Gas Reinjection at Caspian Sea Field
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The Kashagan oil field in the North Caspian Sea off the coast of Kazakhstan is reported as one of the largest fields discovered in the past 30 years, with recoverable reserves of up to 13 Bbbl and offers a tremendous opportunity for the petroleum industry. According to Luca Finardi, engineering manager for GE Energy's oil and gas business in Florence, "The successful and sustainable exploitation of this massive field, however, presents a wide range of environmental, geographical, and technical challenges."

A major concern of project developers is the preservation of the area's sensitive environmental balance. For example, this section of the Caspian Sea is home to a rare species of seal and is a breeding ground for the beluga sturgeon, a producer of high-quality caviar. Maintaining the ecological balance of the Caspian also has major implications for the people who live and work in the area.

According to Agip KCO, the remote location of the oil field and its often harsh weather conditions present obstacles, particularly for the crews who will work in the area during the installation and operation of an offshore, barge-mounted compression station. The oil field lies in waters ranging from 2 to 10 m deep, with strong currents and often turbulent waves. Temperatures can rise as high as 40° C (104° F) in summer and fall below -30° C (-22° F) in the winter. From November through April, the field can be covered by a coat of shifting ice, further complicating the development efforts.

"Adding to the difficulty of exploitation, the wells are located in deep and often difficult positions to reach, and pressures levels up to 800 bar (11,603 psi) entered in the recovery of the oil and associated gases," Finardi says. Also, the oil reservoirs contain a large quantity of associated gas whose composition includes the highest quantity ever found of hydrogen sulfide (H2S), an extremely toxic substance that cannot be dispersed into the atmosphere.

To recover crude oil from the field, associated sour gas will be re-injected into the reservoirs at very high pressure.

"Basically, the sour gas injection process has three main goals: to keep the oil well pressure at levels suitable for full exploitation, to avoid the flaring of sweetened gas and subsequent CO2 production, and to avoid massive sulphur production as a byproduct of the sweetening process," Finardi explains.

While gas re-injection is a well-established technique and has been used for more than three decades, the complexity of a sour gas re-injection at ultra-high pressure requires a new technological approach....a "new frontier" for gas injection, Finardi says. Playing a key role in this technology will be the centrifugal compressors that are the core of the compression plant.

Injection technology

“The compressor manufacturer with the most experience in the re-injection of sour gas at the pressures required by the Caspian Sea fields is GE Energy’s oil and gas business, based in Florence, Italy,” Finardi says. In the past six years, the company has developed technology for two previous ultra-high re-injection pressure projects in the Kazakhstan region in 1998 and 2001 for 550 and 620 bar (7,978 and 8,892 psi) re-injection pressure, respectively.

The development of the Kashagan fields has been committed to the North Caspian Sea production sharing agreement including Agip Caspian Sea BV (Eni Group), ExxonMobil Kazakhstan Inc., Shell Kazakhstan Development BV, Total E&P Kazakhstan, ConocoPhillips and Inpex North Caspian Sea Ltd. As part of the joint venture and acting as the operator, Agip KCO awarded the company a contract to supply two ultra-high pressure, sour gas re-injection lines for the Kashagan project.

The company mounted each line on the barge, which is sized for 5.4 MMcf/d of sour gas re-injection. Using its latest technology, Kashagan sour gas production at 18-20% volume H2S will be injected back into the reservoirs at a discharge pressure of 760 bar (11,023 psi), the highest discharge pressure ever developed for gas injection.

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According to Agip KCO, in the first phase of the field development there will be a total of six barges, located about 60 km offshore in the Caspian Sea. Two of the barges will hold the GE raw gas injection systems. Two will be used for flash gas plants that will compress the sour gas from the dehydration process to approximately 95 bar (1,378 psi) and supply it to RGI plants. The remaining two barges will contain the process units.

“Each of the re-injection barges will be 95 m long, 16 m wide, and more than 25 m high,” Finardi says. “Barge weight is estimated to be around 3,700 tons. The layout has been designed to optimize the weight distribution of the mechanical items and the structures, with the objective of minimizing any deflection of the barge in its elevated position.”

The re-injection plant is being designed to withstand the harsh ambient conditions with low-temperature carbon steel used for many purposes across the barge hulls, plant buildings and structures. A well-proven corrosion-resistant, chromium-molybdenum based alloy is being extensively used for compressor casings, pressure vessels, valves and process piping that, depending on the pressures, can reach a wall thickness of 65 mm (2.55 in.).

The three-casing, raw gas centrifugal compressors, 1,000 bar (14,504 psi) rated, are being specifically developed for this project, leveraging the company's most recent experiences in sour gas applications. The re-injection process will take place in three compression stages: the first from 95 bar (1,378 psi) up to 240 bar (3,481 psi), the second up to 500 bar (7,252 psi) and the last up to 760 bar (11,023 psi).

Limiting emissions

"As in the previous Kazakh projects, driving the compressor lines will be the GE Frame 5D heavy-duty gas turbines, 30-MW-class machines for high-pressure applications. In order to limit exhaust emissions, the gas turbines will be equipped with Dry Low NOx systems. Turbine maintenance will be done directly at the site," Finardi says.

Because of the nature of the fluid to be handled and the location of the project, safety is a primary concern. For GE Energy and the North Caspian Sea joint venture, protecting the workers and the equipment and running the plant to minimize any operational risks are integral parts of the design process.

Finardi continued to say that the entire compression plant is being designed under a "zero leakage philosophy" to meet a stringent set of criteria established to minimize any release of sour gas. Key stages of the process include an extensive application of an ISO "fugitive emission test" on all sour gas valves, a minimum use of flanged connections for piping, and full implementation of a high-integrity pressure protection system (HIPPS) to prevent pressure build-ups.