Annex C: Field Development Examples

C.I. Subsea tieback to shore: Ormen Lange, Norway.

Name of the project: Ormen Lange
Operator: Shell
Water Depth: 850 m / 2,805 ft
Region: Europe - North Sea
Country: Norway

Project Description

Discovered in 1997, Ormen Lange is Europe's third-largest gas field with estimated recoverable reserves of 14 Tcf (397 Bcm) of natural gas. Located on the Norwegian Continental Shelf, 75 miles (120 kilometers) northwest of Kristiansund, Norway, in the Norwegian Sea, Ormen Lange reaches 25 miles (40 kilometers) by up to 6 miles (10 kilometers). Water depths for the field range from 2,625 to 3,609 feet (800 to 1,100 meters), and hydrocarbons are located another 9,843 feet (3,000 meters) below the surface.

Partners in the field include Petoro with 36.48%, StatoilHydro with 28.91%, Shell with 17.04%, Dong with 10.34% and ExxonMobil with 7.23%. Like its development, Ormen Lange boasts a multiphase operatorship. StatoilHydro served as the field's operator during the first phase of development from 1999 through production start-up in 2007. Shell took over operatorship for the production phase of the field, including the second phase of development.

Overcoming Challenges

There were a number of challenges that had to be overcome to bring natural gas from Ormen Lange to market. First of all, the field is in environmentally unfriendly waters. Both temperatures and strong currents sought to stop field development in its tracks. Water temperatures on the seafloor stay below freezing, and especially strong currents in the area threaten field facilities. Additionally, a mountainously uneven sea floor made for difficult subsea development.

Despite these difficulties, designers devised a multiphase completely subsea field development plan, including the world's longest subsea pipeline. Submitted to Norwegian authorities on Dec. 4, 2003, the field development plan was approved on April 2, 2004.

Field Development: Phase I

At an estimated cost of US $8 billion (NOK 50 billion), the first phase of development included two 1,268-ton (1,150-tonne) subsea templates, as well as pipelines to shore and an onshore gas processing plant.

Each subsea template holds slots for eight wells, which are hooked up to the templates via a subsea manifold. FMC was awarded the US $160 million (NOK 1 billion) contract to engineer, procure, fabricate and test the subsea production system, which consisted of the two subsea templates with manifolds, eight xmas trees, control systems, an intervention system, tie-in tools, end terminations and Tee's for the pipelines. The contract also included options for additional xmas trees and control systems.

Measuring 144 feet (44 meters) long by 108 feet (33 meters) wide and 49 feet (15 meters) wide, the subsea templates were installed by Hreema's Thialf crane barge using sound signals produced by subsea acoustic *transmitters. Positioned 2.2 miles (3.6 kilometers) away from each other, the subsea templates are in waters measuring 2,789 feet (850 meters).*

Additionally, a 386-ton (350-tonne) pipeline connection box was installed 164 feet (50 meters) away from the templates. Gas, condensate and water produced from the templates are transported through two 75-mile (120-kilometer), 30-inch-diameter multiphase flowlines up the Eggkanten embankment to the gas plant Nyhamna onshore the western coast of Norway. Saipem was awarded the US $105 million (NOK 660 million) pipeline installation contract, which included tie-in operations.

After installation of the subsea equipment, development drilling for the first phase of development was performed by the West Navigator drillship. The largest deepwater wells in the world at the time, Smedvig completed the US $167 million (NOK 1.17 billion) drilling contract over a two-year period.

Innovative Solutions

To overcome icy water temperatures on the seafloor, Vetco Aibel was awarded the US $96 million (NOK 600 million) contract to engineer, procure and build a Monoethylen-Glycol (MEG) regeneration system, which included a tank farm. MEG is used as anti-freeze to prevent ice formations and plugs in the subsea production facility and pipelines.

To counteract the strong currents in the deepwater of the Norwegian Sea, Van Oord ACZ was contracted to install 3 million tons (2.8 million tonnes) of rock on the seabed to protect and support pipelines and umbilicals from Ormen Lange to Nyhamna for a consideration of US $112 million (NOK 700 million).

Production

Production from Ormen Lange commenced on October 1, 2007. With daily rates expected to increase over the first couple of years, production rates for the first phase of development is 2.5 Bcf/d (70 MMcm/d) of natural gas and 50,000 barrels of condensate a day. Peak production is predicted for 2010.

Natural gas is transported to market via the Gassco-operated Langeled pipeline, the world's longest subsea transport pipeline, traversing 746 miles (1,200 kilometers to connect Nyhamna in Norway to Easingtown in the UK.

Ensuring Long-Term Production: Phase II

The second phase of development on Ormen Lange includes the fabrication and installation of another two subsea templates. The first of them is under construction, and the fourth will be commissioned when necessary. In total, the four wellhead complexes on Ormen Lange will accommodate up to 24 wells.

Both the Leiv Eiriksson semisub and the West Navigator drillship are employed on Ormen Lange for the second phase of development drilling. West Navigator was used through the summer of 2008 for development wells and to complete and make ready new wells for production. Leiv Eiriksson is drilling the planned monitoring well and several production wells through October 2009.

Total costs for the second phase of development have not been released. Ormen Lange is expected to have a field life of 40 years.

Offshore Compression

Inevitably, as production decreases from Ormen Lange, so too will pressure. Once pressure can no longer drive produced gas to shore for processing, offshore compression will be required. There are two options for supplying offshore compression: a floating deepwater platform or a subsea compressor station.

While an offshore platform is more conventional, it is also more expensive than a subsea compressor.

Two subsea compression pilot programs are being designed for use on the field. Aker Solutions was tapped to engineer, procure and fabricate a full-size subsea compression station pilot, and Vetco Aibel was chosen to engineer, procure and construct a long step-out power supply pilot.

The subsea compressor will be located between the two original subsea templates in 2,789 feet (850 meters) of water. If chosen, the subsea compressor will be an industry first. At a cost of about US $ 401 million (NOK 2.5 billion), the subsea option is about half the cost of the offshore platform option.

Testing of the two subsea compression pilots is expected to commence in 2009, and the best system will be chosen by 2011 with installation slated for 2015. Much of the decision will be based on reservoir properties.[Subsea IQ, 2010]

C.II. Subsea tieback to existing platform: Canyon Express, Gulf of Mexico U.S.A.

Name of the project: Canyon Express
Operator: Williams
Water Depth: 2,346 m / 7,742 ft
Region: N. America - US GOM
Country: US

Project Description

An innovative development project for its time, the Canyon Express allowed three different operators to bring three marginal gas fields into production through a subsea gas gathering system. Located in deepwater Gulf of Mexico, the Canyon Express traverses a number of blocks transporting gas from the Aconcagua, Camden Hills and King's Peak in the Mississippi Canyon.

Although combined, the fields' boast a reserves reaching 900 Bcf (25 Bcm), none of them were commercially viable to be developed separately. Solving that problem, the Canyon Express project commingles gas from the three deepwater fields all located about 120 miles (193 kilometers) south of New Orleans, before transferring them to a third-party shallow-water production platform called the Canyon Station.

Although the fields used to be operated by three different companies, all three fields, as well as the Canyon Express subsea development are now operated by ATP Oil & Gas.

The Fields

Located on Mississippi Canyon Block 348 in waters measuring 7,200 feet (2,195 meters) deep, Camden Hills was discovered in August 1999. Drilled by the Ocean Clipper semisub, the discovery well reached a total depth of 15,080 feet (4,596 meters) and encountered more than 200 feet (61 meters) of natural gas.

Also discovered in 1999, the Aconcagua field is located on Mississippi Canyon Block 305 in approximately 7,000 feet (2,134 meters) of water. Drilled in March 2000, an appraisal well confirmed the discovery by intersecting more than 250 net feet (76 net meters) of gas.

Situated in waters ranging in depth from 6,200 to 6,400 feet (1,890 to 1,951 meters), the King's Peak gas field spans Mississippi Canyon Blocks 217 and 173, as well as Desoto Canyon Blocks 133 and 177.

Canyon Express

A subsea gas gathering system, Canyon Express was the longest and deepest subsea tie-back at the time of its development. The $600 million project encompasses two 12-inch-diameter, 55-mile-long (88-kilometer-long) flowlines that transfer gas from the fields to a shallow-water production platform 55 miles (88 kilometers) away.

Ten subsea development wells are scattered across the fields and daisy-chained together. Aconcagua has four wells, Camden Hills has two wells, and King's Peak has four wells. In order to monitor production at all times, each well is equipped with a wet gas flow meter. Additionally, each well is completed with two gravel-packed intervals and an intelligent well completion system, allowing the wells to be produced independently or in a commingled state.

Each of the wells delivers gas into one of the two flowlines that tie the wells back to the Canyon Station production platform. Canyon Express contains 32 individual pipeline segments, including all flowlines, supply lines, jumpers and umbilicals. Well tie-in sleds installed as a part of the flowlines eliminated the need to install multiple well manifolds and infield flowlines. Wells are connected to the tie-in sleds through an inverted U-shaped jumpers.

Measuring more than 62 miles (100 kilometers) long, the production control, electrohydraulic steel tube umbilical system includes electrical cables and fiber optics. At the time of development the umbilical was the deepest steal-tube umbilical ever.

In 2000, Saipem was chosen as the main subsea provider on the Canyon Express project. Designing a daisy-chain concept, subsea multi-phase flow meters and round-trip pigging, Intec Engineering performed the FEED and project management on the Canyon Express project. Aker Solutions (then Kvaerner) was subcontracted to manufacture the umbilicals, and Clough was tapped to install the umbilicals.

With a capacity of 500 MMcf/d (14 MMcm/d), Canyon Express was the world's deepest producing gas field at commissioning.

Canyon Station

Situated in 300 feet (91 meters) of water, the Canyon Station production platform is located in Mississippi Pass 261, approximately 55 miles (88kilometers) north of the Camden Hills field and 60 miles (97 miles) south of Mobile Bay, Alabama. Owned and operated by Williams, Canyon Station is a fixed-leg platform built to treat, process and handle natural gas and condensate from Aconcagua, Camden Hills and King's Peak.

A four-pile, four-leg platform, the topsides alone weigh in at 3,500 tons (3,127 tonnes), which includes compression and separation facilities, water treatment, and instrumentation and utilities. The jacket was installed in October 2001, and the topsides were installed in May 2002.

Production reaching the Canyon Station shallow-water production platform consists of mainly methane gas, as well as produced water and condensate. Williams personnel located on the platform performs all subsea well monitoring, flow control and chemical injection.

In February 2001, AMEC Paragon was tapped to provide project management, engineering, design/drafting, procurement and fabrication inspection for the platform.

Commencing operations in July 2002, Canyon Station's daily capacity is 500 MMcf/d (14 MMcm/d) and 1,500 bpd of condensate. From Canyon Station, production transported to shore via multiple export pipelines.

Production

In September 2002, Canyon Express/Canyon Station production commenced, first from a well on Anconcagua and another on King's Peak. Over the next two months, the rest of the wells were brought on stream, and the development eventually reached its production plateau of 500 MMcf/d (14 MMcm/d).

Future Development

Further development work is planned for Canyon Express in 2009. The project partner plans to re-develop King's Peak and Aconcagua in the second quarter of 2009. A contracted rig is scheduled to drill four to six wells in the area to net undeveloped reserves, which will be produced through the Canyon Express system.

Additionally, ATP has acquired a number of blocks in the near vicinity of Canyon Express, with expectations of tying any production found into the system.

C.III. Subsea tieback to semisubmersible: Thunder Horse, Gulf of Mexico U.S.A.

Thunder Horse Thunder
Operator: BP
Water Depth: 1,841 m / 6,075 ft
Region: N. America - US GOM
Country: US

Project Description

Situated in a water depth of 6,050 feet (1,844 meters), the Thunder Horse oil and gas field is located on Mississippi Canyon Blocks 776, 777 and 778, about 150 miles (241 kilometers) southeast of New Orleans, La. Considered to be the deepest and largest oil and gas field ever discovered in the Gulf of Mexico, Thunder Horse produces from two areas, north and south, which are tied-back to one of the largest moored semisubmersible platforms in the world, the Thunder Horse Production, Drilling and Quarters (PDQ) platform.

Originally called Crazy Horse, Thunder Horse is operated by BP, which holds 75% interest; ExxonMobil holds the remaining 25% interest in the field.

Exploration

Discovered in 1999 by the drillship Discoverer Enterprise, the Thunder Horse discovery well was drilled to a total depth of 25,770 feet (7,855 meters). The discovery found 520 feet (158 meters) of net pay in three intervals on the south side of the field. A year later, the appraisal well, Thunder Horse 2, was drilled and reached a total depth of 29,060 feet (8,857 meters). The appraisal well, located in 6,300 feet (1,920 meters) of water, 1.5 miles (2.41 kilometers) southeast of the discovery well, confirmed the previous findings.

In February 2001, additional drilling commenced on the north side of the field in order to determine the size of Thunder Horse. The exploration drilling encountered 581 feet (177 meters) of accumulated hydrocarbons in three intervals. The well was drilled in 5,640 feet (1,719 meters) of water by the drillship Discoverer 534 and reached a total depth of 26,046 feet (7,939 meters). Because a prolific amount of hydrocarbons were discovered, BP named this section of the field Thunder Horse North.

The Thunder Horse reservoir consists of upper Miocene turbidite sandstones and lies 14,000 to 19,000 feet (4,267 to 5,791 meters) below the seabed. With extreme pressures of 13,000 to 18,000 psi and temperatures ranging from 88 to 132ºC, the conditions of Thunder Horse presented challenges that weren't yet tackled in *the offshore world. However new capabilities, systems and equipment were created in order to develop the field under extreme conditions.*

Field Development

The challenges encountered on Thunder Horse made it necessary to develop the field in two stages. The Thunder Horse North and Thunder Horse South were developed simultaneously with initial development focusing on drilling and producing six wells. Over an eight-year span, Thunder Horse will have a total of 25 wells tied-back to the Thunder Horse platform.

Phase 1

The first phase of development focused on the southern portion of the field. Two production wells were drilled and tied-back to the platform. Shortly after, two additional wells were drilled, and production commenced from these two wells.

The second part of Part 1 focused on the northern portion of the field, so while production began on the southern portion of Thunder Horse, development drilling continued on the north side of the field. Located on Block 776 in a water depth of 5,640 feet (1,719 meters), an additional two production wells were drilled on Thunder Horse North, which are also tied-back to the platform. This portion of the field commenced production.

The initial six subsea wells, as well as the remaining 19 wells, are and will be connected to production manifolds, which are connected to the platform via riser flowlines. FMC Technologies fabricated the subsea trees, controls, manifolds and well connection systems in water depths of 5,700 to 6,300 feet (1,713 to 1,920 meters). In 2002, Subsea 7 received a $30 million contract for the installation of subsea structures, and controls including umbilicals, totaling more than 37 miles (60 kilometers) in length.

Heerema Marine Contractors received a contract for the installation of two steel catenary risers, a 20-inch-diameter riser and a 24-inch-diameter riser, in a water depth of 6,037 feet (1,840 meters). The 24-inch-diameter SCR is the deepest installation of its kind and a first for Heerema Marine Contractors.

Situated in a water depth of 6,037 feet (1,841 meters), the Thunder Horse semisubmersible platform is located on Mississippi Canyon Blocks 820 and 821. The 50,000-ton (45,359-tonne) Thunder Horse PDQ has the ability to process and export up to 280,000 bopd and 200 MMcf/d (6 MMcm/d). With a displacement of 143,300 tons (130,000 tonnes), and a deck load capacity of 44,092 tons (40,000 tonnes), the platform's topsides consist of three modules: production, generator and compression.

J. Ray McDermott built the process topsides modules; GVA Consultants of Sweden designed the 120,000-deadweight-ton (108,862-deadweight-tonne) hull; and Daewoo's Shipbuilding and Marine Engineering division built the hull and drilling rig for the platform. Kiewit Contractors was responsible for the deck and hull integration.

Production

The Thunder Horse field was initially scheduled to start producing in the second half in 2005, but hurricane damage and equipment problems interfered with startup plans. During that same year, Hurricane Dennis caused damage to Thunder Horse's production platform; and a leaky internal ballast valve went undetected, which caused the structure to list 20 to 30 degrees.

Despite this, production commenced from the first two Thunder Horse wells in June 2008. Another two wells commenced production on Dec. 18, 2008. The final two wells of the first phase of development started producing from Thunder Horse North on March 3, 2009. Since the sixth well came online, production has *increased to 260,000 bopd. Production rates will continue to increase once development drilling is completed on the remaining 19 wells, which should be finished in 2016.*

Thunder Horse oil and gas is transported to onshore pipelines via the Proteus and Endymion oil pipeline systems and the Okeanos gas pipeline system. Both systems are connected to the Mardi Gras Transportation System.

Phase 2

Development drilling of the remaining 19 wells will continue until all 25-production wells commence; the field is expected to operate for 25 years.

C.IV. Subsea tieback to FPSO: Pazflor, Angola, West Africa .

Pazflor Pazflor
Operator: Total
Water Depth: 762 m / 2,515 ft
Region: Africa - West
Country: Angola
Last Updated: Oct 21, 2009 (view update history)

Project Description

Angola's Block 17 has proven prolific for partners in the offshore license, with Girassol and Dalia already producing, Pazflor in development, and the CLOV project in consideration. Located approximately 90 miles (150 kilometers) offshore Angola in ultra-deep waters, the Pazflor project incorporates four fields -- Perpetua, Zinia, Acacia and Hortensia -- spanning 148,263 acres (600 square kilometers) on the eastern edge of Block 17.

Total's Angolan subsidiary, Total E&P Angola, is the operator of Angolan Block 17 with a 40% interest. Partners in the license include Statoil with 23.33% interest, Esso Exploration Angola with 20% interest and BP Exploration Angola with 16.67% interest.

Fields

First of the Pazflor cluster to be discovered, and the 10th field discovered on Block 17, Perpetua is located about 124 miles (200 kilometers) northwest of Luanda in 2,608-foot-deep (795-meter-deep) water. The Perpetua-1 exploration well discovered the field in August 2000, showing a daily flow rate of 8,740 bopd of 20-degree API in production tests.

Discovered in December 2002, the Zinia field was the 13th field encountered on Block 17 and the second of the Pazflor project. Located 90 miles (150 kilometers) from the Angolan coast, Zinia is situated in a water depth of 2,356 feet (718 meters). Also on the eastern portion of the license, the Zinia-1 well tested a flow rate of 3,650 bopd.

The discovery of the next two fields made the Pazflor project a commercial viability. The Acacia discovery followed in the spring of 2003 in water measuring 3,379 feet (1,030 meters). The Acacia-1 discovery well tested a combined 13,712 bopd from two separate zones, including Oligocene. The last to be discovered of the four eastern Block 17 fields, Hortensia is located 6 miles (10 kilometers) north of the Acacia field in waters measuring 2,723 feet (830 meters) deep. Tested at 5,092 bopd, the Hortensia-1 well was also discovered in the spring of 2003.

Field Development

Gathering oil from all four fields and water depths ranging from 2,000 feet (600 meters) to 4,000 feet (1,200 meters), the Pazflor integrated field development will link subsea wells through subsea production lines, injection lines and risers to an FPSO.

Approved by authorities in late 2007, field development calls for drilling to commence in 2009 and facility installations to commence in 2010. Pazflor production will begin in 2011, bringing production rates for Block 17 to 700,000 bopd.

With slots for 49 subsea wells, the FPSO will boast a daily processing capacity of 200,000 barrels of oil and 150 MMcf/d of gas and a storage capacity of 1.9 million barrels of oil. Additionally, the vessel will be able to process two very different types of oil: Miocene, which is found at Perpetua, Hortensia and Zinia; and Oliocene, which is located at Acacia. The topside will be able to accommodate an additional 21 wells and house a separation unit. Spread-moored in 2,500 feet (762 meters) of water, the FPSO will have a 20-year design life and be able to house up to 220 personnel.

Pazflor partners tapped Daewood Shipbuilding to provide the engineering, procurement and fabrication for the FPSO moorings, hull and topsides; and Daewoo awarded a number of subcontracts on the massive project. KBR was chosen to provide topsides engineering, procurement and interface design for the Pazflor FPSO. Dresser-Rand was awarded the $44 million contract to provide the turbomachinery for the FPSO, including four gas compression packages.

Aker Solutions was awarded the contract from Daewoo for the design and supply of the on-vessel mooring system made of eccentric fairlead chain stoppers. BW won the $100 million contract to engineer, procure, construct and install the buoy turret loading system and associated mooring equipment.

The subsea development includes 25 production wells, 22 water injecting wells and two gas injecting wells, as well as the West Africa's first-ever subsea gas/liquid separation system. Targeting two different reservoirs, the field development will recover heavier oil from Miocene reservoirs at a water depth of 1,969 to 2,953 feet (600 to 900 meters) and a lighter oil from Oligocene reservoirs at a water depth of 3,281 to 3,937 feet (1,000 to 1,200 meters).

In January 2008, FMC was awarded the $980 million contract to supply the subsea processing and production systems for Pazflor. The supply scope includes three gas-liquid separation systems, 49 subsea trees and wellhead systems, three four-slot production manifolds, production control and umbilical distribution systems, and gas export and flowline connection systems.

FMC Technologies subcontracted to Tracerco in August 2008, awarding the company the contract for the subsea separation boosting and injection systems. FMC also tapped Oceaneering to supply and install 7.3 miles (11,800 meters) of umbilicals to provide electrical power to the subsea pumps and separation systems. In October, FMC subcontracted to Grenland Group to deliver subsea structures, including 12 utility distribution modules and the materials for the three production manifolds and foundation structures.

Additionally, Pazflor partners awarded a Technip/Acergy consortium the $1.86 billion subsea development contract in January 2008. Under the agreement, for $1.16 billion, Technip will provide engineering, procurement, fabrication and installation of more than 50 miles (80 kilometers) of production and water injection rigid flowlines, conventional flexible risers and integration production bundle risers, as well as the engineering, procurement and construction of more than 37 miles (60 kilometers) of umbilicals. For $700 million, Acergy will engineer, procure, fabricate and install 34 miles (55 kilometers) of water and gas injection lines, gas export lines, and umbilicals, as well as more than 20 rigid jumpers. Acergy will also install the subsea manifolds, separation units and associated umbilicals, and the FPSO mooring lines.

In December 2007, while still under construction, Saipem's 12000 ultra-deepwater drillship was contracted for five years of drilling on Pazflor with an option for an additional two years.

C.V. Subsea tieback to SPAR: Boomvang, Gulf of Mexico, U.S.A.

Boomvang Boomvang
Operator: Anadarko
Water Depth: 1,052 m / 3,472 ft
Region: N. America - US GOM
Country: US
Last Updated: Nov 6, 2009 (view update history)

Project Description

Boomvang is a deepwater oil and gas field located in the Gulf of Mexico, south of Galveston, Texas in East Breaks Blocks 642, 643 and 688. The play is located in Lower Pleistocene/Upper Pliocene in age. The water depth of the field is 3,450 feet (1,052 meters) and it is currently producing 160 MMcf/d (4.5 MMcm/d) and 32,000 bopd.

Boomvang is 30% owned by Anadarko, formerly Kerr-McGee, 50% owned by Enterprise Oil Gulf of Mexico, Inc. and 20% owned by Ocean Energy, Inc.

The discovery well at Boomvang was drilled by Shell in 1988. In early 1999, Kerr-McGee bought s 50% interest and acquired operatorship. Production of the field didn't begin until January 2002, but development completion, final design and engineering was completed in February 2000. Although initial discovery was in 1988, additional hydrocarbons needed to proceed weren't discovered until the latter part of 1999.

Field Development

Development on the Boomvang field included Global Producer VI, the world's first of two production truss spars. Boomvang, along with its sister field, Nansen represents two significant deepwater field development projects successfully implemented simultaneously by a major independent E&P company.

Spars International Inc. was contracted to provide the hull, monitoring system, topside fabrication, spar installation, topside installation and overall project management. Spars International at the time was co-owned by CSO Aker Maritime and J. Ray McDermott. Mustang Engineering performed the topside and equipment procurement; Intec Engineering performed the subsea design. CSO Aker Rauma Offshore provided the hull project management; and PI Rauma Engineering performed the spar design.

Boomvang consists of a truss spar moored near the center of the field and two subsea systems tied to the spar. Each spar has a center wall of 40 feet (12 meters) by 40 feet (12 meters) where slots for nine dry tree risers are located in a three by three pattern. Each platform consists of a processing and shipping facility designed to handle 40,000 bopd and 200 MMcf/d (5.6 MMcm/d) of natural gas and 40,000 bwpd.

Satellite Fields

Balboa

The Balboa field, situated roughly 6 miles (10 kilometers) from the Boomvang field, is located on East Breaks Block 597 in 3,352 feet (1,022 meters) of water in the Gulf of Mexico. Discovered in July 2001, the field is *etimated to contain 7 to 8 million barrels of oil equivalent. Balboa is operated by Mariner, which holds a 50% interest; Marubeni holds the remaining 50% interest.*

In November 2009, it was reported the field's discovery well was completed and the designing of the subsea tie-back to the Boomvang facility was nearing completion. The operator is anticipating for the commencement date to occur in the fourth quarter of 2010.

C.VI. Subsea tieback to TLP: Auger, Gulf of Mexico, U.S.A.

Auger Auger
Operator: Shell
Water Depth: 872 m / 2,878 ft
Region: N. America - US GOM
Country: US
Last Updated: Oct 21, 2009 (view update history)

Project Description

Located 255 miles (410 kilometers) southeast of Houston and 214 miles (344 kilometers) southwest of New Orleans, the Auger field spans Garden Banks Blocks 426, 427, 470 and 471. Acquired through two mid-1980s OCS Lease Sales, the field is wholly owned and operated by Shell.
Drilled in 1987 by the Zane Barnes semisub (now the Jack Bates semisub), the discovery well on Garden Banks Block 426 was followed up by an appraisal well and three sidetracks across the fields' four blocks. These successful wells, in addition to 3D seismic, were used to determine field development.

Field Development: Auger TLP

Announced in December 1989, the field development plan for Auger included the installation of a tension leg platform with both drilling and production facilities.

Located on Garden Banks Block 426, the Auger TLP is a fixed platform installed in waters measuring 2,860 feet (872 meters). Seventeen Auger wells are connected to the facility; ten of which were drilled by the George Richardson semisub, and the other seven were drilled by the TLP post production start-up.

Measuring 3,280 feet (1,000 meters) from seabed to flare tower, the massive Auger TLP weighs in at 39,000 tons (35,380 tonnes). Designed and engineered by Shell, the Auger TLP was constructed and installed by a number of different companies.

The facility is comprised of a steel hull and a production and drilling topsides deck. At 20,000 tons (18,144 tonnes), the hull includes four circular steel columns connected by four rectangular steel pontoons, fabricated by Bellelli. With a production capacity of 100,000 bopd and 300 MMcf/d (8.5 MMcm/d), the topsides are an open truss box girder design measuring 290 by 330 by 70 feet (88 by 101 by 21 meters) and weighing 10,500 tons (9,525 tonnes). J. Ray McDermott tacked the topsides construction, hull and deck mating, TLP installation and mooring, and pipeline installation for the facility.

Built for drilling, completion and workover operations in addition to processing, the facility also contains a five-story accommodation unit. With 32 well slots, the Auger TLP gathers well production around a rectangular well bay.

Consisting of templates held in place by four piles, four foundations were constructed by Aker-Gulf Marine and installed at the facility's corners by Herremac. Additionally, the Auger TLP is moored through a lateral eight-line mooring system. Each line consists of 8,650 feet (2,637 meters) of five-inch-diameter wire rope and 1,800 feet (549 meters) of 5-inch-diameter chain.

Production Hub

With installation, hook-up and commissioning completed in November 1993, the Auger TLP commenced first production on April 15, 1994. Oil and gas from the development is piped to platforms in shallower waters before final export.

Since first production, the Auger TLP has been designated a processing hub for nearby fields. Now, Cardamom, Habanero, Serrano, Llano, Oregano and Macaroni also produce through the Auger TLP development.

In 1997, the pipelines exporting oil and gas from the Auger TLP were expanded. The existing oil pipeline was converted to a gas system, and a new oil pipeline was built between the Auger TLP and Shell's Enchilada platform on Garden Banks 128. The new system better delivers produced hydrocarbons from Auger to the Garden Banks Gathering System.

Satellite Fields

Cardamom

Located on Garden Banks 427 and 471, Cardamom is situated in 2,860 feet (872 meters) of water approximately 2 miles (3 kilometers) east of the Auger TLP. Discovered in 1995, the field was further delineated by a second well, drilled in November 1995.

Cardamom is developed directly to the Auger TLP, with production commencing in October 1997.

Macaroni

Located on Garden Banks 602 in 3,700 feet (1,128 meters) of water, Macaroni is situated 12 miles (19 kilometers) away from the Auger TLP. Discovered in 1995 by the Transocean Rather, the field underwent appraisal drilling in 1996 and 1997.

Acquired in the August 1989 OCS Lease Sale, Macaroni is operated by Shell, which holds 51% interest in the lease. Project partners include Eni with 34% and Devon with the remaining 15% interest.

Field development for Macaroni ties the field to the Auger TLP. Three subsea wells are clustered around a four-slot subsea template on Garden Banks 602, and then oil and gas is transported via two flowlines to the Auger TLP. The Transocean Richardson and Noble Paul Romano semisubs performed development drilling on the satellite field, and major contractors on the subsea development included FMC Technologies, J. Ray McDermott, Intec, Kongsberg Offshore and Alcatel. Production commenced on the Macaroni subsea development on Aug. 23, 1999.

Serrano

Located on Garden Banks Blocks 516 and 472 in 3,400 feet (1,036 meters) of water, the Serrano gas field is wholly owned and operated by Shell. Discovered in 1996 by the Ocean Worker, the field was further extended in 1999 by the Transocean Marianas.

Development for the satellite field included a subsea system tied-back to the Auger TLP 6 miles (10 kilometers) away. Consisting of two subsea wells, the development utilizes a subsea flowline sled to transport gas and condensate to the Auger TLP.

With estimated recoverable reserves of 50 MMboe, Serrano commenced production on Dec. 1, 2001, peaking at 160 MMcf/d (4.5 MMcm/d) of natural gas in 2002.

Oregano

Situated on Garden Banks Blocks 558 and 559, Oregano is in waters measuring 3,400 feet (1,036 meters) deep and is located 8 miles (13 kilometers) from the Auger TLP. Wholly owned and operated by Shell, the oil field was discovered in 1999 by the Noble Paul Romano.

Mirroring each other, Oregano was developed in conjunction with Serrano at a combined cost of $250 million. Oregano was also developed through a two-wells linked to a subsea manifold and tied to the Auger TLP through a subsea flowline sled.

Diamond Offshore performed the drilling and completion work on both Oregano and Serrano. A major contractor on both developments, FMC supplied the wellhead and completion equipment, including six vertical trees.

Pulling from an estimated recovery of 50 MMboe, production commenced on Oregano on Oct. 17, 2001, four months ahead of schedule. The field peaked at 20,000 bopd at the close of 2001.

Habanero

Located on Garden Banks Block 341 in 2,015 feet (614 meters) of water, the Habanero oil and gas field is located 11.5 miles (19 kilometers) away from the Auger TLP. Discovered in January 1999 by the Ocean Concord, Habanero consists of two pay zones. Situated in the H52 and H55 sands, a 225-foot (69-meter) column of oil is located in an upper zone, and a 70-foot (21-meter) column of gas condensate is located in the lower zone.

Shell serves as the operator of the satellite field with 55% interest in the block. Project partners include Murphy Oil with 33.75% and Callon with 11.25%.

Developed as a satellite field to the Auger TLP for a total investment of $190 million, Habanero field development includes two subsea wells connected to a dual pipe-in-pipe flowline system, which is then tied to the Auger TLP. Major contractors on the project include Transocean, which performed drilling and completions; and FMC with provided the subsea hardware.

With a daily peak rate of 22,000 bopd and 75 Mmcf/d (2.1 MMcm/d) of natural gas, production commenced from Habanero on Nov. 29, 2003.

Llano

Located in 2,600 feet (792 meters) of water on Garden Banks Blocks 385 and 386, the Llano oil and gas field is situated 11.5 miles (19 kilometers) from the Auger TLP.

The operator, Shell owns 27.5% interest in Llano. Lease partners on the blocks include Hess with 50% and ExxonMobil with 22.5%.

Discovered in 1998 by the Transocean Voyager & Omega, the field was delineated by two sidetrack wells. Reserves are located in the Pliocene and Miocene formations at a thickness of 150 feet (46 meters) and 95 feet (29 meters), respectively.

Developed as a subsea tie-back to the Auger TLP, Llano field development includes two wells tied through a pipe-in-pipe looped flowline. FMC also served as a major contractor on this development.

With a peak rate of 25,000 bopd and 75 MMcf/d (2.1 MMcm/d) of gas, production commenced from Llano on April 29, 2004.

Ozona

The Ozona oil and gas field is located in approxiamtely 3,280 feet (1,000 meters) of water on Garden Banks Block 515, about 175 miles southeast of Sabine, Texas. Marathon serves as the operator and holds a 68% interest; Marubeni holds the remaining 35% interest.

At a development cost of $300 million, Ozona will consist of one well subsea tied-back to the Auger platform, which is located six miles from the field.

Ozona is expected to commence production in 2011 and reach a peak production of 6,000 bopd and 13 MMcf/d.

C.VII. Dry tree SPAR: Mad Dog Field, Gulf of Mexico, U.S.A.

Mad Dog Field, Gulf of Mexico, USA
Name: Mad Dog
Location: Gulf of Mexico
Operator: BP
Distance from shore: 190 miles south of New Orleans
Water depth: 4,500ft
Equity: BP 60.5%, BHPBilliton 23.9%, Unocal 15.6%
Drilling unit range: 5,000ft to 7,000ft of water

The Mad Dog field is located in Western Atwater Foldbelt, Gulf of Mexico, approx. 190 miles south of New Orleans. The nominal water depth is 4,500ft and the field runs along the Sigsbee Escarpment. The field is operated by BP 60.5% on behalf of BHPBilliton 23.9% and Unocal 15.6%.

The drilling unit is located in 5,000ft to 7,000ft of water in Green Canyon blocks 825, 826 and 782, about 150 miles southwest of Venice, Louisiana. The gross estimated reserves are in the range of 200 to 450 million barrels of oil equivalent. The development has cost $1.54 billion to bring onstream.

The discovery well, in water depths of approx. 6,600ft, was spudded in May 1998 in Green Canyon 826 and was drilled to a measured depth of 22,410ft. The discovery was followed by a 1999 well drilled to a total depth of 22,410ft and a further successful appraisal well in February 2000. The project was sanctioned in 2001.

Mad dog's pre-drilled wells were drilled by the Ocean Confidence.

The Mississippi fan fold belt is characterised by basinward-verging anticlines and associated thrust faults. Mad Dog is one of a number of discoveries occurring in the western portion of the fold belt, where shallow salt tongues have flown over some of the folds, making seismic imaging difficult.

Development

The field is being developed by 12 wells produced with a single-piece truss spar permanently moored in 4,500ft water depths in Green Canyon Block 782, 306km south of New Orleans.

The fabrication of the spar hull commenced in Finland in July 2002, and the topsides in Morgan City, Louisiana, one month later.

Topsides

The deck measures 220ft by 163ft by 50ft (67m x 50m x 15m) and was designed around the heaviest hook load available (around 8,000t). The host facility includes production facilities with 16 slots in a 4 x 4 pattern (13 production slots, a drilling riser slot and two service slots), and quarters for 126 personnel, although the temporary quarters can accommodate an additional 60 persons. The spar also has a BP-owned drilling rig with an operating weight of 5,500t.
HULL

The 20,800t hull measures 128ft in diameter and is 555ft long. The facility is designed to process approximately 100,000 barrels of oil and 60mscf of gas per day. The spar has a maximum operating payload capacity of around 18,500t excluding hull storage. The topside and integrated decks total 10,500t

The trus spar took three weeks to travel from Finland to Passagoula, Mississippi, on the Mighty Servant 1, where it was floated off and pre-assembly preparations were completed. The Thialf was then used to lift the topsides into place.

Mooring

The spar is moored by an 11-line taut mooring configuration. There are three mooring line groups - two with four lines and one with three. The polyester mooring lines are attached to suction piles, resulting in a saving of around 1,000t of buoyancy over rope and chain systems. It is the first such use of synthetic moorings approved by the US Coast Guard or MMS.

Oil from Mad Dog will be transported via the Caesar pipeline to Ship Shoal 332B, where it will interconnect with the Cameron Highway Oil Pipeline System (CHOPS). Mad Dog gas will be exported via the Cleopatra pipeline to Ship Shoal 332A, where it will interconnect with the Manta Ray Gathering System, and from there to the Nautilus Gas Transportation System into Louisiana. Both Caesar and Cleopatra pipelines are part of the BP-operated Mardi Gras Transportation System.

C.VIII. Dry tree TLP: Matterhorn Field, Gulf of Mexico, U.S.A.

Matterhorn Field, Gulf of Mexico, USA
Operator: TotalFinaElf E&P USA
Location: Mississippi Canyon Block 243, 170km southeast of New Orleans
Water: 850m of water
Production rate: 40,000 barrels of oil equivalent per day
Production system: Mini tension leg platform
Hull fabrication: Keppel Fels
Main column diameter: 84ft

The Matterhorn field is located in Mississippi Canyon Block 243 in the deepwater Gulf of Mexico, approx. 170km southeast of New Orleans. It lies in 850m of water. The field came onstream in November 2003 and has a production capacity of 33,000 barrels of oil equivalent per day.

"The field came onstream in November 2003 and has a production capacity of 33,000 barrels of oil equivalent per day."

The Matterhrorn field is wholly owned and operated by TotalFinaElf E&P USA. After examining a number of development options, the designers settled on the use of a mini tension leg platform. The company opted for an Atlantia SeaStar design of the type previously installed on such deepwater projects as Chevron's Typhoon and British-Borneo's (Agip) Morpeth and Allegheny fields. Because of the field however, a larger version than the existing designs was deemed necessary.

The Matterhorn platform, at 4,500t, stands as the biggest of its type - double the size of the previous units and the first unit of this design to incorporate supporting vertical access production flowlines running through the central moonpool and controlled by surface (dry) trees. The contract for the hull was won by Keppel Fels in Singapore, making Matterhorn also the first one built outside of the Gulf of Mexico.

MATTERHORN SEASTAR HULL

The fabrication of the Matterhorn SeaStar hull structure began on 28 January 2002 and was completed by the end of the year. The construction is based on a relatively large central main column with a diameter of 84ft. It has a design draft of 104ft.

At the base of the column are three pontoons which project out to give the structure an effective radius of 179ft. At the point where they are attached to the main column the pontoon heights are 42 ft, however these taper down to just 27ft at the tip. "In early 2003, the structure was sailed out of Keppel Fels yard across to Pascaguola, Mississippi."

This hull structure is designed to support a payload 16,850kips (thousand pounds). The hull itself will weigh approximately 12,280kips, of which the primary hull structure will account for 10,420kips. Altogether, the platform has a displacement of 52,800kips.

In early 2003, the structure was sailed out of Keppel Fels yard across to Pascaguola, Mississippi, to await mating with the topsides.

MATTERHORN TOPSIDES

The Matterhorn topsides design is distributed over three decks. This deck arrangement was constructed at the Gulf Marine Fabricators in Ingleside, Texas. Paragon Engineering was responsible for the design of the topside facilities, employing the 3D PDMS (Plant Design Management System). The company expended over 60,000 man-hours on the design.

The deck free board is designated at 69ft and the decks have an area of 140ft^2. The operating weight of the decks and facilities is 13,350kips.

In order to process the Matterhorn hydrocarbons the platform design has process capacities of 35,000b/d of oil, 55 million scf/d of gas, 20,000b/d of water treated and 30,000b/d of water injected.

The wellbay design is centred on nine well slots although production currently flows through risers in only seven of them. Located at the top of the platform is a SuperSundowner XVI1,000hp drilling rig. Total also has one subsea injector well on the seafloor, leaving capacity for future tiebacks.

The design includes quarters for 22 men.

The Matterhorn TLP is connected to the seabed by six 32in neutrally buoyant steel tubular tendons. These were fabricated by Kiewit Offshore Service, also in Ingleside. Each tendon is secured by means of an independent, 96in-diameter, 415ft pile at the seabed, fabricated by Gulf Marine Fabricators. At 400t, the piles are among the heaviest ever installed.

The offshore installation was carried out by Heerema's Balder crane vessel.

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