Wanted: efficient gas treatment system to fit tight FPSO footprint

FPSO operational viability depends on processing systems that rate the high-priced vessel real estate they occupy.

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In the area of gas processing, it would be hard to argue that selecting topsides treating systems that stay within capex and opex budgets is not challenging. It is currently estimated that FPSO real estate is going for $10,000 to $15,000 per 0.09 sq m (1 sq ft). The ever-increasing demand for higher production rates forces a strict adherence to designs that deliver maximum performance for the smallest footprint and at minimum weight. Doing that means FPSO equipment footprints must be occupied by application-specific technologies that operate at the apex of safety and efficiency.

To identify the key cost-inducing variables for a topsides treatment design, most planners start with a basic economic axiom: The cost of treating a gas stream to obtain the required levels of purity must be low enough and the revenue realized from its subsequent sale must be high enough to justify the overall processing investment.

Together with the type of gas that is to be treated, this economic principle usually leads planners to select processing technologies that have the following operating characteristics:
• Proven reliability;
• Maximum production uptime and volume;
• Flexibility to tolerate varying gas feed conditions; and
• Operational simplicity.

Traditional system
Meeting natural gas pipeline transmission specifications requires processing operations to treat or condition produced gas that contains acid gases such as hydrogen sulfide (H₂S) and CO₂. These acid gases are removed because they lower the heating value of natural gas and accelerate the corrosion of pipelines and transmission control equipment. Typically, these are termed “sour” gases, and the amount of the impurities they contain can vary across the globe. Gas reservoirs can contain as little as less than 1% and as much as 90% CO₂, and amounts of the toxic and often deadly pollutant H₂S can range from a few parts per million (ppm) or zero to a number of percentage points.

A complete gas-processing train has a number of unit operations, all of which must work in concert to achieve operational efficiency and safety. Regarding the actual sour gas separation process, the most prevalent technology being used today is amine absorption. In this process, produced gas containing acid gases is conditioned using an alkaloamine solvent or similarly formulated amines.

The amine solvent is fed top-down into a contactor tower, where it washes past the gas stream flowing in the opposite direction, absorbing the H₂S or CO₂. With

While amine absorption strips out CO₂ very efficiently, the tall towers required increase the processing system’s size and weight. (Source: Cameron)
the acid gases removed, the conditioned gas, or “sweet” gas, exits through the top of the contactor tower. The used amine liquid exits the bottom of the tower and is sent to a stripper column, where it is heated to remove the absorbed H₂S or CO₂, which enables the amine to be regenerated and recycled.

**Alternative system**

An alternative to the amine process is the membrane treating system, which treats produced gas through the use of polymer-based filtering material to separate CO₂ and H₂S from gas streams. To construct a membrane module, manufacturers use large quantities of hollow fiber tubes that are about 100 microns in diameter, or the size of the average human hair. Hollow fiber membrane elements provide a high amount of fiber surface area per 0.09 sq m of space required and allow the feed stream to separate easily into two flows.

The fiber tubes are systematically assembled into a single, compact element containing a central perforated steel core tube. The membrane element is then housed in an enclosed steel vessel to control the natural gas surrounding the membrane element.

As the hydrocarbon-inlet produced-gas stream enters the module, it passes around the membrane fibers. The hollow fiber membranes allow the smaller CO₂ and H₂S molecules to pass through (or permeate) the fiber walls much faster than the more complex natural gas components, which pass around the fibers and into the center core.

A low-pressure stream of permeate (rich in CO₂ and H₂S) exits the element through the horizontal tubes near both ends of the module body. The high-pressure natural gas stream (the residual, with the bulk CO₂ and H₂S removed), exits through the steel core tube at the bottom of the module.

When compared with amine systems, fiber membrane systems are more compact and largely self-contained. The membrane process works on the principle of diffusion and solubility-based separation and has no moving parts or chemical requirements. Membrane systems also eliminate the need for liquid recirculation, thereby reducing maintenance. Beyond eliminating the weight of liquid chemicals and the need to maintain liquid recirculation equipment, membrane systems don’t require the logistics associated with the transportation and storage of liquid amine chemicals.
“We offer both gas-processing systems,” said Rick Peters, director of membrane operations with Cameron’s custom process systems. “Our CYNARA membranes are capable of meeting low CO₂ pipeline specifications, even when gas streams contain up to 90% CO₂. And they can provide bulk separation of CO₂ for gas streams with varying production rates and varying inlet CO₂ content. Cameron’s CYNARA PN-1 CO₂ separation system combines two different types of hollow fibers within a single membrane element to provide a specific process duty that will reduce the overall size and weight of the membrane system.”

However, membrane systems are not always the best answer. For a gas stream containing 600 ppm to 700 ppm H₂S that needs to be reduced to 4 ppm with a little amount of inlet CO₂, the amine system is a better choice. “For extremely low CO₂ specifications, like LNG pretreatment, it would be economically more viable to use a hybrid system, employing membranes for bulk removal followed by an amine system for the polishing step,” Peters said.

**Design considerations**

When considering treatment system designs, planners also should note some additional operating characteristics: Membrane units require gas pretreatment, mainly in the form of gas dehydration. Amine treatment is an aqueous process that saturates the product gas stream with water. So the amine process will need to be upstream of the gas dehydration step or else the product gas will require a secondary dehydration step prior to being routed to the pipeline. Amine units also are prone to create foam in the presence of very heavy hydrocarbons.

“We discovered that there is a quantifiable difference between the two systems,” Peters said. “Amine absorption has multiple moving components and requires chemical solvent management. Modular membranes have eliminated those operating characteristics. This can be extremely important when you’re talking about a tight FPSO footprint because of the limits on expanding those facilities or modifying their treatment processes.”