
# Trends in cylinder technology

## Cylinder technology goes green

By Stephen B. Harrison

Compressed industrial gases, fuel gases and refrigerants rely on cylinders for their distribution. As the world goes green, the trends in cylinder technology are also heading in that direction. Cylinder manufacturers, industrial gas operators and end-users are all equally impacted by these dynamics.

Through a series of case studies, we can better understand how shifts in energy usage in the transport sector, the transition to low global warming potential refrigerants, and the growth in demand for recyclable materials are driving cylinder technology forward.

**Towards sustainable mobility**

The EURO 7 automotive emissions legislation is likely to focus on reductions in carbon dioxide emissions from passenger cars. Lower emissions mean that cars attract lower road taxes and are therefore more affordable for road users and more environmentally friendly. So, there is a strong motivation for car makers to reduce the weight of their vehicles to reduce carbon dioxide ($CO_2$) emissions targets.

The fuels mix in the auto industry is in a state of transformation as we drive the road towards sustainable mobility. Electric vehicles, hydrogen as a transport fuel, liquefied natural gas (LNG) for trucks and compressed natural gas (CNG) for passenger cars are all finding their place. For many years, Fiat pioneered CNG as a transportation fuel and there now are more than one million CNG vehicles on the Italian roads. Other major European OEM's are beginning to challenge Fiat for that leading position. Putting these things together means that lightweight CNG cylinders will be an essential component in many modern cars going forward.

"Worthington Industries is committed to being part of the future of CNG vehicles," as Gabi Zeilerbauer, Director of European Sales for Worthington's Industrial Products group, confirms. "We have invested heavily to ensure that our CNG cylinders are the first choice for the auto industry. For example, our new proprietary cleaning process ensures that particulate carry over from the internal walls of our cylinders is the lowest in the industry. This helps to protect the sensitive CNG filters and control valves and ensure that cars are reliable."

"Furthermore, our Longlife PowerCoat exterior surface treatment ensures that the cylinders are corrosion resistant for the maximum possible duration. In many countries, salt is used to make icy roads safe in winter. So, corrosion resistance for CNG cylinders, which are often suspended under the car and exposed to road spray, is essential."

Achieving a high energy density is essential for fuels. Petrol and diesel, being liquids at normal ambient conditions of temperature and pressure, both score well in this respect. Gases such as hydrogen and methane (the main component of natural gas) must either be liquefied or compressed to achieve a similar energy density. As a marine fuel, or for trucks, LNG is a practical choice. For passenger cars, however, CNG and high-pressure hydrogen gas are favoured.

Use of hydrogen at 700 bar and CNG at up to 250 bar are emerging standards for compressed transportation fuels. When we consider that the industrial gases industry is upgrading from 200 to 300 bar in some countries, this leap to pressures up to 700 bar will clearly present tremendous challenges that must be met with transformational solutions.

Type IV composite gas cylinders are one of the technologies that will have a significant role to play in the next steps towards sustainable mobility. Zeilerbauer again explains, "At Worthington Industries, we produce Type I, II, III and IV cylinders. We see the plastic-lined, fibre wrapped type IV cylinders as particularly promising for the automotive industry in the future. They are capable of pressures up to and beyond 700 bar and can have a 75% weight saving when compared to a Type I steel cylinder with the same volume and working pressure specification – that's a huge benefit for the auto industry and will support the goal of reduced $CO_2$ emissions."

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"Our business development strategy revolves around innovations in new products, such as the Type IV cylinder, and to the way we build and nurture customer relationships. Our company has a strong history of transforming and evolving. Our roots 200 years ago were in turning wooden axles, then about 100 years ago we began to produce our first steel gas cylinders. Now and in the future, we will be developing products with a range of composite materials and plastics, serving the market in ways that once were not possible."

**Containing the problem of global warming**

In recent decades the refrigerants industry has made tremendous strides to reduce its environmental impact. The agreement of the Montreal protocol in 1987 was a turning point in the progressive elimination of ozone damaging CFC's and HCFC's. These two groups of refrigerant gases were largely replaced by HFC's which contain no chlorine in their molecular structure and therefore do not deplete the Ozone layer.

In 2016, the Kigali amendment to the Montreal Protocol took another major step to phase down the use of HFC's in favour of gases that have a lower global warming potential (GWP). However, some of the emerging fluorocarbon refrigerant gases have a higher vapour pressure that their predecessors. Also, some of the new generation HFO's are flammable, and this is a new risk in the refrigeration industry, where inert gases have been the norm in most applications for decades.

These changes in product attributes have meant that refrigerant gas distributors must adapt their operations. Ennio Campagna, Technology and Product Manager at Rivoira Refrigerants in Italy, now part of Nippon Gases, informs us that, "Our previous working pressure standard for refrigerant gas cylinders was 36 bar. Since the introduction of R410A for air conditioning applications about 15 years ago, we decided to increase to 48 bar for all new refrigerant cylinder purchases. Our older low-pressure refrigerant cylinders are now restricted to R134a service and we foresee that these packages will become redundant as this gas is phased out in favour of lower GWP alternatives, such as R1234yf."

The consequences of using flammable refrigerant gases also work their way through to the cylinder valves. The thread connection between the cylinder and the valve remains unchanged, but safety standards in many countries stipulate that the valve outlet thread for a flammable gas must be left handed to avoid any inadvertent connection to the right-hand threads used for air, oxygen and inert gases. Cylinder paint markings must also reflect the contents and the newer flammable refrigerant gases are identified with a red shoulder ring in the EU.

The shift in the refrigerant gas product mix is not the only driver of change. End-user cylinder handling safety and convenience are also key factors. Campagna explains why, "Refrigeration engineers often need to access air conditioning systems located on roof tops and for them, the use of lightweight composite cylinders with a thin steel shell and fibre wrap is more attractive than older heavier steel cylinders. Investment in composite cylinders is more expensive for Rivoira, but we have now converted between 10 and 15% of our cylinder fleet because of the clear end-user benefits. We recover some of the additional costs through a small premium on the cylinder rental charge."

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**Eco-friendly low-pressure cylinders**

LPG and refrigerant gases are contained in low pressure cylinders. Traditionally these were of a steel construction, but in today's market composites and plastics are increasingly being used. Filipe Pedrosa, Vice-President of Sales and Marketing at Amtrol-Alfa, now part of Worthington Industries located in Portugal, confirms the trend, "Twenty years ago, we exclusively used steel in our operation. Today, about 20% of the materials that we handle are plastics and composite fibres. With the introduction of our Type IV LPG cylinder, the Fourtis, which has a polymeric liner wrapped with recyclable composite fibre and a polymeric outer shell, we could see this ratio further shift towards non-steel materials."

Steel can easily be recycled: melt it down and start again. The same is true for many plastics, but some resins can be more problematic. Pedrosa adds: "To ensure that our low-pressure Type III and Type IV cylinders are fully recyclable, we avoid the use of thermosetting resins. Instead, we opt for polypropylene to bind the fibres. It can be melted and re-used just like the other plastics that we select."

The introduction and growth of plastics is only one major trend that has driven the low-pressure cylinder sector in recent decades. Another major change has been the progressive shift away from disposable cylinders. These are now fully banned in the EU and Canada for refrigerants applications. Some countries, such as Turkey, have this target on the horizon too.

Pedrosa explains the logic behind this trend when he says that, "disposable steel cylinders are recyclable, just like refillable steel cylinders: that's not the problem."

"The issue with disposable cylinders for refrigerants is that when they are thrown away, they generally still contain a small amount of residual gas. And, regulations in Europe to reduce greenhouse gas (GHG) emissions have banned the use of disposable steel cylinders for refrigerants to reduce the environmental impact of product release to the atmosphere". gw

**ABOUT THE AUTHOR**

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