Nitrogen Separation Technologies: Best Served Hot or Cold?

Today's market of sustainable high gas prices and dwindling reserves has caused producers to consider non-traditional sources of revenue generation. Once considered trash gas or a waste stream, high nitrogen reserves are now being reexamined as economically viable. In the past, smaller gas wells that tested high in nitrogen were simply shut in because the cost of producing such gas was not feasible. Today, however, advancements in technology, in both cryogenic separation and pressure swing adsorption and absorption have made nitrogen rejection a profitable reality, even for smaller gas streams.

In order to effectively evaluate the most applicable nitrogen technology available for a specific high nitrogen gas scenario, several factors should be considered. On the market today there are essentially three types of processing appropriate for nitrogen rejection; cryogenic processing (conventional cryogenic systems), the single column Nitech™ process, and non-cryogenic processing including pressure swing absorption, membrane systems, and lean oil adsorption. The differences in the competing technologies are substantial. In addition to upfront capital costs, the producer should also consider the following factors when selecting a valid nitrogen rejection technology for their gas processing demands.

Flowrate

One of the first elements that should be considered when selecting a potential processing technology for high nitrogen gas streams is the sustainable flowrate of the inlet gas. While more efficient than other technologies, cryogenic processing has long been seen as capital intensive and therefore unrealistic for gas streams of less than 20 MMSCFD. With the advent of the Nitech™ process, the capital cost has been significantly reduced thus making cryogenic processing for smaller flowrates (> 3MMSCFD) economically feasible. For inlet gas flowrates of 5 MMSCFD or less, non-cryogenic separation technologies could be considered.

Nitrogen Content

For many reasons, the initial inlet nitrogen content of a project may fluctuate. It is extremely rare to have a facility designed for the conditions that are actually realized at project startup. Despite the best efforts of the producer, inlet gas composition, inlet gas pressure and especially inlet gas flowrate are all subject to extensive fluctuation from initial design conditions. Another cause of nitrogen content fluctuation is nitrogen flooding. In a nitrogen flooding project, the nitrogen content of the gas produced from the structure will increase over time. During the early stages of a nitrogen flood, nitrogen content may not exceed pipeline specifications (typically <4% inerts) however over the duration of the flood, nitrogen levels may increase to greater than 80 mol%. Another scenario that may alter the inlet gas composition from original design conditions is the addition of new gas wells over the life of the project. As different gas wells are drilled and brought on-line, they will intermingle with the existing inlet gas and could create a substantial change in inlet nitrogen content.

The producer should consider how these nitrogen fluctuations will be handled by the processing plant. Conventional cryogenic plants typically cannot handle inlet nitrogen swings to the facility without modifications to equipment, operation of the facility and significant downtime. The cryogenic Nitech™ technology is designed to be flexible with regard to inlet nitrogen content and can handle nitrogen swings from 5-70 mol% with only minor operational set-point changes as can non-cryogenic technologies. Non-cryogenic technologies have been effective for projects with inlet nitrogen fluctuations from 5-40 mol%.

Efficiency

Cryogenic processing has long been seen as the most efficient method for removing nitrogen from contaminated gas streams. Cryogenic facilities typically recover in excess of 99% of the inlet hydrocarbons with little to no downtime. The Nitech™ process also realizes efficiency rates in excess of 99%. Non-cryogenic separation cannot consistently achieve the efficiency of a cryogenic unit and will typically achieve a separation efficiency of less than 90%, depending on inlet nitrogen content.

Compression Requirements

Simply put, horsepower is money. Due to the nature of cryogenic processing where pressure drop is used to generate cooling and pressure swing adsorption where separation across a molecular sieve causes a drop in the inlet pressure of the gas, sales compression to pipeline requirements of roughly 800-900 psig will most likely be required no matter which technology is selected. However, the producer must also consider horsepower requirements from additional compression that may be needed to augment the selected nitrogen rejection technology in order to improve efficiency of the process. Additional horsepower that may be required could include, recycle horsepower, refrigeration horsepower, and pump horsepower (circulation pumps, cryogenic pumps, etc.) Inlet compression requirements should also be considered in the economic evaluation. All horsepower requirements should be taken into consideration when evaluating the competing technologies. Additionally producers should be aware that compression is typically the leading source of downtime and adds to the overall complexity of the facility design when considering NRU technologies.

NGL Recovery

Should heavy-end hydrocarbons be present in the gas stream, the producer should consider whether or not the nitrogen rejection processing technology is capable of NGL recovery as part of the NRU process. While limitations on the hydrocarbon dewpoint of the downstream pipeline may require that the NGLs be extracted, the value of the separated NGLs to the producer is the driving force behind efficient NGL separation. Nitech™ and conventional cryogenic processing allows for the extraction of NGLs as part of the NRU process without requiring additional processing equipment, and in most cases can provide high ethane recovery. Non-cryogenic technologies will typically require the additional processing equipment to handle NGL extraction, and in order to achieve high ethane recovery would require the use of an expander plant.

Other Contaminants

In addition to nitrogen, other contaminants may be present in the gas creating challenges for processing. Acid gas including carbon dioxide and hydrogen sulfide must be reduced to low levels to meet pipe line specifications. Nitech™ and the conventional cryogenic process generally require carbon dioxide treating below pipeline specifications for satisfactory operation. For the Nitech™ process, the carbon dioxide removal can typically be handled with conventional amine treating; however, conventional amine treating may be inadequate for carbon dioxide removal for a conventional cryogenic system. Non-cryogenic units, which use adsorbent pore size to separate contaminants, are better equipped to handle higher levels of carbon dioxide without the addition of additional removal equipment.

Operating Expenses

The ongoing day-to-day expenses of operating an NRU facility must be factored into any economic decision. Simplicity of the processing technology will minimize the potential for operational headaches thereby reducing operating expenses and plant downtime. Cryogenic rotating equipment used in conventional cryogenic facilities present distinct challenges to operators potentially causing both plant downtime and higher maintenance cost. Nitech™ technology does not utilize any cryogenic rotating equipment, and was specifically designed without any cryogenic rotating equipment.

As a general rule, the shear number of components present in an operating facility, primarily compression and pump horsepower, could affect operating expenses in the ongoing challenge to keep the system operating smoothly. This again emphasizes the importance of simplicity of design in the selection of a processing technology. The producer should also consider whether or not the plant will be capable of unmanned operation as increasing labor costs could cause a significant increase in operating expenses.

With rising power costs, the producer should factor in the power demands for the facility. As previously mentioned, compression is a major economic factor in the selection of a processing technology. The producer should also consider additional power demands including those for necessary pumps and heaters.

Environmental Concerns

More stringent permitting requirements are forcing gas producers to take a hard look at VOC emissions. Inherent with design of Nitech™ and conventional cryogenic processing technology is the ability to recover near 100% of the non-methane hydrocarbons as either NGLs or saleable on-spec natural gas. Lost hydrocarbons from these processes are only a small amount of methane, allowing the rejected nitrogen stream to be vented directly to the atmosphere. However the non-cryogenic technologies cannot provide a vent stream that does not contain VOCs. There would typically be an off-gas stream from these processes containing the rejected nitrogen and the lost hydrocarbons (VOCs). This stream must then be incinerated or burned as fuel. This must be considered not only for the environmental permitting aspect, but also for the facility economics. The lost hydrocarbons account for a significant amount of lost revenue. It is true that these can be used to offset the fuel gas requirements of the facility, but the total horsepower installed must be considered when looking at this solution. If a large amount of horsepower is required for the process, it is still lost revenue. The requirement to burn these lost hydrocarbons also removes the option to utilize electric motor driven compression, thus removing the option to dramatically reduce emissions and affect project economics where low cost electric power is available.

Other Revenue Generating Potential

Should the producer be fortunate enough to have gas containing helium, Nitech™ and conventional cryogenic technology will allow for the extraction of helium as part of the NRU with the addition of minimal equipment. The helium can be trucked to market or sold to an available pipeline. Helium separation is not an option for non-cryogenic separating technologies without the addition of another process.

Liquified natural gas (LNG) is gaining momentum as a potential method to increase the supply of clean and affordable natural gas to the United States. As the market for LNG increases and additional LNG terminals are constructed, LNG will allow the United States to diversify its natural gas supply. Should a producer decide to generate LNG from his incoming gas supply, Nitech™ and conventional cryogenic nitrogen separation technologies will be able to liquefy the product stream as part of the same NRU process with minimal additional equipment and allow the product to be trucked to market. A considerable amount of additional and separate processing equipment would be required for non-cryogenic technologies to produce an LNG product.

Conclusions

Economists believe that the market will be strong for natural gas for the foreseeable future thus increasing the demand for creative processing technologies for atypical reserves. With respect to high-nitrogen reserves, several competing technologies are available to producers. It is imperative that the producer asks the right questions and is able to select the processing technology that will maximize revenue while minimizing operating expenses.

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Author:
Greg Hall
Vice President – Sales/Planning
2500 North Big Spring, Suite 230
Midland, Texas 79705
432-685-6095
432-685-7021 (fax)