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What makes specialty gases so special?

Today's high-tech industrial processes demand specialty gases with higher levels of purity and more precise accuracies than ever before. An increasing number of specifications for these gases now go down to parts per billion (ppb) and sometimes even to parts per trillion (ppt). Gas supply companies have to ensure that specialty gases – whether pure gases or mixtures – are those that best correspond to the applications they will be used for.

The characteristics of these exotic, non-standard 'specialty' gases, in comparison with standard industrial and medical gases, divide the gas supply market into two specific segments. Applications calling for specialty gases are being added every day and the already broad spectrum of uses includes air quality monitoring, biological growth control, breath alcohol testing, calorimetric testing, car exhaust testing, confined space monitoring, commercial diving, emission and natural gas trading, and explosimetry. Then there are the applications involved in olfactometry, process control, soil and water measurement, solvent, VOC and stack emission monitoring.

Within the pure specialty grades, purity can reach up to 99.99999% (7.0). Higher purity means fewer and lower levels of the impurities that cause problems with high-tech production processes or instrumentation and analytical measurement. This high level of purity, compared to the same gas at an industrial or medical purity, is one of the differentiators that make a specialty gas 'special'. Oxygen, for example, is a common medical gas and its purity must be suitable for people to breathe. It is also used in industrial applications, for instance, in cutting and welding applications. Oxygen is also used in speciality gas applications, such as laboratory instrumentation, but the purity of oxygen required in this laboratory application is much higher.

Another characteristic of specialty gases in comparison to medical or industrial gases is the complexity of the product. While a gas mixture for a welding application could comprise a mixture of argon and carbon dioxide to weld steel, and a gas mixture used in a medical application could harness a mixture of nitrous oxide and oxygen for anaesthesia, speciality gas mixtures are far more complex. Instead of two or three different chemicals in the mix, there could be a combination of 20 or 30 chemicals. In addition, instead of blending these chemicals to a tolerance of plus or minus 5%, the end-user might require the component to be blended at an accuracy of +/- 1%. This is a third differentiator of specialty gases; the high specification tolerance of the mixture.

The complexity of the special gas mixture could also be magnified by the presence of one or two components at an extremely low concentration, such as a few parts per million (ppm). This makes manufacturing the gas mixture, and handling it at the point of use, very challenging. Avoiding contamination is absolutely essential, because even the smallest amount of contamination in the surrounding air could result in a few ppm of this contamination entering the system and significantly changing the composition of the mixture.

Scale of supply is another major differentiator between specialty gases and industrial and medical gases. The quantities in which specialty gases are requested by end-users are frequently much smaller than the other gases. How much of the gas will be used, and how many customers will want this particular product, also influences scale of supply.

Some of the most common industrial gases are supplied to customers through pipelines in quantities such as thousands of tons per day, or in bulk format by 20-30 tonne road tankers, where the liquefied gas is supplied to customer facilities and vaporised on-site to yield the gas required. This is a cost-effective way to buy high quantities of standard industrial or medical gases. In contrast, specialty gases are typically supplied in cylinders containing about 10 cubic metres of the gas or in small portable cylinders that only contain one cubic metre of the product.

Specialty gas production

In many cases specialty gases and mixtures are unique 'one-off' products developed for a specific customer application and they require a great deal more product engineering compared to the standard industrial or medical gas products. For this reason, they are not always 'off the shelf' items and can even take several weeks to produce, in the most complex of cases.

The high purity and extreme complexity of specialty gases has implications relating to the way they are produced. Where a raw material of the required purity cannot be sourced, the gas producer must buy the highest purity available and introduce additional purification processes in-house to achieve an end product of a sufficiently high purity.

Packaging is an issue on its own. Since these gases are generally required in small quantities, they are typically supplied in cylinders and extreme care must be taken when introducing the specialty gas into the cylinder. The materials of construction for these cylinders are also very important in maintaining the integrity of product. While steel cylinders can be used for most industrial and medical gases and some specialty gases, specialty gas products often require aluminium alloy cylinders, which are more compatible with the purities and chemicals associated with specialty gases. The valves on top of the cylinders must ensure that the contents remain inside and contaminants from the atmosphere remain outside. Specialist materials, such as stainless steel or a very high grade brass, are therefore also needed for valve construction.

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Packaging of specialty gas mixtures is a challenging task, because the tolerance, or accuracy, of the component percentages must be maintained. Often these highly accurate mixtures are needed to calibrate a measurement and gas producers must utilise highly sophisticated filling equipment and processes to ensure the products' integrity. Speciality gas cylinders have to be heated, evacuated and purged to expel any traces of moisture or other impurities before the product is introduced, creating yet another production step that is not necessarily required for the majority of industrial and medical gases.

Finally, the level of quality control associated with specialty gas production is far higher than with industrial and medical gases. Sophisticated laboratory instrumentation is used to analyse and verify the constitution of many specialty gases and in these cases, customers are normally provided with a certificate declaring the analytical results. In some cases, for example where chemically reactive molecules exist in a gas mixture, this analysis is repeated over an extended period of time to ensure consistent results which indicate a 'stable' gas mixture. In these cases, this is another reason for the extended production lead time of specialty gas mixtures compared to more standard off the shelf industrial gas mixtures that might be used for welding.

Specialty gas equipment

Complex industrial processing and instrumentation demand products of the highest quality to maintain peak performance. Distribution systems for specialty gases must meet increasing demands for optimal standards of performance, new analysing methods and production refinements. Impurities occurring in just a few ppm can have serious consequences to the end-user.

The demands made on regulators and valves in these environments are extremely high and components must be capable of handling high and low pressures, large and small flows and must also be suitable for high-purity inert gases, as well as reactive, flammable, corrosive or toxic gases.

Beyond the high precision production technology required to produce specialty gas products, there is therefore also an onus on end-users to ensure that their gas delivery equipment is capable of maintaining the high purity or accuracy in the gas coming out of the supply cylinder, up to the point of use. At this critical moment, the quality of the gas is only as good as the gas distribution system. Specialty gases are often used in conjunction with expensive analytical instruments or sensitive technical devices, so using the proper gas delivery equipment is needed to ensure they are protected from any impurities that might enter them from the ambient air.

Since there can be potentially dangerous substances in specialty gases, safety and the environment are top priorities and gas distribution systems must meet stringent requirements to protect the health and safety of the people who work with them. Many speciality gases are classified as hazardous – toxic, carcinogenic, flammable and stored at high pressure – and safety legislation is rapidly tightening to boost gas handling

SPECIAL FEATURE

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and usage to entirely new levels. This legislation impacts on product registration, classification and labelling, packaging and transportation, storage, product information and product disposal.

Gas handling equipment functionality is critical and must be suited to the sophisticated gas being handled. This encompasses factors such as pressure reducing regulators and purge functionalities. Materials of construction are once again critical to the integrity of the distribution system, particularly where speciality gases contain corrosive components. Joints, seals, moving parts and fittings in regulators and valves must be absolutely tight and impermeable – much more so than for the equipment used to supply industrial/medical gases.

In these applications, the term 'helium leak tightness' is often used to determine leak potential, referring to how much helium will leak out within one second under certain circumstances from the inside of the system to the outside. Typically, with industrial and medical equipment one cubic centimetre of helium could leak within an hour from a component. On the other end of the scale, other gas distribution systems might display far better leak rates, capable of maintaining their integrity up to and even far beyond 30 years for the loss of one cubic centimetre of helium.

To avoid any reaction between the specialty gas product and the material of construction of the distribution system, sophisticated materials such as stainless steel or Hastelloy® can be utilised to construct the system components, owing to their excellent anti-corrosive characteristics and their first-rate sealing qualities. These components must also be impermeable, both in terms of gas leaking out of the system and atmospheric gases infiltrating into the system. The sum of the leaks is critical and all connections, components, piping and tubing must be as tight as possible. Bar stock and forged components are favoured, rather than the cast componentry suitable for industrial and medical gas distribution systems, which does not provide sufficiently tight housings for specialty gases.

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In these specialty gases distribution systems, connections between the gas cylinder, the gas distribution system and the application are generally comprised of PTFE hoses or thin walled, flexible stainless steel hoses, because rubber hosing, which is often used for industrial gases, is porous. In addition, compression fittings and orbital welds are used to ensure uncontaminated and unyielding joins. Where very low ppm or particularly corrosive mixtures are being supplied, metal gaskets are also favoured above rubber or plastic alternatives.

Another factor is the internal roughness of the distribution system and this must be very smooth to ensure contaminants such as oxygen and water cannot attach to the rough surface during the purging process. Stainless steel tubing is less rough internally and is therefore preferred over copper. It is imperative that no impurities remain in the system when a new installation is commissioned or when a cylinder is changed out. For this reason, extreme care must be taken when making or breaking a connection in an existing specialty gas pipeline to conduct maintenance, add on to the system, or even change out a cylinder connected to the gas distribution system. In all these instances, technicians are effectively opening up a closed system to the atmosphere.

High purity argon is generally used as a shielding gas during welding of stainless steel pipework for specialty gases applications to ensure that the joints are smooth and non-porous. Furthermore, the gas used to pressure test the system after any welding activity must be of a similar quality to the product the system is being used for. Purging with a lower quality gas could introduce moisture and other impurities into the system that can be difficult or impossible to remove afterwards. Other tests prior to bringing a specialty gases piping installation on line might include vacuum testing and helium leak testing, depending on the sophistication of the system and the customer's requirements for the process gas. gw

DEMANDING

The demands placed on gas handling equipment in the specialty gases business are often even greater than those in industrial gas environments. In these applications it is often routine to check for helium leak tightness, for example. Typically, with industrial and medical equipment one cubic centimetre of helium could leak within an hour from a component.