Helium

Scarcity prompts the search for alternatives

Part 1. As the world faces up to sustained shortages in helium supply and an uncertain future ahead, **gas**world explores the quest for alternative options in helium usage

With the current global helium supply market dynamics the way they are, this poses a challenge to the new century's leading scientific minds – could helium be replaced in the myriad applications that presently rely on it, and if so, with which gases?

Worldwide demand for helium has been steadily increasing to meet the requirements of both conventional applications and the latest new-frontier uses. Helium is used in gaseous form in welding and cutting, fibre optics, electronics, in aerospace applications, in leak-testing, deep-sea diving, growing crystals to make silicon wafers, as well as inflation of balloons.

Additionally, it is employed in liquid form for cooling superconductive magnets used in magnetic resonance imaging (MRI) scanners for medical diagnostics and nuclear magnetic resonance (NMR) laboratory instrumentation. Helium is also commonly used with a wide range of analytical instruments as a carrier gas or in calibration gas mixtures.

In terms of usage worldwide, the greatest demand for helium comes from the US (36%), while Asia (28%) and Europe (22%) are the second and third-largest markets, respectively. Up to 20% of global demand alone comes from the manufacture and operation of MRI scanners, which use liquid helium to cool the superconducting magnets that generate high resolution images of the human body. Rising demand for MRI, along with growth in the electronics, semiconductor, liquid crystal display and fibre optic industries is fuelling increased requirement for the gas in China, India, Korea, Taiwan and in the Middle East.

Carlos Nulman, Head of Global Helium Business at Linde, says, "Today, the entire industrial gases industry is facing one of the most prolonged shortages in the history of global helium supply. This is a temporary situation, and with significant efforts being made to secure additional helium sources, one that will improve in the medium-term. Nevertheless, issues around helium scarcity and temporary supply disruptions will continue into the future and unfortunately are a natural consequence of the fragile supply chain characteristic to the helium industry."

There is a growing feeling that the scientific world needs to navigate a safe transition from helium, and indeed other scarce gases we have traditionally used for their convenience, to other suitable and sustainable alternatives, wherever possible.

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Dan Baciu, Head of Global Helium Business Development at Linde, said of the current market, "The extended helium shortage is being caused by the imbalance between supply and demand. In 2009 the global economic crisis caused a downturn in the need for helium from a number of sectors, and gas suppliers expected a slow recovery from this downturn."

"Instead, these sectors made a strong recovery, including sectors that had suffered the most, coming back with a vengeance. On the back of this, we saw the rapid emergence of a number of processes that did not previously require helium, adding to the demand."

Nulman adds, "While demand has increased, supply, which is largely governed by sources linked to fossil fuel reserves, has not kept pace. Some existing sources have experienced disruptions and have performed below expectations. Furthermore, a number of sources that were planned to come on-stream a couple of years ago, have not yet done so. We anticipate these to become operational in the near-term and provide some relief to the industry."

Supply sources

The largest helium source that industrial gas suppliers take advantage of is the Bureau of Land Management (BLM) complex in the US that provides around 50% of worldwide demand. The system has physical constraints, however, that force the BLM to allocate the amount of crude available to refiners thus affecting the entire supply chain. Reductions in volume – impacting the whole industry – have been in place for a year.

In addition to the BLM, Linde also sources a significant portion of its helium from a number of other sources to ensure diversity and stability of supply. One such example is Qatar in the Middle East via the Qatar 1 Helium Project. Linde also operates the first helium liquefaction plant in the southern hemisphere in Darwin, Australia.

Nulman expects a respite in 2013, as a result of several new sources coming on-stream, including the Qatar 2 helium project, expected to be the world's largest. Linde has secured access to a high proportion of its output. Once these new sources are operational, there will be sufficient helium to satisfy existing demand and also to support Linde's customers' growth aspirations.

"This will, however, only be a temporary respite," he cautions. "Supply from the BLM system is depleting and will be winding down over the next 4-7 years. Replacing this supply will take time and potentially multiple helium sources need to be identified and developed in the medium-term. Furthermore, many of these new sources will be located in some challenging geographies like Siberia and North Africa, and on the back of very large and complex projects such as LNG trains and intercontinental pipelines. So, the complexity, cost and risk of helium extraction will increase significantly over time."

Another challenge to industrial gas companies, who are distributing helium to end-user markets, is the lack of full visibility of all the new processes using helium. An example of this is in the electronics industry, where demand growth has been significant – almost exponential – and somewhat unexpected. Although this industry is typically guarded about exactly how the helium is being used, one process that is well known is the advent of the larger diameter silicon wafer.

Around six years ago, these wafers were being produced with a 150mm diameter and the amount of helium required to cool down a wafer of this diameter was not significant. When the design progressed to a 300mm diameter, it resulted in a doubling of the wafer rod surface area coupled with a quadrupling the wafer rod volume, thereby placing higher demands on the heat extraction capacity of the cooling gases surrounding the wafer rod. This caused a substantial increase in helium demand.

Baciu notes, "Now the 450mm diameter wafer is on its way and Linde expects the electronics industry to use considerably more helium to satisfy its cooling needs."

Recovery and recycling

One area that it is felt could be significant in the helium supply chain is recovery and recycling.

"We continue to work with our customers to incorporate recovery and recycling of the helium in their processes. If we're successful this could have a beneficial impact on the supply and demand balance," says Baciu.

"There are a number of trends that actually go in both directions. The MRI manufacturing business is showing no significant growth, so the amount of helium required for production is not going to change appreciably. However, what is going to change quite significantly is the amount of helium we manage to recover, liquefy and plough back into these manufacturing facilities."

"Some key MRI manufacturers have, for many years and with our support, managed to capture helium, re-liquefy it and put it back into their processes. Other manufacturers are likely to follow suit."

Linde Kryotechnik, a division of The Linde Group and a market leader in helium liquefaction and refrigeration technology, has been installing these liquefiers at a number of manufacturing facilities throughout the world. So while the amount of liquid helium required to cool down an MRI unit after the manufacturing process will stay more or less the same, the amount of product recovered will increase. As a result, the quantity of fresh helium required by these factories will decrease.

During operation, MRI scanners also require liquid helium to cool down their superconductive magnet coils to 4.3 Kelvin. Baciu says that where MRI scanners are used in the healthcare industry, there are two clear trends. One is the incremental growth of the number of scanners being used in the developing world, specifically India, China and Brazil, pushing up demand for helium. On the other hand, the scanners being manufactured today are considerably more efficient than they were only five years ago. Therefore the average amount of helium required per scanner while in operation is decreasing, with the net result likely to be a constant level of demand of helium for the MRI scanners in operation.

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Also likely to be of interest to the medical equipment and cryogenic research sector is a recent announcement from southwestern Europe. The Spanish National Research Council (CSIC), the University of Zaragoza and the US company GWR Instruments recently revealed that they has entered into a global collaboration agreement with Quantum Design International for a new helium recovery system.

This technology, developed jointly by Conrado Rillo and his team at the University of Zaragoza, CSIC and GWR Instruments, makes it possible to recover and liquefy nearly 100% of the liquid helium used in cryogenic research and medical equipment. In addition, Advanced Technology Liquefiers (ATL's) allow scientists and medical laboratory professionals to produce liquid helium from helium gas, thereby removing the previous requirement to start operations with liquid helium – both a costly and limited natural resource.

The new ATL technology comes at a time when laboratories and medical facilities are struggling to obtain and afford the liquid helium that is vital to their ongoing efforts. It's thought that this efficient method of recovering and liquefying helium will be of great value to those small and medium-sized operations presently struggling with their supply of liquid and gaseous helium.

The University of Zaragoza and Quantum Design International are now working together to improve and expand the ATL technology; the former has received up-front licensing fees for the technology from Quantum Design International as well as significant funding for further research and development work by Prof. Conrado's team.

One of the newer applications for helium is being driven by passenger safety considerations in the automotive industry: airbags. About 80% of car airbags harness a helium and argon gas mixture compressed in a steel cartridge at 600 bar. Helium has a number of advantages in this application, foremost of which is the fact that it does not generate heat during the inflation process. This means both driver and passengers are at far less risk of burns as airbags deploy, than they were with older technology which used other gases to inflate the airbags. ❑

PART 2 NEXT MONTH

Part 2. Helium: Economising world usage
What the gases business is doing to develop alternatives to helium across a myriad of applications and economise world usage of this finite resource.