The world's first LPG FPSO

The Sanha LPG FPSO will be operating offshore Angola by 2005. It will be the world's first newbuild LPG FPSO. By Sean Pellegrino, project manager, and David Moore, manager, marine operations, ChevronTexaco Shipping Company

THE *SANHA LPG FPSO* (floating production, storage and offloading vessel) will be operating in Block "0" Cabinda Association in Angola for the partnership of Sonangol, ChevronTexaco, Total and Eni. This vessel, offshore Cabinda, is the key component of the Sanha condensate project, the objective of which is to reduce routine gas flaring, while increasing oil and LPG production.

FPSO projects are becoming more popular, particularly for marginal fields and in deep-water locations where other infrastructure may not exist. While FPSOs have been operating since the early 1980s, the complexity and size of the units has been increasing. Vessels are now purpose-built for each project, rather than being converted from existing trading tankers. And FPSOs are now being used in gas projects, rather than just for oil production.

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A merging of standards

FPSO projects and operations are complex because they require the merging of the standards, practices and cultures of two industries – marine and offshore. This merging of standards includes design, construction and operations. And the standards, practices and regulatory framework are evolving as technology and experience develop. This evolution includes the engineering perspective, staffing and other human-factor considerations.

From the offshore perspective, an FPSO is not a fixed production platform or simply a process plant on top of a tank farm. It is subject to the routine motion and inclinations that a floating vessel experiences, plus the stresses and flexing of the hull associated with storage and transfer of the product. In addition to these factors, there are significant equipment and operations related to cargo conditioning, export operations and the mooring of export vessels that are not common in production operations.

From the marine perspective, an FPSO is not a ship. There is a continuous feed of product that requires processing. Co-ordination with the production operations of the associated field prevents independent action for routine operations. This all happens while routine marine operations and exports are undertaken. The vessel must maintain continuous and reliable operations, without dry-dock or interruption to production, for up to 20 years in locations that are not always conducive to logistics of material and technicians. The size, weight and power requirements of the production facilities are normally significantly higher than in a trading vessel.

The 260-metre long *Sanha LPG FPSO* will have the ability to process more than 37,000 barrels a day of LPG into propane and butane products. It will receive the majority of the liquid LPG from the nearby Sanha condensate complex and a smaller amount of LPG from a nearby facility. The vessel can refrigerate and store 135,000 cubic metres (cm) of propane and butane products in six specialty LPG cargo tanks. It will be the world's largest in terms of LPG storage capacity and the first new-build LPG FPSO.

The *Sanha LPG FPSO* is moored by a 30 tonne, single-point turret system. The system is cantilevered from the bow of the vessel and anchored by nine chain legs, which are secured to 28 tonne, high-holding-power MAG anchors on the seabed. The MAG anchors are amongst the largest ever built.

The turret-mooring system comprises both a rotating and a fixed part, connected by a main slewing bearing. The bearing allows the turntable to weathervane freely around the anchoring system, so that the FPSO can always take up the position of least resistance to the prevailing weather.

The function of the turret is to transfer products coming from subsea pipelines to the FPSO topsides. The transfer from the fixed to the rotating part of the turret is achieved through a series of swivels. The turret receives products from subsea pipelines through a pipeline end manifold (Plem). The Plem is on the seabed, in about 60 metres of water, and is designed to act as an in-line transition unit to connect the pipelines to the FPSO through flexible, fluid risers. An umbilical is also connected to the Plem to control subsea shut-down valves.

The de-propaniser module provides a means of separating the LPG feed into propane and butane products. It was fabricated by JGC in Japan and consists of a number of equipment skids and materials supplied from vendors from all around the world. Included in this equipment is the 50 metre de-propaniser column, the largest column installed on a floating vessel. The completed components were lifted

The Sanha LPG FPSO

on-board the *Sanha LPG FPSO* at IHI Marine United's Kure yard and interconnected to form the de-propaniser module, with a total weight of around 3,000 tonnes.

The five electrically powered, oil-filled, screw-compressor refrigeration skids, built by HKSE in Norway, are some of the largest ever constructed for this purpose – each skid weighs around 75 tonnes with a power consumption of about 2 megawatts (MW). The refrigeration system cools the propane and butane products to permit the products to be stored as liquids in the near-atmospheric cargo tanks.

A separate butane-refrigeration system also provides cooling to the reliquefaction system, which takes vapour that is flashed from the cargo tanks or recovered from offloading operations and condenses it, returning the products to designated cargo tanks.

Cargo tanks

The *Sanha LPG FPSO* has six insulated self-standing prismatic IMO Type-B (SPB) tanks for storage of either propane or butane products. The six tanks provide a total storage capacity of 135,000 cm at a design temperature of –50°C. (The SPB tank is a proprietary IHI Marine United design.)

The vessel is due to arrive offshore Cabinda in December 2004. First LPG and subsequent turn over to operations is scheduled for early 2005

Machinery

Forward and aft machinery rooms have all the equipment necessary to supply utilities for the accommodation and topsides operations. FPSO utilities that are provided include around 30 auxiliary systems, such as control air, utility air, inert gas, nitrogen, cooling water, fire water, potable water, sewage treatment, hydraulic oil and fuel oil.

The forward machinery room extends 14 decks from the funnel, above the top of the accommodation, to 13 metres below the ocean surface. In this space alone, there are over 60 pumps, 1,200 valves, and 10,000 spool pieces of piping. A machinery-room control centre (MRCC) is provided for ease of operation when the FPSO is in service.

The key equipment installed in the forward machinery space includes three dual-fuel, 90 t/hour, 28-bar, Mitsubishi boilers. The boilers provide superheated steam for power generation, in three 9 MW Shinko steam turbines, and saturated steam for the topsides-process heating demand.

In the aft machinery room, a 4,000 horse power Rolls Royce Tunnel Thruster engine is installed for maintaining the FPSO heading relative to ocean swell. This increases uptime and throughput by minimising vessel rolling and the associated negative effect on production and export operations.

Offloading

The FPSO has offloading flexibility, particularly:

- The capability to export cargo to LPG tankers moored either in tandem at the stern of the unit or side-by-side, on both sides of the FPSO;
- The ability to accommodate all sizes of export tankers, from small, 2,000 cm pressurised coastal vessels to fully refrigerated Very Large Gas Carriers (VLGC) of 85,000 cm capacity. The tandem mooring is designed for future VLGCs of 125,000 cm capacity; and
- The capability of exporting side-by-side refrigerated propane and butane simultaneously, with vapour returns from the export tankers (starboard side only) back to the FPSO.

Accommodation

For safety, the accommodation is positioned on the forward area of the FPSO so it is up wind of the main gas-processing facilities in the unlikely event of a gas leak. The accommodation is built to accommodate 60 crew members. In addition to the standard eating areas, offices, recreation areas and bedrooms, there is a complete medical facility. The seven-story accommodation area will provide the FPSO personnel with a safe, comfortable and enjoyable living environment.

M&CS

The *Sanha LPG FPSO* monitoring and control system (M&CS) is the brain of the facility. The M&CS is based on a Yokogawa CS3000 platform. The M&CS processes and displays more than 11,000 data points collected throughout the FPSO. The safety shutdown system in the M&CS ensures the facility has the required cause and effects to provide a near fail-safe operation. An operator can monitor alarms and manually initiate shutdowns all from the M&CS system. Man-machine interface stations included in the M&CS are installed in the FPSO control centre and in the MRCC.

A selected amount of data are archived into a historian server and can be used to produce cargo-export reports. Additionally, the historian server is connected to the computer network, providing the possibility to view any FPSO point available within the M&CS.

Safety in design

Special attention was given to the design and construction to ensure the safety of future operators, the asset and the people working on construction activities. Numerous engineering-safety analyses were carried out to validate and ensure that the FPSO would operate safely. Some of the more important analyses include:

- A fire and explosion analysis, which simulates various fire and explosion scenarios and their potential consequences on the asset;
- A smoke- and gas-dispersion analysis, to confirm that, in the unlikely event of a gas leak or fire, any gas or smoke clouds would safely disperse into the atmosphere;
- An emergency-systems survivability analysis, which evaluated qualitatively the robustness of all safety systems;
- An emergency escape and rescue analysis that studied qualitatively means of egress and rescue; and
- Hazard and operability studies and hazard-identification studies were conducted during the design phase. All essential FPSO systems were extensively analysed.

A pro-active safety-behaviour process was adopted during the design phase, requiring the designer and the approving parties to detect and correct unsafe design features at the drawing-board level. Special attention was paid to avoid the most common of incidents, such as tripping hazards. In addition, planned safety workshops were held throughout the construction, with daily and weekly safety audits performed by the contractor and the company, individually and jointly. The project adopted a strict incident and near-miss reporting and countermeasure follow-up policy. The project team lived by its motto: "Safety first, always."

Current status:

In July 2004, the *Sanha LPG FPSO* was finalising pre-commissioning activities in the IHI Marine United's Kure, Japan, shipyard prior to going to gas trials. Sailway from Japan is scheduled for September 2004, with vessel arrival offshore Cabinda in December 2004. First LPG and subsequent turn over to operations is scheduled for early 2005. □