Composite gas cylinders for fuel gases

By Stephen B. Harrison, sbh4 Consulting

Fuel gases are where industrial gas products intersect with the energy sector products. LPG (liquefied petroleum gas) is produced on refineries and distributed in cylinders by industrial gas firms. Natural gas is compressed to become CNG (compressed natural gas) and can be distributed to end-users by the industrial gases sectors.

Shale gas and natural gas is liquefied at scale in the energy sector and distributed as a cryogenic LNG (liquefied natural gas) by industrial gas companies to end-users.

Hydrogen is produced on and for refineries in the energy sector and is distributed by industrial gases companies as high pressure gas or liquid hydrogen. Traditional 'petrol stations' are still the domain of the energy sector, but industrial gas companies are involved in hydrogen fuelling stations. The dividing lines are sometimes clear, but with fuel gases, the sectors share common ground.

For LPG, CNG, and hydrogen, the distribution to small-scale end-users is often done in transportable gas cylinders. Due to the high pressures required to achieve a high energy density in the compact space of a car chassis, compressed hydrogen storage in the automotive sector is standardising to 700 bar in carbon-fibre, Type 4 composite cylinders. Type 4 composite cylinders are also popular for CNG storage on vehicles, and pressures of 200 bar in Europe and 250 bar in the US are common. For CNG, Type 4 composite cylinders and steel cylinders are in use.

LPG has traditionally been filled into welded steel cylinders. However, composite cylinders are now an increasingly popular alternative. Steel cylinders are low cost to purchase but are heavy and rust. The long-term cost of ownership of composite LPG cylinders can be lower than steel due to savings in maintenance and logistics costs. They also offer a more attractive aesthetic appearance and can be translucent to provide a visual content indication. These benefits have secured their place in the LPG cylinder market.

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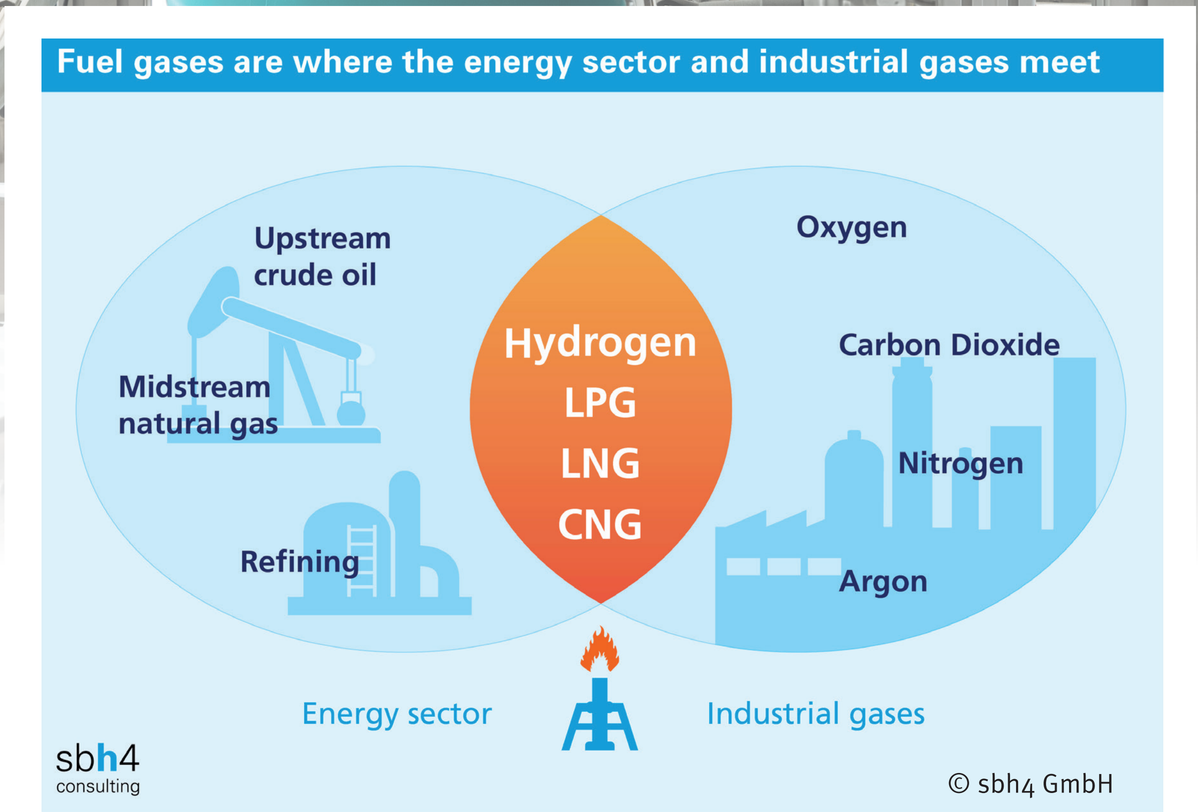
Type 4 composites – making inroads

LPG is produced from the light fraction of crude oil or the heavy fraction (condensate) from natural gas processing. It is a mixture of propane and butane.

The product name 'propane' is often used to describe LPG, which has a low vapour pressure of approximately 9 bar at 20°C. This means that gas cylinders may be of a thin-wall welded steel construction. These are cheaper to produce than drawn steel cylinders that are used for the distribution of high pressure air gases such as oxygen or nitrogen.

As the temperature rises, the vapour pressure of the LPG increases and, if cylinders are left in direct sunlight, they can get quite warm. The test pressure is, therefore, typically 30 bar in Europe and up to 36 bar in some warmer countries. Tomm Martin Døsen, Head of Projects at Hexagon Ragasco in Norway, adds, "Our LPG cylinders typically burst above 130 bar, much higher than the 60-75 bar that is required by various national standards. This margin of safety means that we are complying with the relevant codes and standards, and we can be confident that our glass-fibre Type 4 composite LPG cylinders are safe for operators to use all around the world." ▸



Standards such as EN 12245, ISO 11119-3, and ISO 14427 are relevant to the design and testing of composite gas cylinders. The requirements are often like the processes for steel cylinders but, there are important differences.

One difference between Type 4 composite cylinders with a plastic liner and steel cylinders is the permeability of the material of construction. Døsen says that, "Hexagon has lately improved the permeation rates further using a state-of-the-art process to produce Type 4 composite cylinders. The state-of-the-art process to produce Type 4 composite cylinders with exceptionally low gas permeation, significantly below the requirements of the relevant international standards."

Manufacturing Type 4 composite cylinders is far from being a 'cottage-industry'. Safety management systems, automation, and precise process control are used to maximise repeatability and minimise variation. "We have full attention on manufacturing and documenting 100% quality products, securing regulatory authority, and customer safety requirements. This has our highest priority," confirms Døsen.

Environmental considerations come closely behind safety in terms of

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priorities for Hexagon Ragasco. Døsen supports this by confirming that, "We have been re-using scrap and waste plastics in the production processes for more than 20 years, and the percentage of recycled material in the final product is increasing year on year."

He continues to say that, "At end-of-life', the cylinders can be disassembled, and the materials can be recycled or reused. Hexagon Ragasco supports several projects locally and internationally developing products based on recycled materials. We also focus on R&D projects extending the cylinder lifetime beyond the proven 20 years, which will be good for the sustainability footprint."

Recently, the Hexagon team updated the Life-Cycle-Assessment process for their products. Based on that, they will issue an Environmental Product Declaration for their Type 4 composite LPG cylinders, which are compatible with Bio-LPG, also called renewable LPG.

Hexagon Ragasco supplies LPG cylinders to industrial gases and fuel gases distributors. When ownership of the gas cylinder transfers from the producer to the operator, the responsibility for safe operations,

700 – 1,800
Burst testing for Type 4 composite hydrogen or CNG cylinders must take place between 700 and 1,800 bar

testing, and maintenance also transfers. The periodic inspection requirements are country-specific, but a hydraulic test and visual inspection every 10 years is typical.

Cylinder testing and equipment

LPG is a low pressure liquefied gas. In contrast, CNG and hydrogen are stored as gases at very high pressures. The design pressure for a CNG fuel tank cylinder for trucks or cars is generally 200 bar. For hydrogen cylinders for use in vehicles there are two typical design pressures: 350 and 700 bar.

When cylinders are manufactured, each one must undergo a non-destructive hydraulic proof test at a pressure significantly higher than the design pressure. In addition to that proof test, some cylinders must undergo a burst test to validate the production process. The frequency of this destructive test is typically one cylinder per 200 but, fewer tests may be done when a production process has been validated over the long-term.

According to the relevant standards for Type 4 composite CNG or hydrogen cylinders, burst testing must take place between 700 and 1,800 bar. Testing composite cylinders at these elevated pressures requires specialised equipment to generate the high pressures and to contain the energy of the cylinder as it ruptures.

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When developing new products, composite cylinder manufacturers can ship cylinders to a competent hydraulic testing centre where the burst test will be undertaken. The results will be documented and reported to the cylinder producer. Those test certificates can then be used to obtain type approvals for commercial production of the cylinders. When production scales up, it makes sense for the cylinder producer to invest in burst testing equipment.

"Bursting is just one of the tests that composite cylinders undergo," says Patrick Schulte, Sales Engineer in the Solutions Division at MAXIMATOR GmbH. "To validate a production batch, a pressure cycle test and boss-torque test followed by a leak test must also be done following EC79/2009. Furthermore, every cylinder produced must undergo a hydraulic proof test and leak test. We manufacture and supply test equipment and provide services for all of these requirements."

The leak-test can use either the vacuum method or the accumulation method. In either case, it is very time-consuming. The vacuum-method test cycle begins by connecting the fully valved cylinder to a vacuum chamber in the test-rig. A vacuum is then pulled in the test chamber, and the cylinder is filled with a gas mixture up to a pressure that is higher than the cylinder would experience during normal operation.

The first stages of the leak test cycle may take between 10 and 20 minutes. Then the test gas must be vented from the cylinder – that is a very slow process. Schulte adds that, "High pressure hydrogen cylinders for automotive fuel storage applications are fitted with excess flow valves. That is a safety feature that cuts off the hydrogen if a high flow is detected. This means that venting must be done very slowly to avoid triggering the automated shut-off mechanism."

A slow release of gas is also important to maintain the cylinder temperature within design limitations and avoid excessing chilling of the cylinder. The gas mixture used for the leak test must contain a tracer-gas which can easily be detected even if there is the smallest gas leak from the cylinder.

Mixtures such as 5% hydrogen in nitrogen or 10% helium in nitrogen are commonly used. The test gases are recycled within the system to ensure efficient operation and minimise the total cost of ownership (TCO) of the test equipment. gw

ABOUT THE AUTHOR

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