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WHITE PAPER / **DESIGN-BUILD SOLUTIONS**

CLOSING THE LOOP: INCORPORATING A DESIGN-BUILD APPROACH TO ADDRESS HELIUM SUPPLY CHALLENGES

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Helium has rapidly transformed from a commodity to a precious resource. Helium liquefaction recovery systems implemented by a trusted and proven partner can recover up to 95% of used helium and place it back into bulk liquid helium tanks.

Helium plays a critical role in a variety of industries from medicine and semiconductor manufacturing to party balloons and space exploration. Without it, companies and research organizations cannot accomplish their missions or meet production milestones. However, helium is rapidly becoming a scarcer commodity. It is currently in short supply, increasing in cost and becoming more difficult to obtain.

Helium recovery and liquefaction systems that use cryogenic technologies can help address this shortage by capturing used helium and preparing it for reuse. But these highly precise systems are challenging to design and build. Many of the physicists, doctors and engineers who have an urgent need for helium lack the time, knowledge or experience required to design these systems, procure the custom equipment and coordinate installation, oftentimes in occupied facilities.

The design-build approach to project delivery can streamline implementation of helium recovery systems. In the design-build approach, an experienced engineer-procure-construct (EPC) team designs an effective helium recovery solution, anticipates and mitigates problems related to its construction and installation, and implements best practices to save you time and money in the long run.

HELIUM IS IN SHORT SUPPLY

Sourcing helium is a complex process. It can only be stripped out of natural resources like natural gas and oil, and harnessing those natural deposits is challenging. Accordingly, helium is in short supply.

Administered by the U.S. Department of the Interior Bureau of Land Management, the Federal Helium Program is responsible for the conservation and sale of all helium owned by the U.S. government. Located near Amarillo, Texas, the program's storage reservoir and associated facilities supply more than 40% of domestic demand for helium.

According to Gasworld, recent price increases indicate continuing strong demand for helium. At its FY 2019 Crude Helium Auction, the average price per million standard cubic foot had increased 135% over the average price from the FY 2018 auction. Nonetheless, the Federal Helium Program is set to close at the end of September 2022, further decreasing the available domestic supply.

With current supplies already low and future capacity uncertain, finding alternative solutions is becoming increasingly urgent for manufacturing and research organizations alike.

LOOKING TO INNOVATIVE SOLUTIONS

As technology advances, industries are using more helium and depleting it more rapidly. Today, helium is used to cool the superconducting magnets used in magnetic resonance imaging machines and particle accelerators. It is required for the manufacturing of semiconductors and fiber-optic cable essential for digital devices and the internet. Helium is also used in numerous applications by the military, the Department of Defense and NASA.

To meet this growing demand, we have to change the way we think about helium. Instead of focusing on capturing more of this limited resource, we need to explore ways to use our existing supplies more efficiently. Helium recovery and liquefaction systems offer one solution. These systems cryogenically recover raw helium from natural gas, purify the raw helium and liquefy the resulting high-purity helium so it can be reused. Helium liquefaction can also be used to recover aspirated, spent and used helium to be placed back into a liquid tank at up to a 95% recovery rate.

These innovative technologies and solutions are being implemented and tested to see if they are viable methods to meet helium demand. In addition to cryogenic distillation, a membrane gas separation system can also be used as an alternative method to produce helium according to a study completed by *Computers & Chemical Engineering*. Both helium separation technologies are being tested in an energy-integrated scheme to evaluate and compare various applications.

Additionally, a 2020 study from *Chemical and Petroleum Engineering* discussed a non-cryogenic technology developed to extract from natural gas in a membrane installation operating in an unsteady mode. Microcapsules, or cenospheres, make up the separating membrane within the process providing a microscopic high diffusion of helium unattainable in stationary operations.

While helium recovery and liquefaction is a promising solution for many industries, implementing these systems presents many challenges:

- **Advanced startup and commissioning:** Installation is a highly technical process with many components that have to work together within precise tolerances. It requires enhanced commissioning, including checks and balances and failure scenarios to provide repeatable performance of equipment.
- **Complex installation:** Facilities must meet strict permitting requirements, including international building and fire codes and emergency preparedness planning. Installation requires coordination between equipment suppliers and utilities.
- **Complex technical design:** Cryogenic systems require precise specification, engineering and installation.
- **Long lead and procurement times:** Custom equipment must be built to precise specifications using high-grade stainless steel. Cryogenic welding is a specialty that not all fabrication shops can offer. Procuring some items may require a year or more lead time.
- **Rapidly changing technology:** Helium recovery and liquefaction systems are used primarily by highly scientific facilities that are always evolving to keep up with changing technologies. It's important to design and build solutions that are modular and adaptable, so they can be adjusted to fit how the client uses the space in the future.
- **Sophisticated support from utilities:** Large, complex equipment must operate within tight tolerances. High-quality utilities are required to achieve the correct operating conditions, for example, by providing high-voltage power and cooling systems that meet precise specifications to re-create the reclamation process. In some cases, it may be more cost-effective to cool the compressor with liquid nitrogen than to source electric power for cooling water. Analysis can determine the economic feasibility of electric power versus liquid nitrogen pre-cooling. Liquid nitrogen systems also require sophisticated design and construction considerations.

STREAMLINING PROCESSES WITH DESIGN-BUILD

The design-build project delivery approach can help simplify many project challenges. In this approach, design and construction are integrated. This creates a single point of responsibility and can help shorten schedules, reduce cost and produce higher-quality results more efficiently than traditional methods. According to research by the Design-Build Institute of America, having a single point of responsibility also reduces change orders and disputes and speeds construction and delivery. Because it facilitates collaboration among stakeholders early in the project, design-build is also highly effective at turning the owner's vision into reality.

Design-build spans the entire project delivery cycle, from planning to commissioning. A single EPC team can deliver design, procurement and construction services, including providing all interfaces between engineering, vendors and construction teams. This allows the EPC team to anticipate and remove roadblocks — such as permitting delays, regulatory hurdles and long procurement lead times — and identify potential project efficiencies.

Integrating the builder and designer early in the project allows the owner to leverage the experience of the entire team. This provides insight into the cost and schedule impacts of each design decision. The design-build approach also offers cost certainty by providing a transparent fixed price or a guaranteed maximum price, typically at the 30% -60% design stage. Together, these factors allow the owner to make necessary adjustments for optimum value, as well as budget and schedule requirements.

Additionally, integration of owner, designer and builder supports an early and competitive bidding process that allows the owner to select subcontractors, equipment suppliers and materials based on both cost and non-cost factors. This opportunity creates a value-based decision-making process that balances capital, risk and life cycle cost.

CONCLUSION

As helium shortages continue, the ability to reuse helium will provide organizations with greater flexibility in meeting their product and research milestones. Helium recovery and liquefaction systems present one promising solution for organizations that require reliable access to helium in order to operate critical equipment.

Though these cryogenic systems are challenging to design and build, utilizing a design-build project delivery method makes it possible to implement them efficiently and cost-effectively. Working with an EPC team that brings experience to the table further streamlines the process.

BIOGRAPHY

SHANE PUCKETT, PE, is a project manager and senior mechanical engineer at Burns & McDonnell where he helps clients develop high-tech manufacturing, research, mission-critical and pharmaceutical facilities. With nearly 25 years of experience, Shane has developed specialties in many areas, including cryogenics, distributed energy systems, HVAC, manufacturing, and EPC project delivery and design-build construction delivery methods.

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