

Cryogenic Distribution & Technology Improvements

Drive Sustainable Growth for Chart Industries

By Tim Neeser and Paul Shields

Twenty-five years ago there was grave concern that on-site gas supply solutions would largely displace distributed cylinder gas and merchant liquid supply modes. While on-site gas generation continues to evolve and play an active role in a wide range of industrial gas end use applications, the merchant liquid model continues to thrive. This is a result of continued improvements in equipment and aggressive management of all aspects of production and distribution costs. Variable duty cycles and purity requirements also favor merchant liquid based supply modes in many applications.

Liquid Storage & Distribution Equipment Trends

Bulk Markets

As cryogenic trailer transports have evolved to higher payloads, ground storage equipment has gradually increased in capacity to accept full trailer loads along with room to spare for additional gas molecule inventory. Suppliers and end users have realized the value of installing larger storage tanks to help offset the rising distribution costs. The user also sees the added security benefit of excess molecule storage on site that mitigates supply risks. A reflection of this is noted in reviewing the history of bulk tank production at Chart Industries. In 1990, bulk tanks were offered in a capacity range of 315 gallons to 11,000 gallons. The average size bulk tank at that time was around 6,000 gallons. Today, sizes for industrial gas storage range from 525 to 15,000 gallons, and the average size is 13,000 gallons for the major gas producers. New bulk tank demand has increased steadily for units 6,000 gallons and larger in size.

In 2000, Chart began working on technology improvements in telemetry to further reduce delivery costs. The remote monitoring of tank inventory has allowed gas suppliers to reduce the refill point at the customer site from 40 to 20 percent without the risk of a runout. This technology was also rapidly adopted by the micro-bulk market where level monitoring is even more im-

portant. With micro-bulk liquid storage, the user does not have the excess gas molecule storage to absorb for delivery tolerance or unforeseen production increases compared to bulk users. Today, telemetry is generally considered a standard feature on all new permanent installations.

Micro-bulk Markets

The biggest impact in cryogenic gas distribution and storage in the last 25 years is the emergence of micro-bulk, a solution offering all the benefits of fill on-site storage to end users traditionally served by full for empty swap deliveries. The development of bulk CO₂ for fountain soft drink carbonation was the genesis of true micro-bulk.

Gas distributors realized moving molecules instead of metal was the right solution for their larger packaged gas customers to reduce costs throughout the entire molecule value chain. Bulk CO₂ has continued to flourish from its earlier days in 400 lb. tank capacities serving one establishment to 1000+ lb. tanks today used in a variety of applications from swimming pools to microbrewery installations. For some restaurants, bulk CO₂ has become as common as the grill requirements on new expansions.

To support the micro-bulk movement for industrial gas distribution, Chart announced the Perma-Cyl® line of micro-bulk storage containers in the mid-1990s. The original offering of 450 liters in medium tank pressure gradually grew to 2,000 liters and then to 5,500 liters at very high pressure offered today. The Chart ORCA™ delivery equipment also improved along the way from 1,500 gallons to 4,500 gallons capacity. The technology in the ORCA back-end emerged with a variable speed submerged pump, auto shut off with the Perma-Cyl tank, and submerged metering for inert service at a flow of 40 gpm. Since those paradigm-shifting days, the pump performance gradually changed to 100 gpm at twice the delivery pressure to reduce fill times and to support laser assist nitrogen gas accounts, so prevalent today. The growth in the micro-bulk

market has gradually grown from high pressure cylinder displacement to become an alternative to transportable liquid cylinder and small bulk supply.



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Applications Trends

The list of applications served, by both bulk and packaged gas, has expanded rapidly during the last 25 years, forcing an evolution of tank design at Chart Industries. Notable applications are nitrogen for laser assist gas and gas chromatographs, argon for ICP-MS machines, vacuum insulated CO₂ receivers, engineered systems, and improvements at the fill plant. Recognizing the standard bulk tank is designed for gas applications, Chart began working on a design for a tank specifically for fill plants. In the early, 1990s, Chart announced the newly engineered Siphon 100®. The Siphon 100® is designed for dual pump liquid removal while managing the heat load for peak pump performance and molecule efficiency. The Siphon 100® is just one example of how tank designs have changed to adapt to the application requirements.

Laser assist nitrogen gas solutions emerged to meet this rapidly changing market. The Trifecta®, the Perma-Cyl® VHP, and HP2™ bulk tanks provided customers with options to meet their gas distribution model in this high-pressure, high flow, high capacity application. A key application perfect for micro-bulk was the laboratory market. GC's and ICP-MS equipment consumes nitrogen and argon at rates below what would support a conventional bulk installation.

Micro-bulk creates a continuous gas supply that eliminates costly recalibration resulting from full for empty cylinder exchanges.



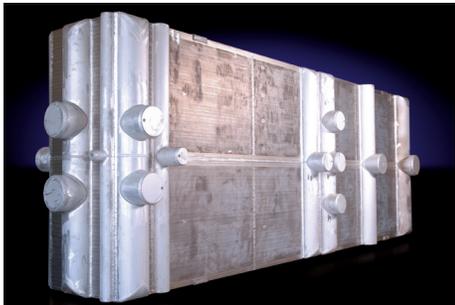
The Trifecta® provides customers with options to meet their gas distribution model in high-pressure, high flow, high capacity gas applications.

Traditional CO₂ receivers were generally foam insulated and built with low temperature rated carbon steel vessels back in the '90s. Today, vacuum insulation is recognized as a lower life cost alternative by most customers and pressure strengthening facilitates the use of a stainless steel inner vessel for food grade compliance and maximum safety. The increasing abundance of CO₂, primarily from ethanol production, and the demand for new applications from MAP (Modified Atmosphere Packaging) to food chilling/freezing creates continued growth in CO₂ distribution.

Another recent trend has been the desire for producers, distributors, and end users to buy completely engineered systems. These bulk installations typically include storage, vaporization, and manifolds sized and factory supplied to meet end use requirements. Recent trends have shown customers are not only looking for the complete solution, but the complete installation as well.

Air Separation Equipment Trends

At the heart of the cryogenic separation process, producing pure components of oxygen, nitrogen, and rare gases, are the brazed aluminum plate fin heat exchangers



Heat exchangers have increased in size by three-fold.

(BAHX). To support the increase in molecule storage capacity and the growth demand for industrial gas, this mission critical piece of capital equipment has improved in sync, solely with the aims of delivering cost and efficiency savings.

BAHX are custom engineered and consist of alternating layers of corrugated fins (secondary heat transfer surface) separated by parting sheets (primary heat transfer surface), stacked together to form a composite block that is bonded together in a vacuum brazing process. Perhaps the most notable of all the developments in the past 25 years is the steady increase in core block sizes and today, Chart is capable of manufacturing exchangers that are over three times larger per brazed load in its vacuum furnaces. For the customer, larger units means increased product flow through a single unit versus having to purchase multiple units, which has obvious potential for reduced CAPEX, but also cost savings through reduced shipping and installation costs. It also affords customers with increased options for optimization and packaging.

Improved manufacturing techniques and processes have also resulted in other crucial developments, critical to meeting the demands of today's industrial gas requirements. Design pressure capabilities have increased steadily from 900 psig to 2,300 psig. In practical terms this means that customers are better able to optimize process cycles and plant design, which helps support their objective of an overall total low cost solution.

The requirement for increased tolerances on leak tightness, both between process streams and to atmosphere, was driven in the '90s and aughts by the requirement for ultra-high purity (UHP) nitrogen used in semi-conductor manufacture. The test method uses helium and in 1990 the standard was a leak rate not exceeding 1×10^{-3} torr-liters per second. UHP nitrogen demanded a proof rate 1,000 times better than that, which was achieved to the extent that it's now often the norm for general industrial gas requirements, and Chart has manufactured units with a guaranteed leak integrity 1,000,000 times better than the original specification.

Improved manufacturing techniques have also led to increased thermal performance through Chart's development of dozens of new and improved designs for higher performing fin geometries (second-

ary heat transfer surface) with less pressure drop and enhanced manufacturability. Chart also has increased the footprint of our plant by 1.4 x the previous size and added three brazing furnaces. From a customer's perspective this allows Chart to continue to support their growth in demand for the product and continue to optimize our manufacturing processes to reduce their costs.

With cost control in mind, Chart has migrated production of the older, lower pressure BAHX to a brand new state-of-the-art production facility in Wuxi, China. This parallels with the major demand for industrial gas plants and the strategies of the major industrial gas players, including the indigenous ones increasingly prominent in the industry today.

As you'd expect, software development has more than matched manufacturing development and Chart has continuously developed its thermal and hydraulic design and rating software for improved thermal and mechanical solutions to meet increasingly challenging industrial gas exchanger designs with numerous cases. Sophisticated 3D modelling systems have developed to facilitate plant optimization through the provision of early equipment configurations and projected forward to predict potential fatigue damage and equipment life expectancy.

During the past 25 years, Chart has developed technology and new products internally but also has focused on growing by acquisition. Included in the latter are purchases of European-based Marston, Ferro, Flow Instruments, and GOFA; China-based ZBOC, CEM, Golden Phoenix, and Xinye; and USA-based CVI, PEI, Cryenco, Northcoast, MVE, Cryotech, Thermax Inc., Sequel, and AirSep. As a result, Chart has the capability to participate in all phases of the industrial gas market from liquefaction through distribution and a wide range of end use applications. ■

Tim Neeser is Vice President of Marketing & Applications Development for Chart Distribution and Storage. He can be reached at Tim.Neeser@chartindustries.com.

Paul Shields is Director of Marketing for Chart & Energy & Chemicals. He can be reached at Paul.Shields@chartindustries.com.