

Press release

Ship Lengths Ahead

World's first type-approved methanol-powered fuel cell system: RINA awards Freudenberg e-Power Systems

Munich, September 8, 2022. Freudenberg has achieved a significant milestone in the development of sustainable technologies in the maritime sector by receiving “Type Approval” by the international classification society RINA. The methanol-powered fuel cell system makes it possible to operate ocean-going shipping in a climate-neutral manner both efficiently and safely.

Converting commercially operated ships on the high seas to CO₂-neutral drive systems is a huge challenge. One important factor is the range requirement of the individual ship types. This must be as large as possible for cruise ships, tankers and container ships in order to be able to cover the long routes across the world's oceans without stopping. Route flexibility and ranges of more than 5,000 nautical miles are basic requirements of the world's maritime fleet. Purely battery-electric solutions are often out of the question for these deep-sea applications due to their high weight and space requirements. Hydrogen as a direct energy storage medium is also ruled out for these ship types, as its low volumetric energy density would require it to be stored in huge hydrogen tanks in a cryogenic or highly compressed state. This is not a sustainable option for the maritime industry. Nevertheless, fuel cells have tremendous advantages due to their high efficiency and low maintenance requirements. Therefore, it makes sense to chemically bind regeneratively produced hydrogen to achieve a significantly higher energy density. This will make fuel cells economically and practically viable for ocean-going shipping. The fuel cell system can of course be flexibly combined with Freudenberg e-Power Systems' maritime battery systems to create particularly efficient hybrid solutions.

In this context, the use of climate-neutral methanol represents a turning point on the road to maritime sustainability and the achievement of IMO emission reduction targets. Methanol is a simple alcohol that is liquid under normal ambient conditions and has around three times the volumetric energy density of

liquefied hydrogen. As an important raw material for the chemical industry, climate-neutral methanol is characterized by proven manufacturing processes as well as good availability.

Combination of reformer and high-performance fuel cell

Freudenberg e-Power Systems has developed an innovative approach to using methanol for marine applications. This combines highly efficient fuel reforming technology with a long-life PEM fuel cell in a modular, scalable system unit. It generates hydrogen via steam reforming, which then reacts with oxygen from the air in the fuel cell to produce the electrical energy needed for both propulsion and the ship's electrical system. The heat required for the reformer can be obtained directly from the waste heat of the fuel cells. Fuel cell stack, reformer and control electronics as well as all components for media supply are located in a prefabricated, modular unit. This containment design facilitates easy installation on board.

The safety concept of this innovative system architecture has now received Type Approval from the classification society RINA. This confirms the safety of the system and its conformity with maritime standards and regulations. "With our extensive experience in fuel cell systems and hydrogen production by reforming methanol, combined with Freudenberg's proven industrial expertise, we are realizing innovative energy and power solutions for the maritime industry. In this way, we are making an important contribution to decarbonizing this important segment," explained Dr. Manfred Stefener, Managing Director of Freudenberg Fuel Cell e-Power Systems and responsible for the safety architecture. "Achieving Type Approval represents an important milestone for the maritime industry. This lays the foundations for fuel cell systems to be used on a megawatt scale on cruise ships and the international ocean fleet. The marine energy systems of the future will be safe and highly efficient thanks to fuel cell technology."

Freudenberg e-Power Systems is convinced that the best heavy-duty solutions start at the cell level. The special material configuration of the bipolar plates (BPP) and the membrane electrode unit as well as deep value creation, for example through in-house catalyst production, ensure maximum efficiency and durability. Unlike conventional fuel cell systems, which have their origins in the

passenger car sector, the design strategy of Freudenberg's high-performance stacks is geared to achieving high efficiency combined with a long service life.

In addition, Freudenberg's methanol-powered fuel cell system offers further advantages since – unlike drives with combustion technology – it does not emit any harmful nitrogen oxides.

Standardized system design for all ship types

Freudenberg's safety concept was already tested for maritime conformity in an early phase of the "Pa-X-ell 2" research project. For this purpose, it received "Approval in Principle" from the classification society DNV GL. In addition to the focus on the safety concept, the topics of modularization and standardization were considered in order to take account of the aspects of large-scale industrialization from the very beginning. In the future, system units with a respective nominal output of 500 kW are to be combined into total capacities in the double-digit megawatt range. In addition to Freudenberg, the renowned project consortium focusing on passenger shipping includes the partners Carnival Maritime (AIDA Cruises), Meyer Werft as well as Lürssen Werft, besecke, DLR, EPEA and the classification society DNV GL.

The "HyFleet" research project launched in 2021 shows that the consistent design strategy with lifetime and efficiency as priorities is also well suited for other segments. Together with its project partners ZF Friedrichshafen and FlixBus, Freudenberg is working to replace conventional diesel drives in long-distance buses. Initial test results show that a service life of at least 35,000 hours can be achieved. This corresponds to a total service life of 1.2 million km for a truck.

The importance of the Type Approval issued by RINA for the world's first methanol-powered fuel cell system for the development of sustainable technologies in the maritime sector was confirmed by the official handover of the relevant RINA certificate at the leading maritime trade fair SMM in Hamburg, Germany.

About Freudenberg e-Power Systems

Freudenberg e-Power Systems is one of the world's leading suppliers of emission-neutral energy systems for heavy-duty applications. With its experience and expertise in battery and fuel cell technology, the company offers tailor-made solutions, in particular

combined systems, for sustainable and economical e-mobility. With over 700 employees, Freudenberg e-Power Systems supports its customers from application development through to production, commissioning and service.

The company is part of the global Freudenberg Group, which has four business areas: Seals and Vibration Control Technology, Nonwovens and Filtration, Household Products as well as Specialties and Others. In 2021 the Group generated sales of more than 10 billion euros and employed more than 50,000 associates in around 60 countries. More information is available at www.freudenberg.com.

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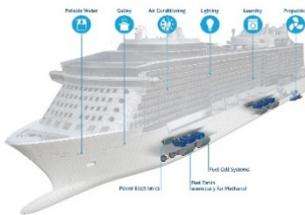
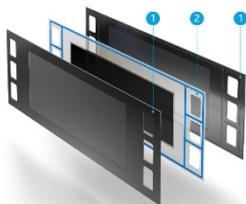


Image 1: A milestone for the maritime sector: The methanol-powered fuel cell system from Freudenberg e-Power Systems makes climate-neutral and at the same time efficient, safe ocean shipping possible.

Single Cell of a Heavy Duty Fuel Cell Stack



- 1 Heavy Duty – Bipolar Plate (BPP)
Corrosion-resistant design with assurance of low fluke damage for the long-term, temperature-stable and homogeneous gas distribution.
- 2 Heavy Duty – Membrane Electrode Assembly (MEA)
Fully integrated MEA with patented sealing concept for advanced energy efficiency.

Image 2: Already optimized for heavy loads at the cell level - the special material configuration of the bipolar plates (BPP) and the membrane electrode unit ensure the necessary high efficiency and durability required for heavy-duty applications.



Image 3: Thanks to the type of material used and its innovative design, Freudenberg's fuel cell stack is specially designed to meet the requirements of heavy-duty applications, such as long service life and efficiency.

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