The Importance of Speciality Gases in Research, Production and Quality Control

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Laboratories all around the world stand or fall by their reputation for accuracy and quality control. Pivotal to this performance is the quality, purity and composition of the spectrum of gases harnessed every day to accomplish laboratory tasks.

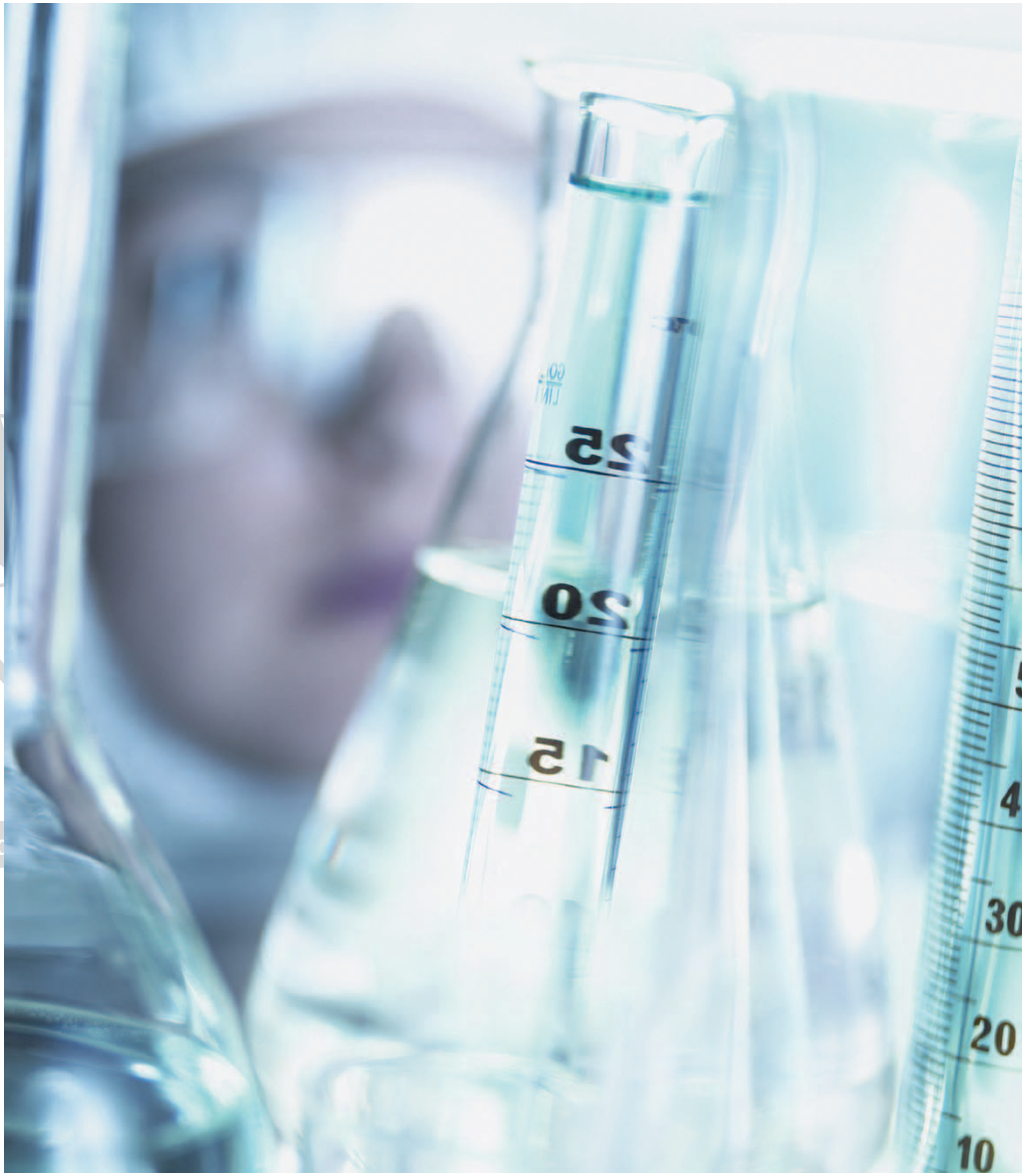
Rapid advancements in production processes across all industry sectors, as well as healthcare, have obliged laboratories to keep up with these changes, while remaining flexible and making allowances for future requirements.

Against this background, a variety of role-specific specialized laboratory types have emerged, each addressing specific industry needs.

Commercial Contract Laboratories

Independent commercial laboratories, for instance, serve companies who don't have these capabilities in-house or who require independent external analysis to support and confirm internal findings. Services might include forensics, environmental, food chemical or medical sample analysis and automotive engine emission testing. The focus in these laboratories is on productivity and repeatability of work standards. These laboratories generally comprise multiple workstations harnessing a broad range of analytical equipment in flexible configurations and are staffed by several lab technicians. In this environment, time is money and the broad range of methods used on a daily basis requires a diversity of speciality gases.

Instrument grade pure gases such as argon, synthetic air, helium, hydrogen or nitrogen are used as carrier and detector fuel gas, and to zero or purge analytical equipment such as GC–FID and HPLC. High purity gases are also used, for example, in inductively coupled



plasma (ICP) analysis and atomic absorption spectroscopy (AAS) measurements. Speciality gas supply equipment in a fixed installation for repeatable use is used in many areas to control gas cylinder pressures and to deliver gases to the point of use, while ensuring purity is not compromised. For the sake of convenience and safety, laboratory gas generators for hydrogen, nitrogen and purified air have become ever more popular in this type of laboratory. Alternatively, a selection of large cylinders is stored outside the laboratory in a central gas compound and the gases piped through to the point of use.

Environmental measurements for atmospheric air, water and ground pollution use a number of individual calibration standards to measure nitric oxides, sulphur compounds, VOC and hydrocarbon emissions. The requirement here is for low level reactive calibration gas mixtures with flat line stability, as well as other environmental mixtures produced to meet the requirements of regulatory agencies around the world. Within all areas of automotive emissions or environmental monitoring, many local governments require that the instrument and sensor calibration gases used be certified to ISO 17025. This is to ensure data is traceable to a national standard and that overall uncertainties for pollution data are within specified limits.

A wide range of speciality gas mixtures is applied to calibrate the analytical equipment and to ensure its correct operation. Normally, these mixtures are supplied in high-pressure or disposable gas cylinders. Depending on the consumption and the required mobility, the size of the cylinders varies from 0.2 to 50 L.

R&D Laboratories

Flexibility is particularly important for R&D labs that operate on a project basis, either in-house or via an outsource agreement. Their projects can be quite diverse, often requiring the lab to "tool up" for each new project, and it is seldom possible to predict the nature and requirements of the next project coming through. In the past, an R&D programme might have been set up for five years but the accelerated pace of industrial progress has meant that today, with faster turnaround times and more information readily available to researchers, the focus of an R&D lab must now be able to shift far more quickly.

Speciality gases and speciality equipment are required in many areas of a laboratory for successful R&D, where sophisticated equipment such as GC–MS and LC–MS systems are commonly used. In addition to the instrumentation gases required in the contract laboratory environment, many speciality gases are used as raw materials for bench or pilot scale chemical synthesis research. Speciality gas supply equipment used in these laboratories is often of a flexible configuration, for example, multiple cylinder regulators to enable rapid changes in application between one research project and another.

The gas mixtures used to calibrate analytical equipment are generally supplied in high-pressure or disposable gas cylinders. Depending on the consumption and the required mobility, the size of the cylinders varies up to 50 L. However, given the short-term nature of many R&D projects, small cylinders in the size range 0.2–10 L are often used and cylinders are often stored inside the laboratory close to the research station.

Both independent contract and R&D laboratories require a very high degree of accuracy to be able to have certainty in their results, as well as traceability to ISO and other international standards.

Distributed Laboratories

Distributed process control laboratories, such as those found in petrochemical production complexes, are unmanned fixed installations primed to collect and monitor samples and feed information to the central quality control or production laboratory within the complex. Their role is dedicated and inflexible, with repeatability being the primary requirement. Individual process instruments or CEM systems installed within a production environment area can also be regarded as "laboratories" at the extreme end of the scale. In these cases, the sample is not taken to the instrument — instead, the instrument operates in the sample's environment.

In these distributed laboratories the speciality equipment is designed to serve the important function of ensuring continuity of gas supply in these un-manned remote environments. This is often achieved using two gas cylinders connected to a gas supply manifold with one of the cylinders being in use and the other in reserve as back-up. The manifold is designed to automatically switch to the reserve cylinder when the in-use cylinder contents are depleted. Sophisticated systems will often trigger an alarm to the instrument engineering team, central lab or process control room to signal a change of cylinder.

Similar examples are environmental ambient air quality monitoring stations, which are located in numerous locations in many countries around the world, often at roadsides or on the roofs of public buildings, such as universities or council offices, and measure atmospheric pollutants such as NO_x, SO_2, CO_2, CO and other hydrocarbons.

In addition, pharmaceutical manufacturers have developed a process analytical technology (PAT) to facilitate production control, resulting in not only reduced production cycle times but also preventing rejects, scrap and re-processing. The recent PAT initiative of the US Food and Drug Administration (FDA) supports "on-", "in-" and "at-line" measurements and controls. Through the knowledge and understanding of the manufacturing process that PAT delivers, critical control points are identified with the goal of ensuring final product quality.

Calibration Gas Mixtures

When it comes to calibration gas mixtures, internationally there is a clear hierarchy associated with the quality of these products. Verification begins with the issuing of a commercial certificate of analysis from the supplier. Internationally, the next level in this hierarchy of quality is DIN EN ISO/IEC 17025, or "general requirements for the competence of testing and calibration laboratories", which verifies that the gas supplier's production processes have been independently checked and approved. The next level is ISO Guide 34, or "general requirements for the competence of reference material producers", where the procedures used to manufacture calibration gases are even more stringently evaluated.

Many customers request calibration mixtures certified by, or traceable to, national measurement institutes such as the Van Swinden Laboratory (VSL) in the Netherlands and the National Physical Laboratory (NPL) in the UK, because of their broad scope of accreditation. These essential partnerships for analysing and validating quality are driven by local market demand. For example, US environmental regulations require accurate, gas standards to calibrate instruments used with measurements directly traceable to the National Institute of Standards and Technology (NIST).

Accreditation also takes place on the laboratory side in a hierarchical manner. Laboratories can be accredited to ISO 9001 for a general quality management system or with higher accreditations as a measurement or a test laboratory. The additional accreditation and certification by regulatory bodies is, in principal, a must for a commercial contract laboratory in the competitive market of today.

Safety

Safety is high on the agenda in a laboratory environment, where different gases are being used in parallel and many people are present and moving through the premises at all times. Many of the speciality gases are hazardous in terms of being toxic, carcinogenic, flammable or stored at high pressure and must be handled according to specific safety guidelines.

Certain gases are supplied in their liquid form, such as argon used for ICP instruments or helium used in Nuclear Magnetic Resonance (NMR) equipment. In this format, the gases are extremely cold and there is potential for cryogenic burns if incorrectly handled.

Safety legislation is rapidly tightening around product registration, classification and labelling, packaging and transportation. This has implications for gas users in the realms of storage, product information, handling and disposal. Preventive maintenance of gas equipment and training laboratory personnel about the properties and potential risks of different gases also promotes increased levels of safety.

The United Nations' Globally Harmonized System of Classification and Labelling of Chemicals (GHS) and the CLP regulation (for "Classification, Labelling and Packaging") came into effect late last year in the European Union and are expected to have a significant impact on the use of gases used in laboratory settings, specifically the pure gases for which the new legislation currently applies.

High Levels of Purity

Regardless of the type of laboratory using gas products, it is critical for laboratory personnel to be confident that the gas being supplied to their facilities is pure. Over the past decade, gas production technology and gas equipment have advanced in quantum leaps to meet the growing and evolving demands of laboratories the world over.

Pure gases today come in various purities from "industrial" or "technical" grades to several high purity "speciality gases" grades. Within the pure speciality grades, the purity supplied from the cylinder can vary from 4.6 grade 99.996% pure to 7.0 grade 99.99999% pure. Use of 5.0 and 6.0 grade purity gases has become the norm in central continental Europe. Higher purity means fewer and lower levels of the impurities that cause problems with instrumentation and analytical measurement, so instruments keep running at optimum levels.

The requirement for high purity gases depends on what is being measured in the laboratory. For example, as a result of the success of stringent environmental legislation that has been applied in Europe, pollutants in water and air today need to be tested at extremely low levels. Because analysts are now looking for smaller needles in bigger haystacks, the purity of the gases that they use is required to be increasingly purer.

Quality is therefore a critical requirement in the supply of pure gas. Pure gas cylinders are provided on the basis of supplier quality assurance. Increasingly, quality conscious customers and stringent industrial quality systems are demanding individual certification of analysis for each cylinder supplied.

The quality of the gas can be no better than the quality of the gas distribution system and the operating techniques, such as purging, that are in place in the laboratory.

Some laboratories also choose to use various gas purifiers between the cylinder and their instruments to boost purity. These can enhance and act as a "backstop" or guarantee to pure gas supply, but purifiers can not convert low purity gases to high purity gases for long periods of time without costly replacement of the purifier element.

While high purity speciality gases are an integral part of today's laboratory, there are situations when the use of a cylinder to supply these gases may not be practical due to transportation, safety or other concerns. High purity laboratory gas generators for *in-situ* production of hydrogen, nitrogen and zero air can be an alternative solution in these instances.

Availability of Resources

Several process-critical gases are derived from finite resources. Helium, as a carrier gas for chromatography, is a prime example as security of supply has long been an issue. Worldwide demand for helium is increasing by about 5% per year.

"Global demand is also on the increase for helium-3, a non-radioactive isotope of helium, as well as for rare gases such as xenon, krypton and neon. Security of supply in regard to these products is critical, not only from the point of view of being able to use them in laboratories, but also in terms of containing the cost of research," says Linde's Steve Harrison, head of Speciality Gases and Speciality Equipment.

"To be able to supply these world-class products and the vast array of other gases, mixtures and equipment required by laboratories operating in the 21st century, The Linde Group has a diversity of source locations each with its own particular specialty," he goes on to say. The Linde Group prides its vision on delivering what customers need, whenever and however they need it.

Stephen Harrison is a British chartered engineer (MIChemE) with a career in industrial gases spanning 20 years, 10 of which have been focused in the area of speciality gases. He has worked in an international capacity for both Linde Gases and previously BOC and now leads Linde's global Specialty Gases and Speciality Equipment business from Munich, Germany. Stephen has a Masters degree in Chemical Engineering from Imperial College, London in the UK.

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