Decarbonizing heavy-duty and commercial transport safely, reliably and efficiently

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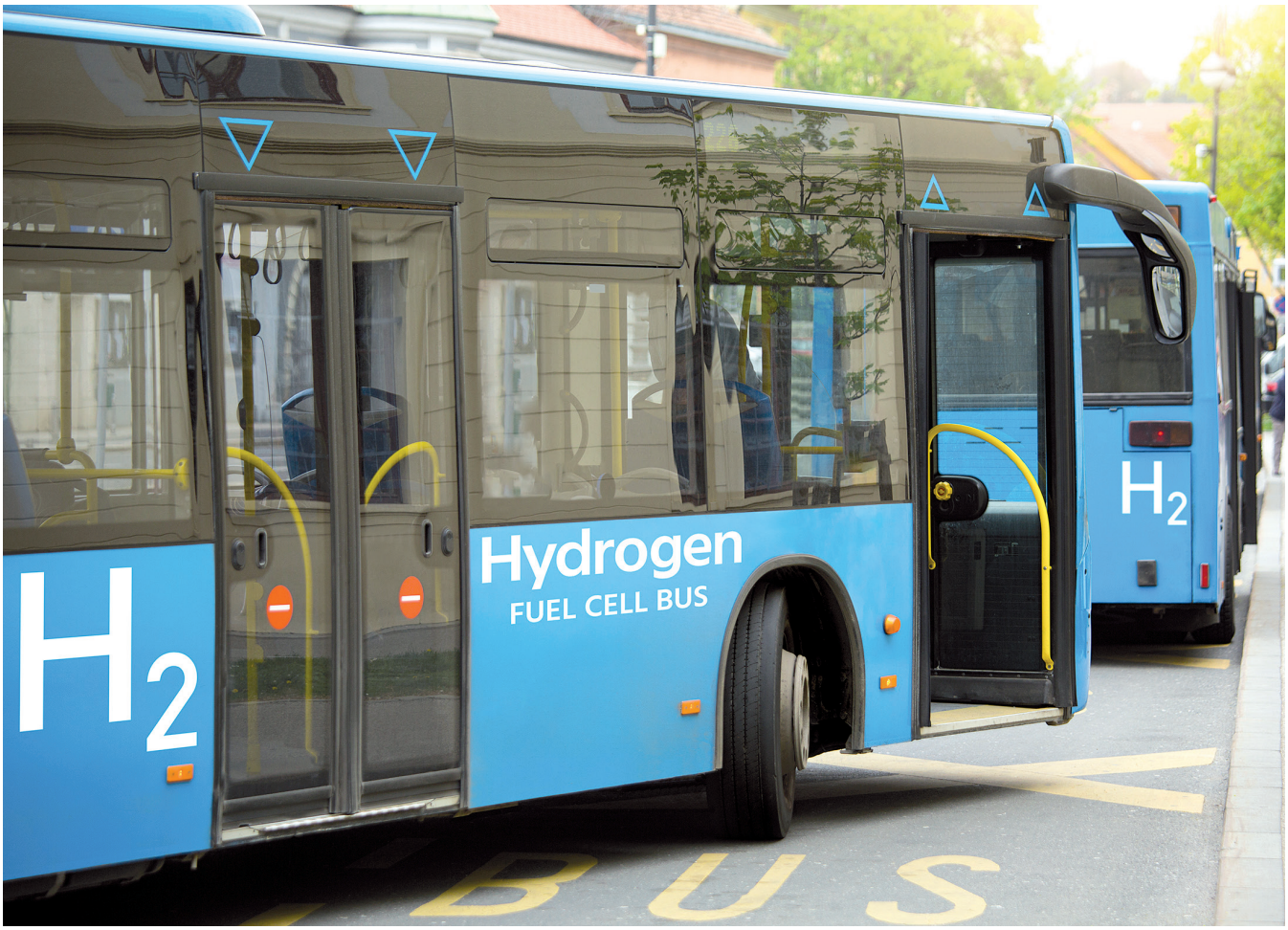

The safety, reliability and efficiency of fuel cell systems used in buses and trucks depend on the use of components that can effectively control hydrogen fuel. *(All images courtesy of Emerson)*

People and organizations across Europe rely on heavy-duty vehicles and buses for transportation and the movement of goods. However, these valuable modes of transport are also responsible for 27% of total EU road transport carbon dioxide emissions at a time when the EU has committed to reducing transport emissions by at least 60% by 2050 compared to 1990 levels.[1]

In response, governing bodies have proposed and passed strict legislation intended to lower emissions from the highest emitting vehicles. For example, EU carbon dioxide (CO_2) emission standards stipulate a 15% reduction in annual fleet-wide average emissions for newly registered trucks from 2025 onward and 30% from 2030 onward, and a pending review by the European Commission may extend the standards to all heavy-duty vehicles. The Commission has also recently proposed new Euro 7 standards to reduce emissions for all motor vehicles, which are anticipated to go into effect for trucks and buses in 2027. And some cities, like Amsterdam, are banning internal combustion engines completely.

With such existing and pending legislation, fleets of low- and zero-emissions heavy-duty vehicles (ZE-HDVs) and buses are more attractive and valuable than ever, and vehicles powered by hydrogen fuel cells are proving to be one of the most effective, especially for long-haul trucking. Compared to battery electric vehicles, hydrogen fuel cell electric vehicles (FCEVs) can refuel faster, offer longer road times and feature lighter-weight, compact technology that leaves more capacity for cargo. These factors are critical for companies to

maximize uptime, productivity and total cost of ownership.

As demand for fleets of hydrogen-powered trucks and buses grows, hydrogen fuel cell technology manufacturers are well-positioned for success. However, since the industry is still young, they may be concerned about dependably increasing the scale of their production to meet it as well as designing equipment that effectively controls hydrogen fuel. To successfully scale up in proportion to demand, it's essential that manufacturers source hydrogen fuel cell technologies that improve system safety, reliability and efficiency.

Controlling hydrogen fuel safely, reliably and efficiently

Due to its low ambient temperature density, hydrogen gas has a low energy-per-unit volume that requires the element to be highly pressurized when used as fuel[2]. In onboard storage tanks, the fuel is typically subject to pressures of either 350 bar or 700 bar. These high pressures combined with the hydrogen molecule's small size make the gas very susceptible to leaks. It is critical that fuel cell technology safely, reliably and efficiently controls the flow of the hydrogen fuel within FCEVs. Regulators and proportional valves engineered for hydrogen fuel cell systems are being designed with safety in mind to provide stable pressure regulation and reliable flow control. The latest components provide stable pressure regulation and reliable flow control that can help prevent fuel leaks and protect people.

Systems should not only be designed with safety in mind, but also with optimal performance and easy manufacturability as concerns. Components must be compact and lightweight to allow manufacturers to design a variety of fuel cell systems for use in an array of commercial vehicles. Manufacturers can extend the life of their fuel cell systems by using solutions that provide stable pressure regulation to the systems' fuel cell stacks.

High pressure fluctuations, especially during vehicle starts and stops, can result in reduced performance of fuel cell systems. Pressure-reducing regulators, such as Emerson's TESCOM™ HV-3500 Series Hydrogen Onboard Regulator or the TESCOM 20-1200 Series Hydrogen Pressure Regulator, can help maximize fuel cell efficiency by controlling that high pressure. They provide consistent pressure and regulate precise flow control of hydrogen to the fuel cells in a variety of operating conditions. With high leak integrity, the HV-3500's dual-stage, positive seal design stabilizes outlet pressure, preventing decaying inlet characteristic and leakage, which improves fuel cell operation and maximizes overall energy efficiency. Better energy

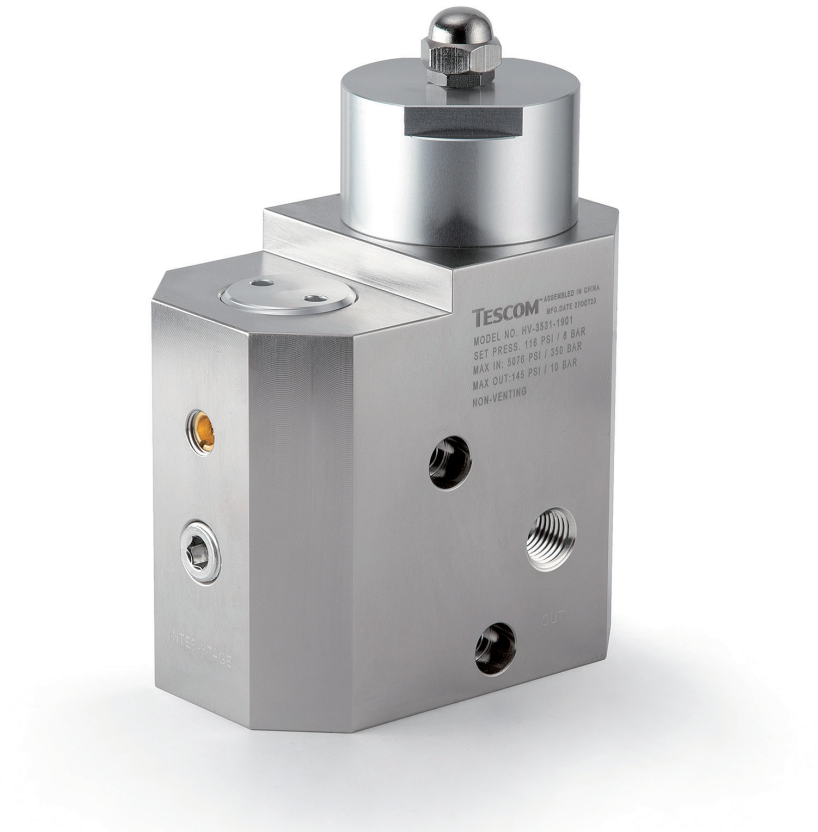

Fig. 1: Emerson's TESCOM HV-3500 Series Hydrogen Onboard Regulator reliably controls pressure fluctuations and maximizes fuel cell efficiency in hydrogen-fueled trucks and buses.

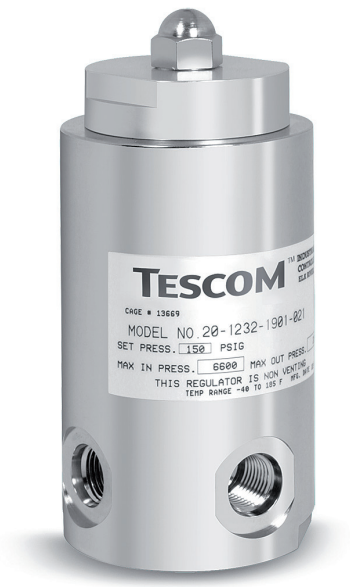

Fig. 2: Proven to control pressure in thousands of commercial vehicles, Emerson's lightweight TESCOM 20-1200 Series Hydrogen Pressure Regulator offers long service life and is suitable for pressures up to 700 bar.

efficiency translates to less wasted hydrogen fuel and more driving time.

The HV-3500 Series Hydrogen Regulator also has additional benefits that streamline manufacturing time and lower costs for OEMs. Its specially designed rectangular shape and mounting holes simplify installation and enable OEMS to quickly secure it to existing panels and frames in the fuel cell system.

It is also important regulators provide a long service life, such as Emerson's TESCOM 20-1200 Series Hydrogen Regulator with a piston-sensing design. Specifically designed for pressure control onboard hydrogen fuel cell vehicles, the 20-1200 Series has been successfully implemented into thousands of commercial vehicles, including systems that have received EC-79 certification. This lightweight regulator is suitable for inlet pressures up to 700 bar. It also includes an integrated 10-micron filter that prevents installation contamination.

In addition to regulators, proportional valves are key to hydrogen fuel cell system designs. It's beneficial to look for proportional valves that can precisely control hydrogen fuel flow rates while remaining lightweight and easy to install, such as Emerson's ASCO™ Series 202 Direct-Operated Posiflow solenoid valves.

It's important to source components, like those mentioned above, from suppliers who have comprehensive, specialized portfolios of safe, compliant products that are already proven in the field. Emerson's TESCOM regulators reliably control hydrogen fuel on more than 20,000 forklifts, including some that have been running for 10 years.

Some, including Emerson, even offer flexible engineering services to supply customized manifold solutions for the fuel cell inlet module, such as a shutoff valve with proportional valve to accompany the pressure regulator or drain modules, such as a drain valve with a water separator and check valve. This level of partnership allows OEMs to obtain high-reliability flow control, pressure regulators, safety junction boxes and flameproof cable glands, as well as educational services and support from a single source, simplifying the supply chain and helping to meet production targets.

Expert suppliers like this will also have knowledge necessary to fulfill all requirements and certifications, as it's critical to comply with regulations where vehicles will operate.

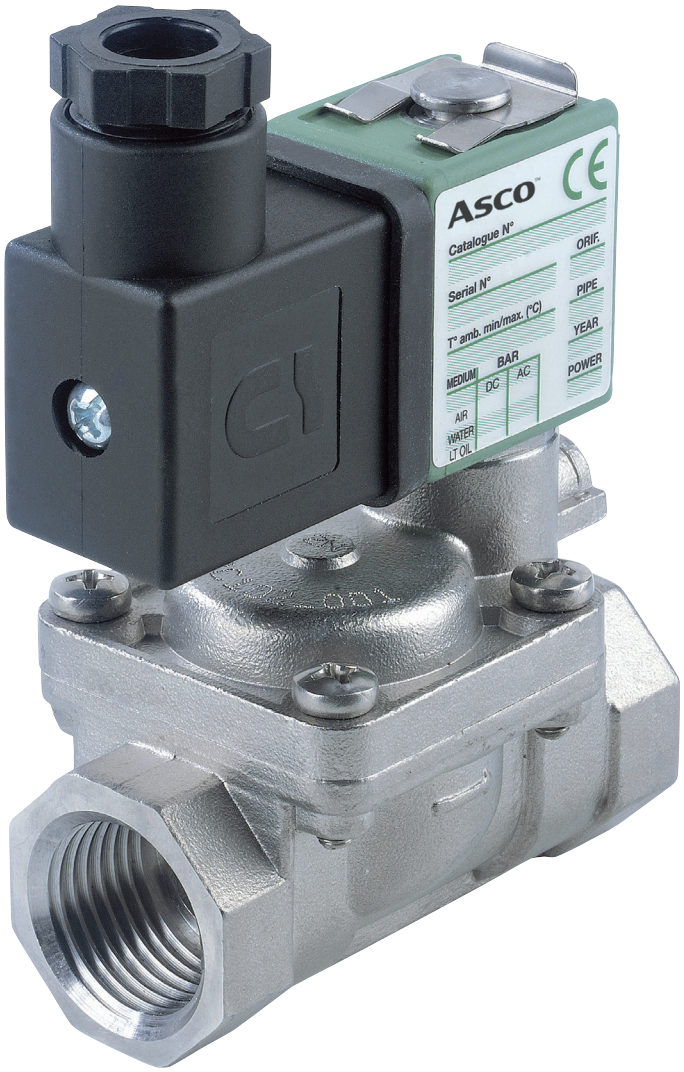

Fig. 3: The compact ASCO Series 238 Pilot General Service Solenoid Valve from Emerson maximizes design space and features a short stroke that increases cycle life.

Scaling production to meet increasing demand

It's predicted that about 850,000 hydrogen fuel cell electric trucks will be on EU roads by 2035, as well as between 1.4 and 3.6 million light-commercial vehicles, buses and passenger cars[3]. While this rapid growth makes it a lucrative time to be in the FCEV truck market, it can also make it difficult to scale designs and capacity to meet demand.

To produce enough hydrogen fuel cell systems to supply fleets of trucks and buses, manufacturers need to quickly scale up in terms of resources, factory extension and

procurement efficiency. One way that OEMs can achieve this is by working closely with supplier partners with a proven history of successfully working to adapt their products as customer needs grow and change. They can meet OEMs at each stage of growth, reduce complexity by ensuring the optimal products are available, and allow hydrogen fuel cell and FCEV vehicle providers to focus fully on their process.

OEMs of all sizes and capabilities are emerging in the hydrogen market. Some may understand all aspects of their unique design process, yet others may need help to optimize their current solutions. For those experiencing this limitation, they can extend their knowledge and teams by leveraging the knowledge and resources of expert suppliers. Educational resources can help OEMs integrate emerging hydrogen technology and design best practices to develop cost-saving strategies and accelerate their new technologies. One example some suppliers offer is a collaborative engineering workshop, which helps OEMs to better understand their design process and develop ways to make it more efficient.

In this workshop, OEMs work with engineers and product experts to identify performance metrics and requirement definitions, create strategies that integrate findings, learn about application-specific technology options, pilots, and more. This comprehensive expertise not only operates as an extension of the OEM's knowledge, but also helps build the OEM's own expertise.

Driving a successful, zero-emissions future

ZE-HDVs and hydrogen-fueled buses are key to decarbonizing EU roadways – and transportation around the world. As demand for hydrogen-powered trucks and buses grows worldwide, scaling up hydrogen fuel cell technology is paramount. Working with expert partners and putting proven processes in place will ensure success as well as the flexibility to adapt. Successful deployment of future fleets depends on smart decisions today: sourcing high-performance, robust components that safely, reliably and efficiently improve fuel cell life and operation.

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