the renewables hydrogen, methanol, and the storage of energy in batteries? What can we learn, where do we need to pay attention? The overall aim shall be to keep the risk low to contain hazards. New risks associated with alternative energy carriers might be:

- Potential fires with very long duration, causing damage to vessel structure
- Accumulation of explosive gases
- Electrical hazards
- Nitrogen System hazards including asphyxiation
- Hazards according to low flashpoint fuels
- Toxicity hazards for both humans and the environment

3.1 Monitoring and measuring

Safety must always be the top priority for every project, especially when testing prototypes, so as not to hinder the further development of technology through accidents that lead to rejection. **Proactive safety measures** are aimed at preventing accidents and incidents. If incidents do occur, **reactive monitoring methods** are the best way to recognise potential hazards, identify the causes and establish effective remedial measures to improve safety in the use of the new technology. The following table presents proactive and reactive, qualitative and quantitative, as well as subjective and objective monitoring methods. No preference should be given to the monitoring methods presented on the right or left column of table 4, as the application of the methods depends on the situation: proactive monitoring helps to prevent accidents; reactive monitoring helps to analyse accidents. Qualitative monitoring gives a good overall impression of a situation, quantitative monitoring helps to analyse details and put them into concrete figures. Subjective analyses by an experienced team are better suited to some situations than precise measurement data.

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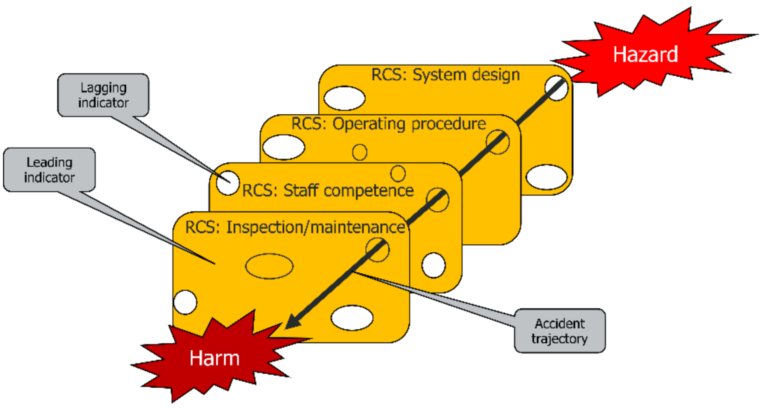
4 | Monitoring methods [2]

- Proactive
  - Inspections
  - Interviewing
  - Audits
  - Monitoring performance / behaviour
  - Checking procedures
- Reactive
  - Accident reporting
  - Accident investigation
  - Incident investigation
  - Ill health and sickness reviews
  - Identifying trends
- Qualitative
  - Descriptive
  - e.g. Behavioural surveys
- Quantitative
  - Specific criteria
  - Numerical assessment
- Subjective
  - Based on opinion / competent judgement (risk assessment)
- Objective
  - Based on facts and figures e.g. measuring, sampling

3.2 The "Swiss cheese" model of accident causation

Even if new energy carriers are not necessarily associated with greater risks, but often with risks of a different kind, these must be monitored and the procedure for maintaining the corresponding safety barriers must also be implemented. Methods from the process industry, which has decades of experience with these substances, offer a good approach here. The hazards that arise, such as toxicity, flammability, etc., are comparable, and the context is also similar: there are trained personnel working on the ship.

In general, it is best to set up a measurement based on the outcome of the risk analysis. This ensures that the right risks are addressed and hazards can be contained. The monitoring system shall observe, whether all systems that are installed to contain risks are in working order to have an early warning before a (catastrophic) failure.



3 | The "Swiss cheese" model was first introduced by James Reason [3] giving a model for accident causes. Later, it was refined within [4].

As it can be seen in figure 3, two types of indicators are used for monitoring: The leading indicator that requires a routine systematic check that key actions or activities are undertaken as intended and the lagging indicator that shows when a desired safety outcome has failed, or has not been achieved [4].

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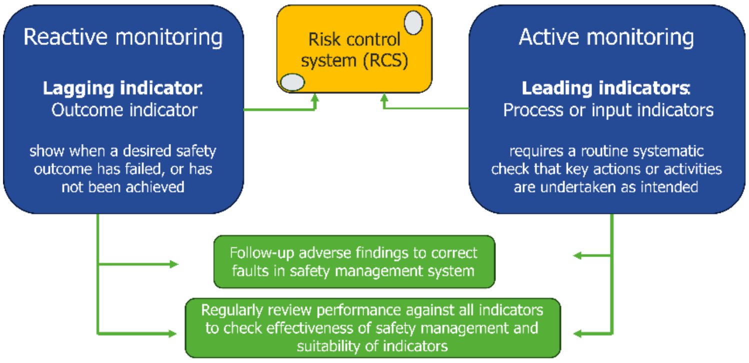

4 | Dual assurance – leading and lagging indicators measuring performance of each critical risk control system [4]

The distinct aspect of this method is that not only the malfunction, but also the success or the desired result is documented. So, the leading indicators can be used as measures essential to deliver the desired safety outcome.

5 | Overview of the six steps to setting performance indicators according to [4]

Step	Aim	Tasks
1	Establish the organisational arrangements to implement the indicators	• Appoint a steward • Set up an implementation team

2	Decide on scope of measurement system. Consider what can go wrong and where.	• Identify the scope of the measurement system:
		  • Identify incident scenarios - what can go wrong?
		  • Identify the immediate causes of hazard scenarios

3	Identify risk control systems to prevent major accidents. Decide on outcomes for each and set **lagging indicators.**	• What risk control systems are in place and why? • What is a success, what a failure? • Set a lagging indicator (negative outcome) • Follow up deviations from the outcome
4	Identify the critical elements of each risk control system, (actions/processes which must function correctly to deliver the out-comes) and set **leading indicators.**	• What are the most important parts of the risk control system? • Set leading indicators • Set tolerances • Follow up deviations from tolerances
5	Establish the data collection and reporting system	• Collect information - ensure infor-mation/unit of measurement is available or can be established • Decide on presentation format
6	Review	• Review performance of process manage-ment system • Review the scope of the indicators • Review the tolerances

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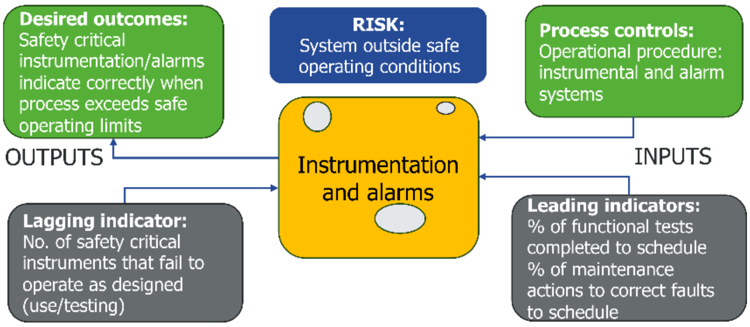
Worked example

In [4] there are several worked examples to make the theoretical approach a bit more practicable. Within the workshop the example of instrumentation and alarms was chosen, since this can be easily transferred to the pilot application.

The desired safety outcomes here would be that safety critical instrumentation and alarms correctly indicate when process conditions exceed safe operating limits.

The chosen lagging indicator is the number of safety critical instruments/alarms that fail to operate as designed, either in use or during testing. The chosen leading indicator is the percentage of functional tests of safety critical instruments and alarms completed to schedule. The critical elements within this analysis are the circumstances whether:

- The instruments correctly indicate process conditions. Alarms activate at desired set points.
- All instruments and alarms are tested and calibrated to design standard.
- The repairs of faulty instruments and alarms are carried out within a specified time period.



5 | Instrumentation and alarm indicators

The chosen lagging indicator will detect all failures in the instruments and alarm systems, regardless of whether this leads to a loss of containment. The leading indicators *percentage of functional tests* and of *maintenance actions to correct faults completed to schedule* ensure that instruments and alarms continue to function as designed.

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4. | Considerations on the role of classification societies with utilization of new technologies

The presentation *Basic ideas and concepts of HSE monitoring* was given by Vedran Klisarić from SYNERGETICS partner Croatian Register of Shipping and is summarised as follows.

There are a large number of considerations related to zero-emission solutions and decarbonisation of industry and transport, but not so much about the impact of the transition on health, safety, and environment. This was recognised by classification societies, so this task is fundamental to them and through their joint work, with leading role of IACS (International Association of Classification Societies), societies are trying to take a holistic risk-based approach to assure that the safety performance of the industry is maintained or improved to help assess the regulatory regime in the fast-moving technology environment. With the potential introduction of many new technologies on ships to address decarbonization and zero-emissions, the human element is being introduced into the societies' strategies as their rules assume a healthy, competent, and well-trained crew.

It is in the societies' collective interests to prioritise and ensure seafarer wellbeing with the critical role of personnel onboard. Dedicated to safe ships and clean seas, classification societies make a unique contribution to maritime safety and regulation through technical support, compliance verification and research and development. One of the most important goals is to ensure that classification societies' instruments are responsive to all parties involved, so this work is a long-term strategic roadmap to support technical, industrial, and regulatory drivers in zero-emission solutions. In that sense, many guidelines are developed with participation and significant contribution of classification societies, especially for international maritime safety and regulation.

International Code of Safety for Ship Using Gases or Other Low-flashpoint Fuels (IGF Code)

The purpose of the IGF Code is to provide an international standard for ships, other than vessels covered by the IGC Code, operating with gas or low-flashpoint liquids as fuel. The basic philosophy of the Code is to provide mandatory criteria for the arrangement and installation of machinery, equipment and systems for vessels operating with gas or low flashpoint liquids as fuel to minimize the risk to the ship, its crew, and the environment, having regard to the nature of the fuels involved. Throughout the development of the Code, it was recognized that it must be based upon sound naval architectural and engineering principles and the best understanding available of current operational experience, field data and research and development. Due to the rapidly evolving new fuels technology, the Organization will periodically review the Code, considering both experience and technical developments.

Guidelines for the approval of alternatives and equivalents as provided for in various instruments

The Maritime Safety Committee, with a view to providing a consistent process for the coordination, review and approval of alternatives and equivalents regarding ship and system design, approved the annexed Guidelines for the approval of alternatives and equivalents as provided for in various IMO instruments.

- Interim guidelines for the safety of ships using methyl/ethyl alcohol as fuel
- Interim guidelines for the safety of ships using fuel cell power installations

For inland vessels in Europe, the latest European committee for drawing up standards in the field of inland navigation (CESNI) regulations are developing two regulations based on methanol, the final draft of the one on methanol storage titled "Final draft requirements for methanol storage" has been released in June 2022.

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Based on these guidelines, some classification societies have created their own rules/requirements:

- American Bureau of Shipping, Requirements for methanol and ethanol fuelled vessels (July 2022)
- American Bureau of Shipping, Requirements for hydrogen fuelled vessels (May 2023)
- Croatian Register of Shipping, Rules for the classification of ships; Part 33 – Ships using gases or other low-flashing fuel (July 2022, amendments January 2024)
- Det Norske Veritas, Handbook for hydrogen-fuelled vessels (June 2021)
- EMSA & DNV GL, Electrical energy storage for ships (May 2020)
- Bureau Veritas, NR670 Methanol & Ethanol Fuelled Ships (August 2022)

Conclusion

The introduction of new technologies on ships to address decarbonization and zero emissions is associated with potential impact on health, safety, and environment. This was recognised by many classification societies and related international organisations, which are trying to take a holistic risk-based approach to ensure that the safety performance of the industry is maintained or improved to help assessing the regulatory regime for innovative alternative and/or equivalent designs, as reliable process. This work is a long-term strategic roadmap to support technical, industrial, and regulatory drivers in zero-emission solutions, where many instructions and guidelines are developed with contribution of classification societies.

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5. | Risks related to new energy carriers

The SYNERGETICS project aims to demonstrate the technologies:

- hydrogen in internal combustion engine,
- battery-electric drivetrains,
  and
- methanol in internal combustion engines.

The current status of regulations for these technologies in comparison to conventional/mature drivetrains and the most relevant risks are summarised in table 6.

6 | Risks associated with energy carriers [1]

Technology	Status	Main safety risks
Diesel, HVO, advanced biofuels	Regular fuel in inland navigation	• Environmental / health damage due to leak-age • Fires in the engine room(s)
LNG / LBM	Regular fuel in inland navigation	• Injuries to crew / damage to vessel structure • Potential fires and explosion • Damage to climate
Batteries	Lithium-ion batteries (LIB) are almost regular energy carriers	• Potential fires with very long duration, dam-age to vessel structure • Accumulation of explosive gas • Electrical hazards
Hydrogen	Hydrogen not allowed as fuel yet (only pilot pro-jects for compressed H_2)	• Potential fire and explosion (especially for enclosed spaces or insufficiently ventilated areas) • Hard to identify leaks without dedicated de-tectors (colourless / odourless). Hydrogen flame almost invisible in daylight.
Methanol	Methanol not allowed as fuel yet (only pilot projects)	• Toxicity • Higher flammability (flashpoint at 11 °C while gasoil is 52-96 °C)

To make it clearer for the workshop partners which new risks can be addressed on board and to develop an HSE monitoring plan, three presentations were given by experts from the respective technology.

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5.1 Methanol

The presentation *Methanol applications: perspective of an engine manufacturer* was given by Patrick Höving from August Storm GmbH. For methanol the risks associated with low flashpoint fuels apply. To mitigate the risk for the personnel on board the following behavioural measures can be taken:

- wearing PPE such as protective gloves, eye, or face protection,
- stay away from heat sources, hot surfaces, sparks, open flames and other ignition sources.

Also, the use of explosionproof electrical, ventilation, and lighting equipment is necessary. In addition, the tools should be of non-sparking type and precautionary measures against static discharge should be taken. Of course, there should be no eating, drinking, or smoking during and after methanol handling, and hands should be washed thoroughly.

Other protective measures on a more organisational base are recurring instructions, the provision of suitable personal protective equipment, medical check-ups and education, training, and continuous training.

Technical factors, that create risks when using methanol in an internal combustion engine are the high pressures and temperatures that may also cause mechanical stresses leading to material failure. The electrical components may also create risks as well as the external periphery installation. Compared to diesel, methanol is more corrosive. It is therefore risky to use unsuitable materials. Attention should be paid to this when designing the system, but also when procuring spare parts.

Technical protective measures that are practicable if not required are the installation of second or third barriers and a well-planned and monitored leakage detection system. Also, high pressure alarms and overpressure valves are necessary. To ensure good combustion in the engine, knock monitoring should be installed.

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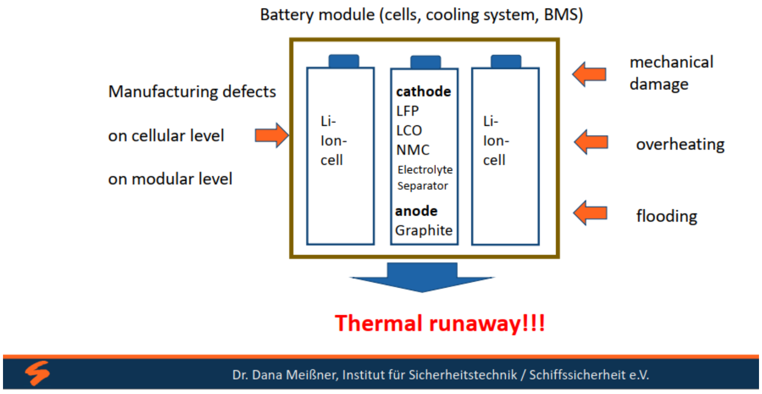
5.2 Batteries

The presentation given on *Risks and mitigation strategies for battery applications* by Dana Meißner from ISV stated that during normal operation the battery system poses no risk. Risks arise when a battery is damaged, overheated, flooded, or otherwise disturbed. Damage can also occur if charging processes are carried out incorrectly or with unsuitable equipment. Therefore, during normal ship operation, care must be taken to ensure that no conditions that damage the batteries can occur.



6 | Causes of Lithium-Ion battery fires

Figure 6 shows the causes of damage to lithium-ion batteries that might lead to thermal runaways. Preventive measures that should be taken are the protection from mechanical damage, overheating and flooding. The installation of early warning systems (gas detectors, surveillance cameras) can help to prevent a catastrophic outcome of a failure. Charging processes shall be carried out in accordance with the manufacturer's instructions and only with the equipment intended for this purpose. Also, the monitoring of the battery management system in connection with the manufacturer. And of course, the personnel shall be trained in the correct handling of batteries to avoid any damages.

During a thermal runaway, a battery cell gets overheated due to a self-reinforcing exothermic process. This process can be caused by a cell failure. The cell failure, in return, can be caused by one of the types of damage described above. Figure 7 describes the process of a thermal runaway in a lithium-ion battery. Due the cell chemistry, not all battery types present the same risk in case of a thermal runaway. Both presentations provided by ISV and ZES concluded that the NMC- and $LiCoO_2$-type batteries present a higher risk, as they can burn with temperatures up to 900 °C, whereas for the $LiFePO_4$ type the fire would burn at a temperature of around 400 °C.

So, it turns out the choice of the cell type has a significant influence on the system safety.

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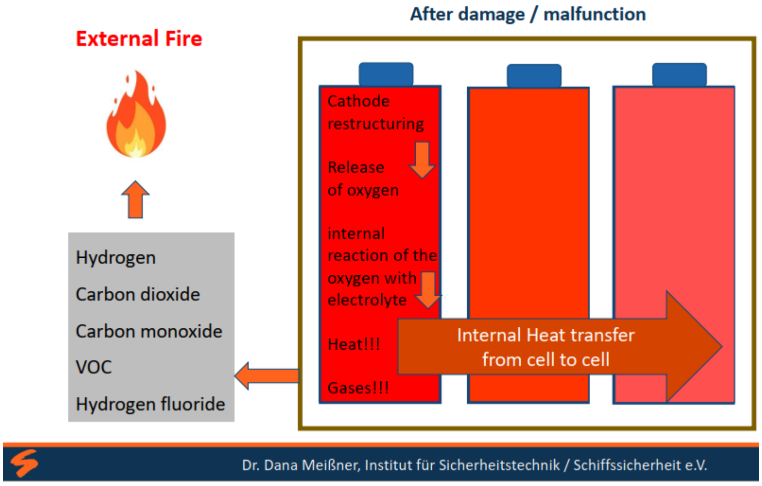

7 | Lithium-Ion-Batteries – Thermal runaway

5.3 Hydrogen

Also, for hydrogen, the risks associated with low flashpoint fuels apply. In the presentation *Risks and mitigation strategies for battery applications,* given by Dirk Fischer from the SYNERGETICS partner ANLEG, those were presented. It was pointed out that the most common cause of accidents involving hydrogen is human error. Therefore, crew training is one of the crucial factors.

From a technical perspective the following means are used to mitigate the risk:

- Tightness
- Detection of leaks
- Avoidance of ignition sources
- Ventilation and warning
- Damage prevention and control

This is now faced with the personnel who operate the system. The following risk mitigation measures can serve as a starting point:

- HSE (Health-Safety-Environment) regulations
- Use SDS (safety data sheets)
- Define quality processes (FMEA, HAZOP, risk-analysis etc.)
- Order consulting support (consulting engineers, notified bodies, experts…)
- Skill operators and responsible persons
- Communicate with authorities, fire-departments, local authorities, hospitals
- Mark areas where hydrogen is used / where hydrogen installations are
- Frequent assessments, audits and re-qualifications
- Inhouse/external trainings in different skill levels, for different person groups

Even if the hydrogen technology is new to the IWT, the use of standards from other sectors or from sea-going vessels is also always a powerful risk mitigation strategy.

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6. | Ships used as the demonstrators in SYNERGETICS

As part of the SYNERGETICS project, three ships are to be retrofitted with new energy carriers and power systems so that their carbon footprint is reduced. These vessels are the Via Donau workboat BAD DEUTSCH-ALTENBURG, a cement carrier called LE SANDRE from partner Sogestran Group and a chemical tanker from partner Mercurius Shipping Group. The special features of all three were briefly presented and then the possibilities for the safe integration of the new systems were discussed. The discussion was led by the partner MARIN, all participants were also shown the general arrangement plans to have a better understanding of the situation on board. Since it is not possible to replace a diesel system one by one with an alternative system of the same power and range, the operational profiles must be considered when choosing alternative power, propulsion, and energy systems for the demonstrators.

The Via Donau workboat BAD DEUTSCH-ALTENBURG is used only from time to time on varying routes but in a fixed area. This makes it difficult from a technical point of view to select a suitable alternative drive system. In addition, the ship does not offer much space to accommodate a new system while maintaining the prescribed clearances and accessibility.

Le Sandre is a 51 m long cement carrier on the river Seine. The vessel has diesel-electric propulsion and is propelled by two Schottel thrusters. The power plant consists of 2 main gensets, each 450 kW, and a smaller harbour genset of 40 kW. From current operational profile it is observed that most of the energy demand occurs when unloading the cargo at an intermediate harbour. This harbour is located in an industrial zone, what would make it suitable for the installation of a high-power shore connection. For this reason, the owner is considering retrofitting the ship with a battery electric power system, or to a hybrid solution combining a diesel electric power plant with batteries. The idea is to use the shore connection to supply the required power while unloading, as well as to charge the batteries. This could lead to a much smaller size of the installation on board. The chemical tanker from partner Mercurius, being a large Rhine vessel, on the other hand offers much more space, but also has a much higher energy demand.

For all three demonstrators the position of new energy storage and power conversion systems was discussed.

An important outcome of the discussion was that the new energy sources for inland waterway vessels pose new challenges for the ship and the crew. Detailed monitoring, planned from the outset and continuously improved, is therefore essential. For example, additional crew training or technical measures or improvements can be introduced at an early stage. The concept of double assurance presented above, i.e. monitoring both errors and successes, appears to be a desirable monitoring method.

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7. | Conclusion

At the HSE partner-workshop, presentations were given on both a theoretical approach for the implementation of a monitoring method and on the view of a classification society on the topic. Afterwards, three experts presented the risks associated with hydrogen, methanol, and battery-electric drive systems. As it could be seen from all presentations the best HSE monitoring option is to have regular checks, audits, trainings and maintenance actions for both crew and system.

In addition, the risks, that are different from those related to diesel-engines and sometimes may present even a higher risk, can be safely contained on board a ship. For this, on the one hand technical measures of all kind are already available on the market; sometimes from other sectors, but always with the highest safety standards suitable for IWT. On the other hand, trainings for the crew are indispensable to establish safe working routines, enabling the crew members to feel capable of acting in all situations arising around the alternative drive systems.

An important outcome of the latter discussion was, that new energy sources for both inland waterway and coastal application pose new challenges for the ship and the crew. Detailed monitoring, planned from the outset and continuously improved, is therefore essential. For example, additional crew training or technical measures or improvements can be introduced at an early stage. The concept of double assurance presented above, i.e. monitoring both errors and successes, appears to be a desirable monitoring method.

In contrast to other sectors, inland shipping is still at the beginning of widespread use of alternative technologies. For this reason, the partners at the workshop concluded that a look at other industries, such as the process industry, which has been working with complex and hazardous systems for a long time, is also very helpful for the demonstrators within the SYNERGETICS project.

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8. | Literature

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