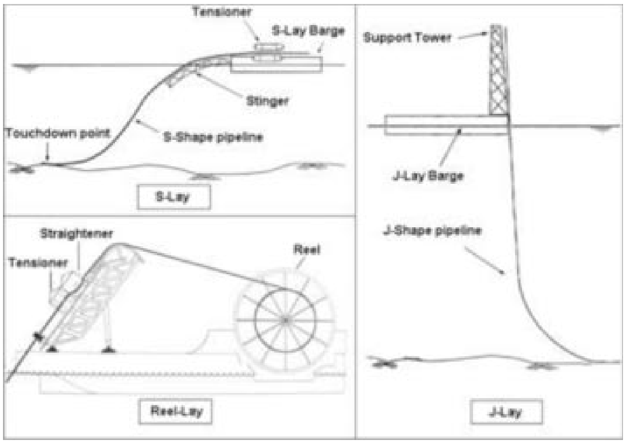
Pipelay Vessels and Techniques

The term "pipelaying vessel" refers to all possible types of such vessels, e.g. barges, modified bulk carriers, semi-immersible laying vessels etc. The laying vessel can thus either be provided with its own propelling machinery or not. Such a pipeline can either be manufactured at sea, starting with pipe lengths welded together on a pipelaying vessel to form the pipeline as it is laid on the sea bottom, or pipe lengths can also be joined together on land into continuous pipeline units which are then transported out to the site for laying on the sea bed. This paper reviews the various methods of laying pipe with different vessels.

Historically, pipelines have been the primary mode of transporting liquids and gases from subsea well sites to production facilities, between production facilities, and from production facilities to onshore facilities. For many deepwater applications, pipeline systems, called gathering lines, transport production from remote subsea well sites to surface processing facilities. These pipelines are usually small in diameter because they transport production from only one or a few wells. Pipelines may also connect a minimal surface structure at a deepwater well site to its supporting host facility. A minimal surface structure may contain well test equipment or free-water knockout equipment to remove water from the production stream. Removal of the water reduces the possibility of hydrate formation in the pipeline.

The operating environment for deepwater pipelines is different from the operating environment of pipelines on the shelf. Deepwater pipelines face higher hydrostatic pressures, colder water and sediment temperatures, different physical stresses during installation, effects from loop currents or eddies during installation or operation, greater amounts or rates of flow assurance chemicals, possibly higher flow rates, greater span (length of pipelines above the seafloor) distances, rugged seafloor topography, and technical challenges to monitoring and repair operations.

Buoyancy affects the pipelay process, both in positive and negative ways. In the water, the pipe weighs less if it is filled with air, which puts less stress on the pipelay barge. But once in place on the sea bed, the pipe requires a downward force to remain in place. This can be provided by the weight of the oil passing through the pipeline, but gas does not weigh enough to keep the pipe from drifting across the seafloor. In shallow-water scenarios, concrete is poured over the pipe to keep it in place, while in deepwater situations, the amount of insulation and the thickness required to ward of hydrostatic pressure is usually enough to keep the line in place.



Installation of pipelines and flowlines constitute some of the most challenging offshore operations. The technical challenges have spawned significant research and development efforts in a broad range of areas, not only in studies regarding different installation methods, but also in the formulation and implementation of new computational tools required to the numerical simulation.

The most common installation methods are the S-Lay, J-Lay, and Reel-Lay methods. In the S-Lay method, as the laying barge moves forward, the pipe is eased off the stern, curving downward through the water until it reaches the touchdown point. After touchdown, as more pipe is played out, it assumes the "S" shaped curve. To reduce bending stress in the pipe, a stinger is used to support the pipe as it leaves the barge. To avoid buckling of the pipe, a tensioner must be used to provide appropriate tensile load to the pipeline (Clauss,1998). This method is used for pipeline installations in a range of water depths from shallow to deep.

In the J-lay method, the pipe is dropped down almost vertically until it reaches touchdown; after that it assumes the "J" shaped curve. J-Lay barges have a tall tower on the stern to weld and slip pre-welded pipe sections. With the simpler pipeline shape, the J-Lay method avoids some of the difficulties of S-Laying such as tensile load forward thrust, and can be used in deeper waters.

In the Reel-Lay method, the pipeline is installed from a huge reel mounted on an offshore vessel. Pipelines are assembled at an onshore spool-base facility and spooled onto a reel which is mounted on the deck of a pipelay barge. Horizontal reels lay pipe with an S-Lay configuration. Vertical reels most commonly do J-Lay, but can also S-Lay.

Towing methods basically consists in weld the pipeline onshore with an onshore pipeline spread. Once the pipeline is complete and hydrotested, the pipeline is dewatered and moved into the water, while being attached to a tow vessel. It is then towed to an offshore location where each end is connected to pre-installed facilities (Silva,2007b,2008).

There are four variations of the towing method: surface tow, mid-depth tow, off-bottom tow, and bottom tow. In the surface tow approach, buoyancy modules are added to the pipeline so that it floats at the surface. Once the pipeline is towed on site by one or two tugboats (Silva,2008), the buoyancy modules are removed or flooded, and the pipeline settles to the sea floor. The mid-depth tow requires fewer buoyancy modules, and the pipeline settles to the bottom on its own when the forward progression ceases. The off-bottom tow involves buoyancy modules and chain weights. In the bottom tow, primarily used for soft and flat sea floor in shallow water, the pipeline is towed along the sea floor

Towing could be cheaper than other methods that use laybarges. However, a case-by-case analysis is required to determine the cost-benefit ratio.

Selected Pipelay Barge Owners

- **Ascot Constructors Offshore**
- **J Ray McDermott**
- **Boskalis Offshore**
- **China National Offshore Oil Company**
- **Emas Offshore Construction**
- **International Offshore Services LLC**
- **NorCE Offshore**
- **Sea Trucks**
- **Swiber**
- **Acergy**
- **Global Industries**
- **Saipem**

Pipeline installation methods for deepwater pipelines may be different from methods used on the shelf. The J-lay and bottom tows installation methods are unique to deep water. Deepwater pipelines may also be installed using dynamically positioned lay barges rather than the traditional anchored systems. While dynamic positioning eliminates the environmental effects from anchoring, air emissions may increase due to combustion of fuel to power positional thrusters.

No known further development work or commercial use of the technique of laying pipe offshore from reels was carried out after World War II. After a hiatus of about fifteen years, research into the reel pipelaying technique was renewed and was carried on by Gurtler, Herbert & Co, Inc of New Orleans, La. (USA); by 1961, Gurtler, Herbert had sufficiently advanced the reel pipelaying technique to make it a commercially acceptable and viable method of laying pipe in the offshore petroleum industry, able to compete with the traditional stovepiping technique. The first known commercial pipelaying reel barge, called the U-303 was built by Aquatic Contractors and Engineers, Inc, a subsidiary of Gurtler, Herbert, in 1961. The U-303 utilised a large vertical-axis reel, permanently mounted on a barge and having horizontally orientated flanges (generally referred to in the trade as a "horizontal reel"). A combined straightener/level winder was employed for spooling pipe onto the reel and for straightening pipe as it was unspooled. The U-303 first laid pipe commercially in September 1961, in the Gulf of Mexico off the coast of Louisiana and was used successfully during the 1960's to lay several million linear feet of pipe of up to 6 inches diameter.

There are increasing requirements in the offshore petroleum industry for laying multiple operational lines in deep water at depths greater than 3,000 feet and in remote areas far from supply bases. To be commercially viable a pipelaying vessel must also be capable of laying either single or multiple operational lines in shallow waters of less than 2,000 feet up to 3,000 feet depth.

In prior-art pipelaying vessels as employed in laying offshore subsea pipelines for such uses as the gathering of oil and/or gas from offshore subsea wells, as, for example, in the Gulf of Mexico, it has been conventional to use one of two main methods to lay the pipe. In the first, or "stovepiping" method, a pipeline is fabricated on the deck of a lay barge by welding together individual lengths of pipe as the pipe is paid out from the barge. Each length of pipe is about 40 feet or 80 feet long. Thus, the pay-out operation must be interrupted periodically to permit new lengths of pipe to be welded to the string.

The nucleus of a "construction spread" is a large derrick barge, pipelaying barge or combination derrick-pipelaying barge capable of offshore operations for an extended period of time in remote locations. These barges, which range in length from 180 feet to 677 feet, are fully equipped with revolving cranes, auxiliary cranes, welding equipment, pile driving hammers, anchor winches and a variety of additional gear. The largest of these vessels are the DB-102, which is one of the world's largest semi-submersible derrick barges in both size and lifting capacity and provides quarters for approximately 750 workers, and a semi-submersible lay barge capable of laying 60-inch diameter pipe (including concrete coating) and operating in water depths of up to 2,000 feet.

The stovepiping method requires that skilled welders and their relatively bulky equipment accompany the pipelaying barge crew during the entire laying operation; all welding must be carried out on site and often under adverse weather conditions. Further, the stovepiping method is relatively slow, with experienced crews being able to lay only one or two miles of pipe a day. This makes the entire operation subject to weather conditions which can cause substantial delays and make working conditions quite harsh.

The Reel

The other principal conventional method is the reel pipelaying technique. In this method, a pipeline is wound on the hub of a reel mounted on the deck of a lay barge. Pipe is generally spooled onto the reel at a shore base. There, short lengths of pipe can be welded under protected and controlled conditions to form a continuous pipeline which is spooled onto the reel. The lay barge is then towed to an offshore pipelaying location and the pipeline spooled off the reel between completion points. This method has a number of advantages over the stovepiping method, among them, speed (one to two miles per hour); lower operating costs (e.g. smaller welding crews and less welding equipment must be carried on the lay barge); and less weather dependency.

Different types of pipelaying vessels provided with rotatably arranged storage reels are already known, continuous pipe being rolled onto the reel when the vessel is docked at an onshore supply base. The apparatus used for laying underwater pipeline wound on a reel mounted on a floating vessel. In these arrangements, a pipeline comprising a plurality of joined pipe sections is wound on a rotatable reel and the vessel is then moved in a predetermined direction while the pipeline is unwound from the reel and lowered to the bottom of the body of water. While the pipeline leaves the reel, but before it enters the water, it is moved through a plurality of rollers so positioned and arranged as to reverse the bend which had been earlier imparted to the pipeline in order to wind it on the reel.

Heretofore, the physical design of the reel and bending apparatus on vessels has generally been somewhat limited in that it is not readily adaptable to various operational conditions such as the depth of water and dimensional characteristics of the pipe. For example, pipe characterized by large diameter and thick walls is not easily bent toward an acute angle because the pairs of rollers applying forces to the pipeline would have to be disposed closely to one another and great forces applied to them. Also, the reeling and bending apparatuses designed heretofore have generally been able to accommodate reeling and unreeling either from the top or bottom of the reel, but not from both, this generally as a consequence of the physical design and location of the bending apparatuses on the deck. Since it is generally desirable to unreel pipeline from the top of the reel when laying in deep water and from the bottom when laying in shallow water, all being somewhat dependent on the characteristics of the pipe though, it is disadvantageous to not be able to do both from the same vessel and apparatus design.

In all cases, however, the vessel has the drum or reel permanently located in it, which means that after all the pipeline on the reel has been reeled off and laid, the pipelaying vessel must then put into port for "recharging" the reel with a new length of pipelne. This involves breaks in laying work costing both time and money, or it requires several pipelaying vessels.

Another drawback with pipelaying vessels working according to the known reeling technique is that the vessels must be large since the reel is very voluminous (reel diameters of about 24 m are used for a 12-inch pipeline, for example) and have a very large weight when the whole continuous pipeline length is wound up on the reel.

It is commonly known that a straight and rigid body may not be bent intermediate its ends except upon the application of at least three forces, one at each end and one in the middle. This principle has manifest itself in the utilization of three-pair roller systems in the pipe-bending art and although two-roller systems have been devised, none are characterized by a satisfactory flexibility of movement on the deck of the vessel, nor teach a method for enabling the laying of a wide variety of pipeline diameters and thicknesses, optionally from the top or bottom of the reel.

The Swiss-based Allseas Group S.A. is one of the major offshore pipelay and subsea construction companies in the world, operating specialised vessels - which were designed in-house. Allseas is one of the major offshore pipeline installation companies in the world. Founded in 1985, we have gained worldwide experience in all types of offshore and subsea construction projects. Allseas' approach is to support clients already in the conceptual design stage and offer its services for project management, from engineering and procurement up to and including installation and commissioning.

Allseas' shallow water anchored pipelay barge Tog Mor is the third pipelay vessel in the Allseas fleet. She is employed world-wide, primarily in shallow water areas, both in support of Lorelay and Solitaire and independently contracted. The trenching support vessel Calamity Jane supports Lorelay and Solitaire with activities such as pre- and post route survey, crossing preparation and mattress installation, and operates as an independent unit with the mechanical trencher Digging Donald. The dynamically positioned survey vessel Manta supports Solitaire, Lorelay, Tog Mor and Calamity Jane, and also works under independent survey contracts.

Solitaire, the largest pipelay vessel in the world, has set new standards in the pipelay industry. Precise manoeuvring on full dynamic positioning allows the vessel to work safely in congested areas. Her high cruising speed and lay speed make her very competitive world-wide. Lorelay was the world's first pipelay vessel on dynamic positioning, representing a new generation. Being able to manoeuvre precisely and safely - specifically an advantage in congested areas - and having excellent workability, she has made her mark world-wide.

While the Solitaire moves forward, the pipeline slowly enters the water from the ship's stern. Proper calculations, including pipe weight, and water depth and density, determine the optimum speed at which the pipeline is laid. To ensure safe delivery, the pipeline is fed onto a computer-operated device called a "stinger." The stinger, attached to the Solitaire, and resembling an insect stinger with pipeline in tow, feeds the pipeline into the water at a gentle curve and a controlled rate. The biggest pipelay vessel in the world is also the fastest. And depending on the weather, Solitaire can lay from 4 to 7 kilometres of pipeline per day-twice as fast as other pipelay vessels.

SpiralLay® is a *n*_ew method to produce, transport and lay pipelines offshore. The prefabricated pipelines are produced onshore and transported to the installation site offshore._

S-Lay

The traditional method for installing offshore pipelines in relatively shallow water is commonly referred to as the S-Lay method because the profile of the pipe as it moves in a horizontal plane from the welding and inspection stations on the lay barge across the stern of the lay barge and onto the ocean floor forms an elongated "S." As the pipeline moves across the stern of the lay barge and before it reaches the ocean floor, the pipe is supported by a truss-like circular structure equipped with rollers and known as a stinger. The purpose of the stinger in the S-lay configuration is to control the deflection of the pipe in the over-bend region above the pipeline inflection point in order to return the angle of the pipeline at the surface to the horizontal. The curvature radius of the stinger corresponds to at least the maximum bending stress. To avoid a bending moment peak at the last roller, the pipe must lift off smoothly from the stinger well ahead of the lower end of the stinger.

In extremely deep water the angle of the pipe becomes so steep that the required stinger length may not be feasible. Deeper water depths will result in a steeper lift-off angle of the suspended pipe span at the stinger tip. This will require the stinger to be longer and/or more curved to accommodate the greater arc of reverse curvature in the overbend region. Accordingly, greater stinger buoyancy and/or structural strength will be necessary to support the increased weight of the suspended pipe span.

The practical water depth limit for a large, conventionally moored lay barge that uses the S-lay method is about 1,000 ft, based on a ratio of anchor line length to water depth of about five to one. Therefore, construction of pipelines by conventionally moored lay barges, if used in conjunction with the development of deepwater oil or gas discoveries in the Gulf of Mexico, will probably be limited to those portions of the pipeline routes located in water depths less than 1,000 ft. The term "conventionally moored" means that the location or position of the installation vessel (lay barge) is maintained through anchors, associated anchor chains, and/or cables.

Smaller lay barges, in the 400 ft long by 100 ft wide size range, typically require eight anchors each weighing 30,000 lbs, and a larger barge operating in 1,000 ft of water typically requires 12 anchors (3 anchors per quarter), each weighing 50,000 lbs or more.

In general, the larger the vessel, that is, the greater the target area presented to wind, wave, and current forces, and the heavier the vessel, the higher the holding requirements will be for the mooring system. The rated holding capacity of an anchor system is a function of the weight and size of the anchor and the tensile strength of the chain or cable that secures the anchor to the vessel. An important factor to be considered when there is a choice to be made between a conventionally moored lay barge and a lay barge that uses other means, such as dynamic positioning, to remain on station is the matter of handling the anchors. To deploy and recover the anchors of a lay barge operating in 1,000 ft of water, two anchor-handling vessels with a horsepower rating of 8,000-10,000 each would be required, and there is a shortage of such vessels. On the other hand, a smaller lay barge operating in shallower water requires only one 3,000-5,000 hp anchor-handling vessel.

The number of anchor relocations per mile of offshore pipeline constructed will be dependent upon the size of the lay barge, the water depth, ocean floor conditions in the vicinity of the pipeline installation, and the amount of anchor line that can be stored, deployed, and retrieved by the lay barge. Assuming a lay barge is operating in 1,000 ft of water and is following the accepted practice of deploying an amount of anchor line equal to five times the water depth, the anchors would have to be relocated after each 2,000 ft of pipeline installed.

Minerals Management Service regulations at 30 CFR 250.1003(a)(1) require, with some exceptions, that pipelines installed in water depths of less than 200 ft be buried to a depth of at least 3 ft. The purpose of this requirement is to protect the pipeline from the external damage that could result from anchors and fishing gear, and to minimize interference with the operations of other users of the OCS. For deepwater pipelines, burial issues are a possible concern only for those pipelines that terminate onshore or at shallow-water host facilities.

The burial of a pipeline is carried out during the construction process and is usually accomplished by either a plow or a jet sled towed along the seafloor by the lay barge. Whether a plow or jet sled is used, the distance of the device from the lay barge is adjusted to position the plow or jet sled just ahead of the point where the pipe contacts the seafloor (the touchdown point). Through the action of high-pressure water jets, a jet sled creates a trench in the seafloor into which the pipeline settles. The jet sled, which generally creates more temporary turbidity in the water column than a plowing device, has an operational advantage over a plow. The area of seafloor disturbed by the pipeline burial process is typically just slightly wider than the outside diameter of the pipeline, for example, a trench approximately 15 inches wide by 3 ft deep for a 12-inch pipeline.

S-Lay Method by Dynamically Positioned Lay Barges

The term "dynamically positioned" means that the location or position of the lay barge is maintained by the vessel's very specialized propulsion and station-keeping system which, instead of or in addition to the conventional propeller-rudder system at the stern, employs a system of hullmounted thrusters near the bow, at midship, and at the stern. When in the station-keeping mode, these thrusters, which have the capability to rotate 360o in a horizontal plane, are controlled by a shipboard computer system that usually interfaces with a satellite-based geographic positioning system.

Dynamically positioned lay barges can be used in water depths as shallow as 100 ft, but generally they are not used in water less than 200 ft deep, depending upon pipe size, the nature of the project, and the location. Dynamically positioned lay barges outfitted with the equipment necessary to install reel pipe are sometimes used in shallow water.

The impact on air quality is one of the most significant differences between using a dynamically positioned lay barge and a conventionally moored lay barge to construct a pipeline. In the case of a conventionally moored vessel, the hydrocarbon-fuel-consuming prime movers that drive the propulsion system are typically shut down or operating at minimum speed, fuel consumption, and pollutant emission levels while the vessel is not under way, that is, while the vessel is engaged in pipeline installation activity. The probable requirement for tug assistance to move from station to station during an installation project and the requirement for the services of anchor-handling vessels to deploy, retrieve, and re-deploy anchors contribute to the pollutant emission levels. Contrast this to a dynamically positioned lay barge which, in order to remain on station during a pipeline installation, must constantly operate its prime movers, which drive the propulsion system.

Some examples of deepwater pipelines installed by the S-lay method from a dynamically positioned vessel (the Allseas ship Lorelay) are the 25-mile long, 14-inch gas and 12-inch oil export pipelines constructed from Shell Offshore Inc.'s Ram Powell tension leg platform at Viosca Knoll (VK) Block 956 to VK 817, and from VK 956 to Main Pass (MP) Block 289, respectively. The water depth along these routes ranges from 3,218 ft at VK 956 to 670 ft at VK 817 and 338 ft at MP 289. The Lorelay also installed three 6-inch gas pipelines in water approximately 5,400 ft deep between three subsea wells in Mississippi Canyon (MC) Block 687 and a subsea manifold in MC 685 (Shell's Mensa project).

J-Lay

Conventionally Moored Lay Barges

A comparatively new method for installing offshore pipelines in deeper water is the J-lay method. The method is so-named because the configuration of the pipe as it is being assembled resembles a "J." Lengths of line pipe are joined to each other by welding or other means while supported in a vertical or nearvertical position by a tower and, as more pipe lengths are added to the string, the string is lowered to the ocean floor. The J-lay method is inherently slower than the S-lay method and is therefore more costly.

The J-curve pipe-laying technique represents a logical extension of the industry's capability into deepwater. The J-lay method offers an alternative to the conventional lay barge in that the stinger requirements for deepwater are greatly reduced. The purpose of a stinger in the J-lay configurations is to change the angle at the top of the pipeline to a vertical orientation. The orientation of the pipeline at the surface does not have a large over-bend region and thus results in relatively small horizontal and vertical reactions on the stinger. The method is attractive as the bending stresses are low, the horizontal force required for stationkeeping is within the capability of dynamic positioning systems, and the use of modular towers allows derrick barges and moderately sized support vessels to be equipped for pipeline installations.

The maximum operating water depth in which a conventionally moored lay barge can operate is a function of its anchoring capabilities. Generally speaking, this is about 1,000 ft, and conventionally moored lay barges are not normally used for J-lay pipeline installations in this water depth because of the required tension on anchors and the pipe-bending stress. The J-lay method is difficult to use in water depths as shallow as 200 - 500 ft because of limited pipe angle and the bending stress imposed on the pipe.

The number of anchors used by a conventionally moored lay barge engaged in a J-lay operation is very similar to the number of anchors used by a conventionally moored lay barge engaged in an S-lay operation, which would be 8 to 12 anchors, depending on lay barge size. The relationship between the size of a vessel and the size of the anchors required for holding the vessel on-station is not a function of the pipeline installation method being used but, as previously discussed under the S-lay method, a function of the size of the lay barge. Stationkeeping requirements would be very similar to those required for a conventional lay barge using the S-lay method.

Similarly, the number of anchor relocations per mile of pipeline constructed is not a function of the installation method being used, but is related to the size of the lay barge, the water depth, and the amount of anchor line that can be stored, deployed, and retrieved by the lay barge. The number of anchor relocations per mile of pipeline installed by a conventionally moored lay barge employing the J-lay method would be very similar to the number of relocations required for a conventionally moored lay barge employing the S-lay method.

The number of anchor-handling vessels associated with a J-lay pipeline installation by a conventionally moored lay barge would be essentially the same as for a similar size barge using the S-lay method: from one vessel rated at 3,000 to 5,000 hp for a smaller lay barge operating in shallow water, to two vessels rated at 8,000 to 10,000 hp for a lay barge operating in 1,000 ft of water.

Dynamically Positioned Lay Barges

The minimum water depth at which dynamically positioned lay barges are believed to have an economic advantage over conventionally moored lay barges is estimated to be about 600 ft because the minimum radius of pipeline bend must be between 80 and 90 in 600 ft.

A dynamically positioned lay barge will typically consume more fuel and therefore emit more air pollutants per mile of pipeline installed than a conventionally moored lay barge. There are two other factors that help to equalize the differences in the air quality impacts: (1) conventionally moored lay barges typically require the assistance of other vessels to move from station to station and to deploy and recover anchors, and (2) dynamically positioned lay barges typically work in deeper water, that is, farther offshore and, therefore, have less potential to impact onshore air quality adversely.

Two examples of deepwater pipelines constructed by the J-lay method from a dynamically positioned installation vessel are the two 12-inch export lines that transport production from Shell Offshore Inc.'s tension leg platform (TLP), (Auger [2,850 ft of water in Garden Banks Block 426] [GB 426]), one a 71-mile-long oil line between GB 426 and Eugene Island Block 331 (water depth 243 ft), and the other, a 35-mile-long gas line between GB 426 and Vermilion Block 397 (water depth 380 ft). McDermott's dynamically positioned derrick barge DB 50, which had been outfitted with a portable J-lay, installed both lines. This vessel also installed 40 miles each of a 14-inch and an 18-inch pipeline to transport gas and oil, respectively, from Shell's Mars TLP at Mississippi Canyon Block 807 (in 2,950 ft of water) to West Delta Block 143 (in 369 ft of water).

Bottom-towed Pipeline

A less commonly used method of constructing offshore pipelines is the method of onshore fabrication whereby the pipeline assembly process, that is, the welding, inspection, joint-coating, and anode installation normally carried out on a lay barge immediately prior to the pipeline going into the water, is performed at a fabrication facility located onshore. The assembled pipe is then towed from the onshore location to its designated position by seagoing vessels. The pipeline is towed near the seafloor along a route that was presurveyed to identify any potential hazards. The assembled pipe can be towed either as an individual pipeline or as a bundle of several pipelines.

This method of installation is particularly well-suited to pipe-in-pipe flowline assemblies, which can be more efficiently fabricated onshore, and which have thermal insulation in the annular space between the inner and outer pipes. Such insulated pipe-in-pipe flowline assemblies are necessary to maintain the temperature of the produced fluids during transport through the very cold water of the deep Gulf of Mexico.

A limitation of this installation method is the increased risk that the pipeline could be damaged during the tow through contact with a subsea obstruction. Such damage could result in potentially catastrophic consequences if the integrity of the outer pipe were compromised, resulting in the exposure of the thermal insulation to the subsea environment.

An example of a pipeline installation using the bottom-tow method is BP Amoco's project that installed dual 10-inch oil pipelines during the summer and fall of 1997 between the subsea production manifold at their Troika Field development in Green Canyon (GC) Block 200 (GC 200) and the host platform, Shell Offshore Inc.'s Bullwinkle (GC 65, Platform A). The water depth along the route varies from 2,700 ft at GC 200 to approximately 1,400 ft at GC 65. The 10.75-inch outside diameter (O.D.) oil lines are encapsulated within a 3-inch thick shell of polyurethane foam insulation, and this assembly is installed within a 24-inch O.D. pipe; the annular space between the outer pipe and the foam insulation is filled with pressurized nitrogen. The pipelines were towed offshore from the fabrication facility on the Matagorda Peninsula on the Texas coast in four sections, each 7 miles long. The tow route used by BP Amoco followed parts of a route that Enserch Exploration, Inc., had previously surveyed and used for bottom-towing several pipelines installed between GB Block 388 and Eugene Island Block 315, and between Mississippi Canyon Block 441 and Ewing Bank Block 482.

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