Optimize Your Deliveries of Industrial Gases

Gas cylinders, commonly referred to merely as "cylinders," can be delivered individually or in multi-cylinder cradles

Save money and improve your plant's efficiency by treating its gas supply holistically

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At the typical chemical process plant, industrial gases rank relatively low on the list of expenditures. But the complexity of choosing the right grades of gas and the optimal supply modes for all the diverse applications at most plants can create significant headaches for any engineer or plant manager. Make the wrong choices, and efficiency, quality and safety can be undermined.

Choosing correctly about gas supply starts with a thorough understanding of how various gases will be used in your operations. Major applications of gases in process plants are discussed in the box, The Gas Spectrum (below), and summarized in Table 1. Most facilities use numerous gases for a surprisingly wide array of applications, from serving as reactants to improving the product yield to monitoring the processes, as well as plant safety, quality assurance and environmental control. An unfortunate consequence of this diversity is that all too typically, a plant has a variety of people, from the plant engineer to the lab chemist, who order gases independently of each other, with no one looking at the overall gas supply chain.

Think of gas supply as an iceberg. For every dollar spent above the waterline for the gas itself, the container rental and the delivery charges, the typical user spends two to three dollars below, due to wastage, process-unit downtime (due, for instance, to a failure to supply enough gas), excess administration, and inefficiencies in gas selection and distribution. However, by rationalizing the sourcing of gases and mode of supply, engineers can improve plant efficiency and product quality and reduce overall costs. To do this requires not only that awareness of the full scope of the basic applications of gases in a typical process plant, but also an understanding how the gas industry classifies gases,

SPECIFYING A GAS

Selecting and specifying the grade of gas for a given industrial or specialty applications can be complicated. With few exceptions, there is no standard terminology nor any universal standards for naming gases or grades. That being the case, it is better to begin with the physical characteristics of the gas requirement, in terms of volume, pressure, temperature and purity.

Volume and pressure requirements are driven by the actual application, and they determine the appropriate mode of gas supply and gas management system, as discussed below. As a general rule, temperature is important only when a liquefied gas is being used explicitly because of its coldness.

Purity of the gas *as received* is gener-

THE GAS SPECTRUM

Industrial gases include atmospheric gases, particularly nitrogen (N_2), oxygen (O_2), and argon (Ar), as well as such common gases as carbon dioxide (CO_2), helium (He) and hydrogen (H_2). Industrial gases also include acetylene and other fuel gases, as well as shielding gas mixtures used in plant maintenance and repair operations (MRO). Certain specialized gases, not discussed in detail in this article, serve niche applications, such as manufacture of electronics components.

Nitrogen, the most abundant industrial gas, makes up 78% of the air we breathe. Because it is inert to most materials, it is used for blanketing, purging and pressurization; for instance, to prevent fire and explosion in flammable liquids, and to protect processes from atmospheric contamination. Nitrogen is also employed for purging in a variety of chemical process applications, and to pressure-check vessels for leaks. Liquid nitrogen finds applications such as process cooling, cryogenic grinding of plastics, and food freezing.

Oxygen constitutes about 21% of the atmosphere. Industrial-grade oxygen is used as an oxidizing agent in the production of fuels and chemicals, for supporting fermentation processes in pharmaceutical and biotechnology applications, and in wastewater treatment to satisfy biological oxygen demand requirements. It also has applications in steelmaking, metal cutting and pulp and paper manufacture. And, of course, medical grade oxygen is used for its life-sustaining properties.

Argon is an inert gas that makes up slightly less than 1% of the atmosphere. This gas is used primarily because of its inertness in applications such as arc welding, steelmaking, heat treating and electronics manufacturing. In situations requiring an inert gas, the choice between argon and nitrogen tends to be application-specific.

TABLE 1. COMMON GAS APPLICATIONS		
Name	**Formula**	**Applications**
Nitrogen	N_2	Blanketing, purging, pressurization, cryogenic applications
Oxygen	O_2	Oxidizing agent for fuels and chemicals, fermentation, wastewater treatment
Argon	Ar	Welding, steel manufacturing, heat treating, electronics manufacturing
Carbon dioxide	CO_2	Blanketing, purging, wastewater treatment, feedstock for chemical processes
Hydrogen	H_2	Petroleum refining (hydrotreating, catalytic reforming, hydrocracking), hydrogenating consumable oils, feedstock for chemical processes, reducing
Helium	He	Lighter-than-air applications, MRI
Acetylene, propylene, propane	C_2H_2, C_3H_6, C_3H_8	Fuel gases for welding and cutting
Industrial gas mixtures	Various	Shielding gases for welding and cutting, modified atmosphere packaging, breathing air, industrial air
Specialty pure gases	Various	Carrier gases, fuel gases for gas chromatography
Specialty gas mixtures	Various	Process and continual environmental monitoring, and quality assurance

ally not a concern for most industrial applications when the plant uses gas obtained from a liquid source, because liquefaction produces gas that is five-nines (99.999%) pure. On the other hand, purity problems can arise due to the equipment that conveys and distributes the gas within the plant; see the box, Drinking Through a Dirty Straw, on p. 5). A different kind of purity issue needs a wider appreciation: customers often rely too heavily on purity without understanding how the actual impurities in a gas can affect an application. This issue, discussed in the next section, is known as the "total purity paradox."

Understanding the paradox

When it comes to selecting and specifying industrial gases, specialty gases in particular (box, p. 3), many inexperienced users specify names and grades. But as implied above, specifications and cylinder size vary from supplier to supplier. So, what one gas firm calls a 300-size (referring to the approximate number of standard cubic feet [scf] of gas available) cylinder of zero-grade helium may be very different from another company's product.

Such supplier-to-supplier variations can be significant when, for instance, engineers or industrial chemists think they need a gas that is five- or six-nines pure (for analysis purposes, perhaps). Instead of the purity per se, they should be looking at the actual impurities found in the gas.

Consider two spoonfuls of sugar, each being nearly pure. One is 99% pure and the other is 95% pure. Given a choice with no further information, most people would choose the 99% sugar. Yet what if the impurity in the 99%-pure spoonful is rat poison, and that in the 95%-pure spoonful is salt? In short, it is in many cases not the purity, but the impurity, that is important.

For example, the three contaminants that affect most chromatographic applications are oxygen, moisture and hydrocarbons. These can create ghost peaks, affect retention times, increase baseline noise and reduce column life. Since, in general, the higher the purity, the higher the cost, users need to select a gas for chromatography that has the lowest level of *these specific impurities* that their system will tolerate. Such selection will enable users to get the results they are looking for, at the lowest possible cost. Selecting a gas that is higher in purity than required may waste money with no reasonable improvement in performance.

Selecting calibration mixtures

An important application of industrial gases in a process plant — but an application which is often overlooked by the process engineer — consists of gas calibration mixtures for quality-control, analytical or related plant uses. Although the quantities needed may be minuscule compared to those required for raw-material gases or other production-related gases, calibration gases can be essential for maintaining the quality of the plant product. As with pure gases, there are no universal standards for naming gas calibration mixtures. So, what one gas supplier calls a "precision blend" or a "primary standard" may be quite different from the mixture to which another supplier applies those terms. (Exceptions to this rule are medical grade gases that must meet specifications outlined by the U.S. Food and Drug Administration, and EPA Protocol mixtures, which must meet requirements outlined by the U.S. Environmental Protection Agency.)

For most calibration gases, specifying the right gas depends on understanding how mixtures are qualified by a given gas supplier, and on being aware of the acceptable tolerances for the application; the latter informa-

Carbon dioxide, while found in small amounts in the atmosphere, is generally a byproduct of other chemical processes, typically recovered from the production of ammonia, hydrogen in refineries, or ethanol. Carbon dioxide also can be extracted from natural wells. Since carbon dioxide is non-reactive in the presence of many materials, it is often used for inerting purposes, such as blanketing and purging of tanks and reactors. Carbon dioxide also serves as a reagent for wastewater treatment, as well as in a variety of chemical processes; for instance, it is a raw material in the manufacture of urea.

Hydrogen is widely used in petroleum refining processes, such as hydrotreating, catalytic reforming and hydrocracking. For example, the increased use of sour crude oil in refineries has increased use of hydrogen to reduce viscosity and remove sulfur. Hydrogen is also used by the food industry to hydrogenate consumable oils to improve product appearance and salability. It is used in power plant generators as a cooling agent. Hydrogen is also a raw material for many chemical processes, such as the manufacture of high-density polyethylene and polypropylene resins, and is used as a reducing gas in metals processing operations. Nowadays, hydrogen is drawing widespread attention as a possible alternative fuel.

Helium is used as an inert gas. Its major applications are outside the chemical process industries. For instance, because of its low specific gravity and nonflammability, it often serves in lighter-than-air applications such as the filling of balloons and blimps. It is used for inerting in fiber optics manufacturing and also for leak testing of tion is likely to be available from the plant's chemists. As a general rule, the level of uncertainty and mixture complexity will dictate the cost. So, it is obviously advisable to choose a gas that meets the minimum requirements of the application, to avoid overspending on gas purchases.

In selecting a calibration gas mixture, consider both the preparation tolerance, which depends on the equipment and procedures used in mixing, and the analytical tolerances defined by the uncertainties inherent in the analysis process, the relevant instrumentation, and the calibration operation itself.

In addition to EPA Protocols, some gas-mixture applications require some level of traceability. For instance, ISO 9001:2000 programs and other quality standards may call for gases that are traceable, either by analytical standards or otherwise.

When it comes to buying calibration gas mixtures, give serious consideration to dealing with gas suppliers possessing their own analytical laboratories accredited under the ISO 17025 standards. Doing so provides the customer with an extra level of validation for analytical techniques, methodology and competency.

MODES OF DELIVERY

The volume of gas required per unit of time, and the pressure(s) at which it is employed, are the main determinants of the appropriate mode of supply. Very large-volume requirements for certain gases, such as hydrogen, oxygen or nitrogen, are usually met by onsite gas plants or pipeline delivery. But for most gas needs, the choices will be among six other primary modes of gas supply: gas cylinders (or multicylinder packs), liquid cylinders, tube trailers, microbulk tanks, bulk tanks, and gas generators (machines that have much lower production rates than the onsite plants).

In general, no single mode will suffice for a plant's entire needs. But a supplier capable of managing multiple modes of delivery can work with a plant engineer to look at the scope and diversity of applications and the similarities of operations, and then design a customized supply system that will meet current and future requirements. (See Table 2: Gas Supply Options.)

Gas cylinders

A pressurized cylinder typically delivers 10 to 350 scf of gas and is commonly used for volume needs of up to 15,000 scf/mo. These cylinders are particularly useful for low-volume or intermittent applications, and can provide gas at a wide range of pressures: from less than 1 psig to approximately 6,000 psig. For applications requiring larger volumes, cradles of 6, 12 or 18 cylinders manifolded together are an option. These can provide volumes from 1,800 to 5,400 scf per cradle, over the broad pressure range indicated above, reducing the frequency of changeouts and ordering.

People handling pressurized cylinders must be familiar with the procedures for safe handling and storage. Cylinders are rented from the gas supplier, who, in the U.S., must maintain and inspect the cylinder according to Dept. of Transportation (DOT) regulations. Cylinders should be secured in storage and in use and must be returned to the supplier with some minimal residual pressure.

Liquid cylinders

For customers with somewhat larger-volume needs, up to 50,000 scf/month, insulated liquid cylinders delivering approximately 4,500 to 5,600 scf of gas are popular. Liquid cylinders retain the advantage of portability while requiring less space than gas cylinders; accordingly, they are in many cases the preferred choice even at plants with gas demands as low as 4,500 scf/mo. On the other hand, these cylinders do not offer the pressure-related versatility of gas cylinders; liquid cylinders cannot discharge at above 500 psig, and most of them are practical only up to 180 psig. Nitrogen, oxygen and carbon dioxide are among the major gases available in liquid cylinders.

Product can be withdrawn from liquid cylinders in either gaseous or liquid form, depending on the application. However, be aware that over time, ambient temperatures will cause unused liquid in the cylinder to vaporize and become vented through a pressure relief valve, in accordance with what is called the normal evaporation rate (NER), a function of the amount of heat leaking into the cylinder. The NER will vary with ambient temperature, the particular gas stored and the rate of usage, and may be as low as 0.4% or as high as 3% of the container's volume per day.

Tube trailers

Tube trailers are like cylinders, but larger. They deliver gas volumes between 45,000 and 180,000 scf, and are useful when high-pressure gas is required in volumes greater than is practical from individual gas cylinders or cradles.

These trailers are also practical for short-term or intermittent uses, such as plant turnarounds. The tubes can be refilled onsite from delivery trucks, or removed when empty.

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various manufactured components. Mixtures of helium and oxygen are employed as breathing gases in deep-sea diving. Liquid helium is also used in superconducting magnet applications, including magnetic resonance imaging (MRI).

Other industrial gases include the fuel gases acetylene, propylene and propane. At process plants, these find usage in not only production operations but also plant maintenance, repair and overhaul.

Mixtures of gases are highly important. For instance, various blends of argon, carbon dioxide and oxygen serve for shielding during welding and cutting applications, including those during MRO. Other mixes — nitrogen and carbon dioxide, for example — are used for processing, such as modified-atmosphere packaging to preserve the freshness and appearance of foods and beverages. Atmospheric air and purified industrial air are also used to actuate valves and to blow-clean work areas.

Specialty gases

Specialty gases fall into two major categories: high-purity gases and gas mixtures. Major uses for specialty gases include performing analyses, monitoring processes and their emissions, and conducting quality assurance programs and new product development.

High-purity specialty gases, including helium, nitrogen, argon and hydrogen, are commonly used as carrier and support gases in gas chromatography equipment. Hydrogen is also employed in combination with air as a flame gas in a flame ionization detector. Argon finds application in ICP (inductively coupled plasma) detectors. All these gases are sup-

TABLE 2. GAS SUPPLY OPTIONS		
Mode of Supply	Quantity, scf	Gallons
Gas cylinders	10 to 350	N.A.
Liquid cylinders	4,500 – 5,600	48 – 61
Microbulk	5,000 – 48,000	61 – 539
Tube trailers	45,000 to 181,000	N.A.
Bulk	> 45,000	> 500
Gas generators	N.A.	N.A.

Although liquid cylinders hold their "gas" in liquefied form, the product can be withdrawn from them in liquid or gaseous form

Microbulk tanks

Microbulk tanks contain approximately 5,000 to 48,000 scf of gas. This mode of delivery is recommended for applications of from 10,000 to 50,000 scf/mo. The tanks, which come in a variety of sizes, can be installed inside or outside the facility, depending upon space requirements. Gas or liquid can be efficiently piped to each point of use. The supplier then refills the microbulk tank onsite from a bulk delivery truck.

Aside from meeting the higher-volume needs, this option eliminates the need to move cylinders, or return residual product in the "empty" cylinders. Nitrogen and argon are the gases most commonly delivered in the microbulk supply mode.

Bulk storage

Bulk gas is generally recommended for storage volumes greater than 45,000 scf, with tanks generally ranging from 500 to 13,000 gal. Gases offered in bulk include argon, nitrogen, oxygen, carbon dioxide and hydrogen. Although gas from bulk storage is generally at below 200 psig, the gas supplier can work with the user plant's engineers to design a tank and gas-management system to provide gases at high pressure. Similarly, systems can be set up to deliver some gases from bulk storage in liquid form.

In most instances of bulk storage, the gas supplier manages the tank, as well as its ancillary equipment. In the newer bulk-tank installations, these auxiliaries includes telemetry equipment to signal the supplier when more product must be delivered by a truck. Because the supplier maintains the tank and its auxiliaries, this equipment usually is the property of the supplier and is leased to the customer.

Gas generators

The most common generator in industrial use is a noncryogenic nitrogen generator. Most nitrogen in cylinders and bulk delivery, or from onsite plants, comes from air separation units that cryogenically extract nitrogen from the atmosphere. Gas generators instead do so by means of membrane separation or pressure-swing adsorption.

Generators are best suited for continuous-flow applications and pressures to 175 psig. They come in sizes that can produce volumes from about 1,000 to millions of standard cubic feet per month. For applications requiring a continuous supply, a cylinder or bulk tank back-up is necessary.

Although gas generators operate at relatively low cost, keep in mind that their usage does require electricity, as well as periodic maintenance. Table 3 compares gas generators with cylinders and bulk storage.

Besides nitrogen, also available are gas generators for industrial grades of oxygen, and proton-exchange-membrane generators for hydrogen. Specialty grades of hydrogen, nitrogen and analytical air (used for supporting a hydrogen flame on flame ionization detectors) can be generated.

Choosing the optimal mode

The first step in choosing a supply mode for a given gas at a plant is to look at the application requirements. What volume does the application demand? What pressure? If the gas is already being delivered to the plant, does the current mode efficiently meet these demands, or is it adding expenses below the iceberg waterline mentioned near the beginning of the article? Consider the following two examples:

Plant usages of nitrogen: A chemical plant uses approximately 100 scf/h (scfh) of nitrogen on a continuous basis to blanket several tanks. Currently, the plant has liquid nitrogen cylinders at each tank, with an automatic changeover manifold that can swap the cylinders as required. In addition to the blanketing, the plant uses nitrogen once a week to pressure-transfer incoming raw material from railcars into a tank. The pres-

plied in varying levels of purity up to 99.999% or "five-nines" pure. Even higher levels of purity — for instance, 99.9999% or "six-nines" — can be obtained for certain applications, although this degree of purity is rarely required. In the main text of this article, see a deeper discussion of the "total purity paradox". Other pure specialty gases are those used in biotechnology applications, including ones that comply with United States Pharmacopea (USP) or National Formulary (NF) standards for purity. And various cryogens, such as liquid nitrogen, liquid carbon dioxide and dry ice, serve for sample storage.

Specialty gas mixtures are blends used mainly in analytical applications, and serving as standards during the calibration of process-monitoring or emissions-monitoring equipment. Among these standards mixtures are the U.S. Environmental Protection Agency's EPA Protocol gases for monitoring substances that cause smog or acid rain; these mixtures are prepared and analyzed in strict accordance with U.S. federal regulations administered by EPA. Other gas mixtures that serve as standards include traceability standards, which are analytically certified against U.S. National Institute of Standards and Technology (NIST) Standard Reference Materials or other NIST-approved "NIST Traceable Reference Materials" (NTRMs). Other precision blend mixtures, such as those used in a chemical-plant or refinery pilot units, can be highly complex and can mimic a process stream.

Some specialty mixtures are very simple. For example, analytic air is a synthetic blend of nitrogen and oxygen used to support hydrogen combustion in a flame ionization detector and acetylene combustion in an atomic absorption flame. ❏

DRINKING THROUGH A DIRTY STRAW

When purity is an issue, gas users must consider not only the purity of the gas per se, but also the state of the gas management system that takes the gas from its container to the point of use.

For instance, most problems with running gas chromatography equipment occur following a cylinder changeout. Analytical chemists often respond by buying their next batches of gas in higher grades of purity. Yet, chromatography issues such as increased baseline noise and ghost peaks are often the result of contaminants introduced by the gas management system, not the cylinder.

Here are five myths about gas stream purity, plus tips to help maintain a clean system.

1. A better grade of gas will improve performance?
This is true only if the gas is the same quality in the cylinder as it is when it enters the instrument or the process equipment. If the gas – no matter how pure – travels through a "dirty" system, it becomes contaminated. If, instead, the system is designed to contain and remove contaminants before they can do damage, as well as provide a visual indication when contaminants enter, and identify the contaminant, the resulting "cleaner straw" will improve the performance of the instruments or plant equipment

2. All pressure regulators are created equal?
Another myth, especially relevant for gases for analytical usage, is that any regulator with a stainless steel diaphragm is suitable. In fact, however, one should insist on bar-stock regulators, rather than forged-body ones, as the bar-stock version has a small internal volume and a straight gas path. If contaminants do enter, it is easy to predict when they will emerge. Make sure the regulator is cleaned for chromatographic service. It should never have lubricants or polytetrafluoroethylene tape on the connection, because these cause leaks and contamination.

Furthermore, consider using a two-stage regulator to maintain a constant pressure in the system. A single-stage regulator will need frequent adjustment as cylinder pressure falls.

3. Leaks only go outward?
This is true when the system is in a static state. However, when gas is flowing, a leak generates a vacuum that can suck in ambient air, which contains oxygen, moisture and, perhaps, traces of impurities such as hydrocarbons. Therefore, make sure that joints and fittings are made correctly and employ compatible materials – for instance, avoid combining stainless steel tubing and brass regulators or ferrules. For fittings, only use two-piece ferrules tightened to manufacturer specifications.

Also, if the system has brazed joints, they must be made using the fluxless brazing method. Orbital welding is a viable alternative as it creates a metal-to-metal fusion joint that has no filler metal. Pipe thread joints must only use polytetrafluoroethylene tape in the absence of a lubricant or sealer.

Plant laboratory personnel also need to consider the types of valves and flexible pigtails they use. For instance, ball valves are popular because they provide a visual indication of when they are opened or closed. However, they lack a positive shut-off for helium and hydrogen, and they use lubricants, which can contaminate a system. Needle valves can also introduce contaminants. The best choice is instead a nonlubricated, packless valve, cleaned for chromatographic service. Also, use pigtails with corrugated stainless steel bellows. Never use pigtails with polytetrafluoroethylene cores with helium and hydrogen, since these will allow small molecules to leak out.

4. Purifiers solve everything?
Gas purifiers do safeguard against contamination. On the other hand, they are not practical for cleaning the gas — in fact, some types can actually introduce impurities, at unpredictable moments. There are three types of purifiers: surface absorbent, chemically absorbent, and self-indicating chemically absorbent.

Avoid surface absorbent purifiers. When they become 40 to 60% saturated, contaminants introduced earlier during changeouts can become dislodged and enter the stream. Chemically absorbent purifiers lock up contaminants, so they cannot become dislodged later. However, if the purifier is non-indicating, it is difficult to measure its saturation level; at some hard-to-gauge point, the medium will stop working, allowing contaminants to pass through unabsorbed. By contrast, a self-indicating chemically indicating purifier gives the user a signal when a contaminant has entered the system, thus indicating that the time has come to change the purifier.

5. It invariably takes at least four hours to recover a baseline purity after a cylinder changeout?
The actual recovery time usually relates to contaminants entering the system. If proper safeguards against contamination are taken, a cylinder changeout can be accomplished in a half hour or somewhat more.

In many process plants, the operators or laboratory personnel replace a cylinder when convenient rather than necessary. On a Friday afternoon, for instance, they will change a gas cylinder even though it still contains gas at more than 500 psig of pressure, to avoid downtime over the weekend.

Consider adding an automatic changeover system. This allows for uninterrupted service, eliminating waste and downtime. When one cylinder is depleted, the system switches to the other side, allowing the "empty" to be returned with a minimum of residual gas.

Keep in mind that although it might not entail four hours, it is indeed easy to contaminate a system, and time-consuming to regain a baseline once contaminated. Building the system correctly can save time and money, and provide the consistency that industrial chemists need in their results. ❑

sure transfer requires up to about 10 six-cylinder cradles per month, each cylinder containing 311 scf. Is there a better way for the plant to meet its overall nitrogen needs? The following calculations help to determine the optimal mode.

Monthly nitrogen usage:

1. *Liquid cylinder:* 100 scfh x 730 h/mo = 73,000 scf/mo
2. *Cradle:* 6 cylinders x 311 scf/cyl x 10 cradles/mo = 18,660 scf/mo
3. *Total monthly usage:* 73,000 + 18,660 = 91,660 Scf

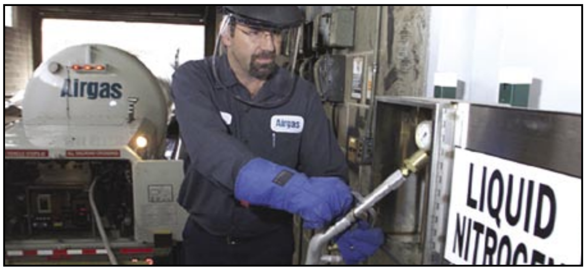
At that consumption rate, a 1,500-gal bulk tank with piping run to the tanks to be blanketed and the railcar unloading station would be a better solution. Since nitrogen has a vaporization factor of 93.11 (1 gal of liquid nitrogen yields 93.11 scf of gaseous nitrogen), the tank would provide 1,500 gal x 93.11 scf/gal, or 139,665 scf, which is sufficient capacity for any upset requirements, and would require a fill once per month. It would also free up the space currently used to house the cylinders, eliminate residual-gas losses, and eliminate issues involved in cylinder handling, disconnecting, and reconnecting from a manifold. As noted above, bulk tank installations available today include telemetry systems that alert the supplier when the tank needs to be refilled, eliminating ordering and inventory hassles.

Keep in mind that adding the bulk tank and the distribution piping would require costs for site preparation and installation. However, the resulting lower gas cost and benefits are likely to provide a quick payback.

Laboratory usage of argon: in many cases, plant laboratories can also benefit from reexamining their delivery mode. For example, a petroleum refinery's quality-control laboratory uses seven to eight 160-liter liquid containers of Ar per month, supplying about 25,000 to 30,000 scf of gas to continuously run an ICP (inductively coupled plasma). A shutdown of the unit may require about a half-day to restart. So, to avoid running out of gas during an

TABLE 3. ECONOMIC FACTORS OF GAS GENERATORS

Feature	Cylinder	Bulk	Generator
Lowest gas cost per SCF			✓
Highest available gas purity	✓		
Large flow fluctuations	✓	✓	
Varying pressure requirements	✓		
>200 psig required at POU	✓	✓	
Customer maintenance required			✓
Electrical power required			✓
Cylinder handling required	✓		



Microbulk tanks, which can be placed indoors or outdoors, are periodically refilled by a bulk delivery truck

analysis, laboratory management replaces the containers while they still contain as much as 20–30% residual gas, which drives up the procurement costs. What's more, the liquid containers, which each weigh 500 lb, create safety issues for plant and laboratory personnel, and storage concerns for the facility.

Switching to a 1,000-liter microbulk tank would supply the volumes required. Since many newer microbulk tank installations include telemetry systems, the supplier could refill the tanks without interrupting operations. This switch would provide the constant supply of high-purity gas needed, without residual returns to the supplier and with less administration and handling.

There are situations in which environmental or regulatory considerations suggest, if not dictate, a particular mode of supply. When considering the use of bulk tanks for flammable gases, for instance, check to see if there are sufficient distances between the proposed tanks and other structures.

Gas generators are available to deliver any of several industrial gases

Managing the supply chain

In selecting the optimal delivery mode, also consider (as the above two examples illustrate) that for cylinders and liquid cylinders, the product comes in returnable, rented containers. Once the product is used, the cylinder needs to be replaced and the used cylinder returned to the supplier. Gas is one of the few supplies that a plant uses that requires this challenging two-way supply chain.

Many gas users' purchasing departments have difficulty managing cylinder rentals because the actual rental costs fluctuate depending on the number of cylinders the customer has on hand at the end of the month. If this cylinder balance goes up, so does the monthly rental charge, and vice versa. For example, assume that a user plant pays $5 per month per cylinder rental, and has a balance of 125 cylinders at the end of a given month. The facility is invoiced $625 for rent. If the cylinder balance creeps up to 140 cylinders at the end of the following month, the facility is then billed $700.

Rental allocation within a typical major chemical-process plant's operation can be complicated and costly, because there are likely to be lots of cylinder users, end-use points, and cylinder stockpiles. Accordingly, most such plants choose to make flat allocations in which each user is allocated a set portion of the bill each month.

Because this in-house charge is a flat fee and is a relatively low expense, many end-users do not actively monitor cylinder balances. They simply want the gas to be available when they need it. The result is that they typically overstock, with most users keeping many months of inventory onsite even though their gas supplier may make deliveries a few times a week.

A competent gas supplier is able to offer an audit of gas usage to determine the optimal cylinder balance and supply mode. Larger customer installations may even contract onsite services from the supplier to manage the gas supply chain and all the gases procured and used on site. Some customer companies also reduce their administrative burdens by employing e-business methods of ordering, tracking and paying for gases.

Ultimately, plants can reduce their headaches by working with a supplier that can help rationalize gas supplies. Ideally, look for a supplier company that understands gas supply in onsite, bulk and packaged modes alike, and has expertise in process and analytical applications, supply chain management and years of experience.

Further, look for a company willing to work with its customers to understand their processes. Some suppliers will even appoint an onsite gas manager to help facilities evaluate their needs, unify the multiple channels of ordering, and reduce overall supply costs. Getting the gas company involved can be the first step in getting the most out of the gas purchases. ■

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