

CMB
.TECH

HYDROGEN STRADDLE CARRIER



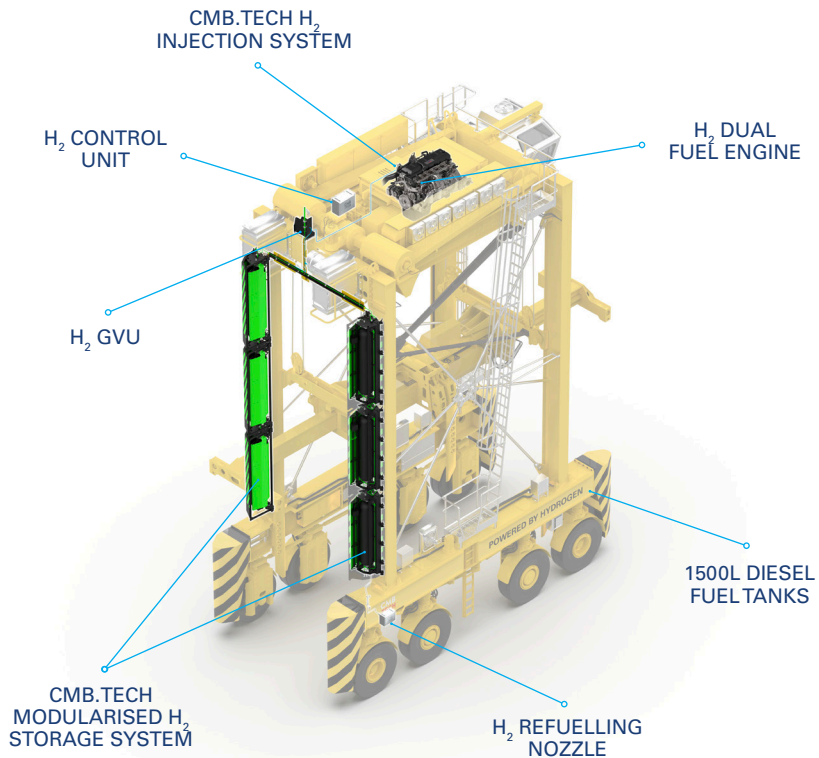
POWERED BY HYDROGEN

H₂ DUAL FUEL TECHNOLOGY

Straddle carriers and other port equipment require incremental innovation instead of disruptive innovation. CMB.TECH's H₂ dual fuel technology is the first step towards the zero emission goal. This technology has been proved to reduce carbon emissions significantly on the existing platforms.

The dual fuel technology is able to replace 70% of diesel consumption with hydrogen on new straddle carriers, with the eventual goal of 100 percent hydrogen injection.

In the H₂ dual fuel technology, hydrogen is aspirated into the combustion chamber. The energy aspirated with the hydrogen substitutes directly the amount of diesel fuel required to power the engine. The clean H₂ fuel contains no carbon, drastically reducing the CO₂ emissions whilst maintaining same power output and whilst relying on the proven technology of diesel engines.





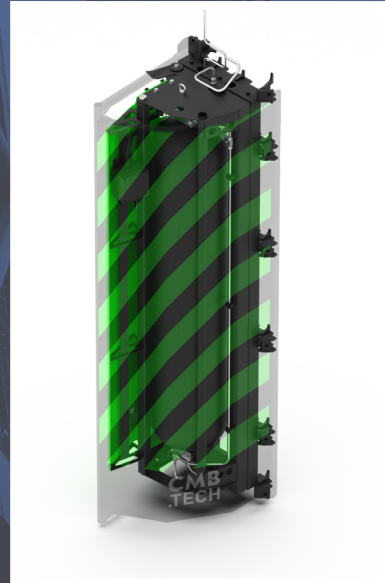
H₂ STORAGE

- 6x Type III, 350BAR H₂ cylinders
- Individual solenoid valve per cylinder
- Integrated pressure regulator
- EC79/R134 compliant
- 30kg H₂ storage



H₂ REFUELLING

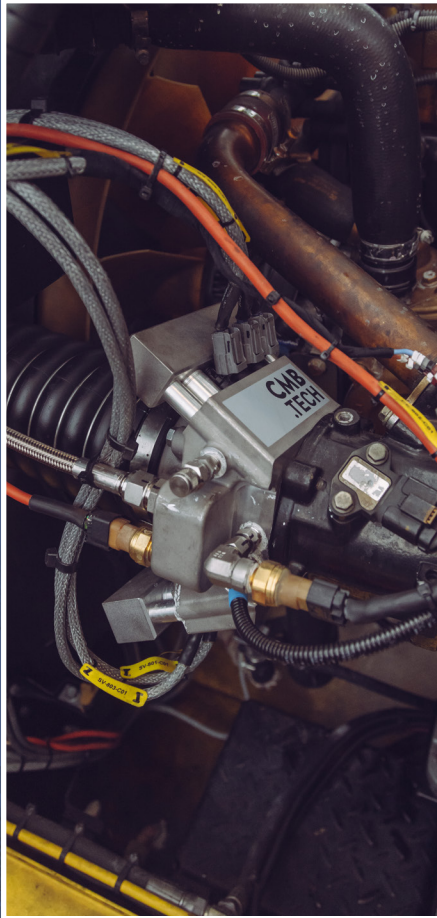
- Standard H₂ high-flow receptacle
- Flow rate up to 120 g/sec
- No cooling required
- Less than 15 mins refuelling time



SAFETY

With one click, the system can be switched to diesel only, instantly shutting down and closing the H₂ system to safe mode. This also happens automatically when a sensor or fault is active. The diesel engine goes back to 100% diesel and operability of the machine is guaranteed. Because of this strategy, the dual fuel system has no influence on the reliability of the original machine. In addition, the hydrogen system is:

- Based on CMB.TECH's 3 layers of safety strategy
- Multi layer crash protection covers



H₂ INJECTION SYSTEMS

- Custom injector ring assembly
- No changes to the base engine
- Injects H₂ based on engine load
- Integrated safety features



H₂ STRADDLE CARRIER KEY FEATURES

- The best available technology for clean container handling operations in 24/7 operations
- Lowest cost technology for the highest CO₂ savings
- The base machine is not modified so maintenance can still be undertaken by the same technicians
- Enable the energy transition, whilst not dependent on the availability of the H₂ refuelling infrastructure
- Phased approach:
 - Generation 1: Direct Drive with 30% emissions savings
 - Generation 2: Hybrid Drive with 70% emissions savings
- Full diesel backup in case hydrogen is not available



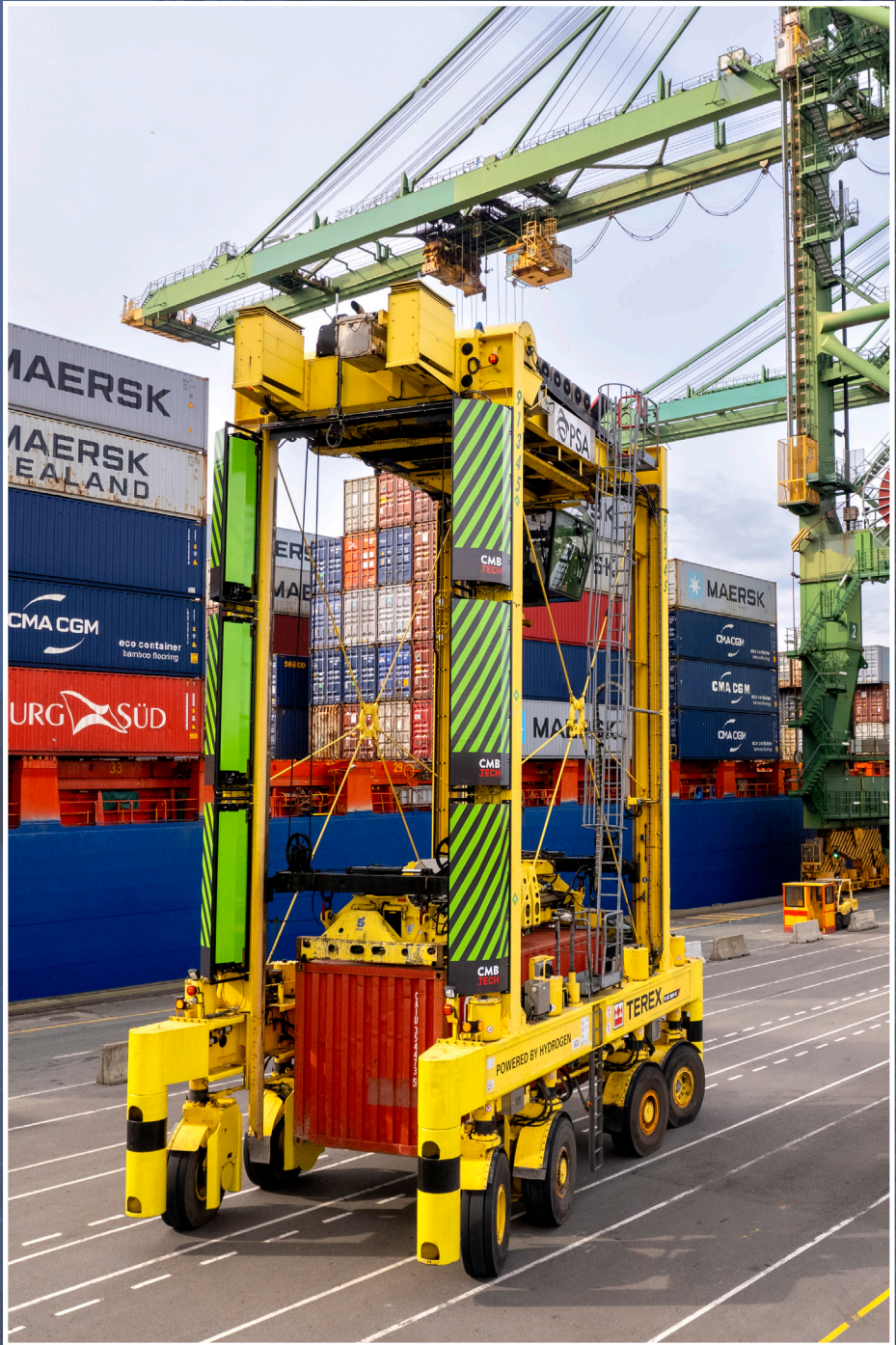


CMB.TECH'S 3 LAYERS OF SAFETY

The H₂ dual fuel system is designed supervisory, allowing the switch back to diesel if needed, ensuring operational reliability of the machine. On top of that, the hydrogen system itself has 3 different layers of safety to ensure redundant safety:

- 1 - The first layer is provided by using high integrity components, as used on other CMB.TECH projects, that are conforming to all the relevant class and safety requirements. All hydrogen components are carefully selected to be the industry's most reliable of its class and are EC79 and/or UN/ECE-R134 approved.
- 2 - The second layer is provided by leak detection software and control system that is developed from the ground up at CMB.TECH. The H₂ control strategy allows for safe and efficient operation of the system and comprises of two parts:
 - **Dynamic Leak Detection** – The H₂ control system will constantly perform a dynamic leak test when the engines are running in dual-fuel mode. The test isolates one bank of cylinders within the H₂ storage container at a time and monitor it over a calibrated time period. If there is any pressure decay, the system is shut down, a fault flagged and a static leak test then performed. This test is performed continuously throughout operation.
 - **Static Leak Detection** – At engine key-off, integrity of the storage cylinders and gas lines is checked in static condition under pressure. Any decay in pressure results in an alarm, causing a shutdown of the dual fuel system until a positive static leak test is performed at the next key-off.
- 3 - Safe design strategy: Next to the use of high quality components, the system is designed to ensure no hydrogen can be trapped in a place where it could cause issues. The system is designed to have as a worst case scenario a safe controlled venting of hydrogen from the top of the machine, where hydrogen's buoyancy ensures the safe evacuation of the gas in case of an emergency. Upon release, hydrogen dissipates extremely fast, preventing it from being trapped sufficiently energy-dense to cause any risk.





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