PIPELAYING IN THE NORTH SEA

by

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Wind and weather in the North Sea constitute a major impediment to the efficient and economic exploitation of oil reserves. To meet the demands for bringing oil ashore from wells at increasingly greater depths and offshore distances, new technologies in shipbuilding, pipelaying, and electronics have been combined in an operational concept featuring a Third Generation Laybarge.

The Viking Piper is the world's largest semisubmersible vessel, launched in April 1975, and presently laying pipe off the Shetland Islands in the U.K. This paper describes the new vessel, the new tools, techniques and teamwork, that are making it possible to lay pipe, accurately and efficiently in water depths and under sea conditions that have previously made the task impossible.

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Problems and uncertainties continue to be facts of life in the field of petroleum exploration and production. Over the last few decades a great amount of time and money has gone into new technology and tools for offshore exploration, to improve both the chances of success and the cost of locating new fields. This same evolutionary process has characterized the drilling and production phases. One indication of progress is the fact that exploration efforts have been locating sources increasingly farther offshore, and at much greater depths. Technology has provided solutions that permit access to the oil but there remains the problem of transferring it to shore for processing.

In the recent past we have seen the advent of huge storage tanks at the production sites, to serve as buffers in the flow process and to transfer the crude to carriers as they arrive on location. Where direct submarine pipeline from the production site to shore has been possible, this has been a more efficient alternative. But what alternatives are available for use when conditions at sea exceed the capabilities of the vessels and equipment available? This was the question facing the operating companies in the early seventies as the North Sea potential began to unfold. How, for example, can one lay pipe up to 44 inches diameter, in water depths to 500 feet or more, with winds of 50 to 60 mph, and wave heights up to 15 or 20 feet? These are the conditions offered by the North Sea about 20% of the time.

Such challenges demanded new and technically advanced solutions. This paper describes the main features of an approach conceived in 1969 and brought to operational condition in April 1975. Although the total operational concept that emerged involves important contributions from a number of locations, organizations, and vessels, the focus here is on the characteristics and the functions of the people and equipment that work offshore to accomplish the actual laying of pipe, where it should be laid.

The central element in this concept is what has been termed the Third Generation Lay Barge. This photo shows the implementation of the concept - the Viking Piper which is the world's largest semi-submersible laybarge. It reflects the culmination of an extraordinary combination of efforts by financiers, engineers, shipbuilders and operators.

The 3GLB Project

Focusing attention first on the laybarge itself, the physical magnitude of the vessel suggests some of the problems that had to be solved.

Conceived by Dutch shipbuilders and American marine pipeline engineers, the construction of the vessel required a pooling of technical, financial and physical resources. A combination of Norwegian, French, and Scottish-UK interests forms the consortium of Viking Jersey Equipment Ltd. that managed the vessel's construction under supervision of the Dutch shipbuilder, IHC Gusto.

Overall length of the barge itself is 800 feet. Its breadth is 192 feet, and the height to the work deck is 109 feet. It is a semi-submersible vessel and uses a superstructure, supported by six columns, mounted on lower hulls. In its semi-submersible stable operating mode, the barge's work deck is about 45 feet above water level. Because some of the work areas are 60 feet below water level, the columns had to be equipped with elevators.

Six Dutch yards built the columns, bracings, and parts of the upper hull. The lower hulls were constructed at Cork, Ireland, and towed to Rotterdam. Final assembly and launching were completed in April, and turned over to the operating company established to manage pipelaying programs. The operating company is Viking Offshore Pipelines S. A., and the Viking Piper's first assignment is for British Petroleum in the North Sea. At the present time, the barge is laying a 103-mile pipeline from the Shetlands to the Ninian field. Ninety-six of these miles are underwater.

Pipelaying Operations

The pipelaying operation involves considerably more than the Viking Piper itself. Logistic support for the vessel and its 380-man crew comes from Bergen, Norway. Pipe construction material is handled out of Lerwick, Shetland Islands, U. K.

In addition, the Viking approach entails the interrelated activities of several other vessels whose functions of surveying, barge guidance, or pipeline inspection, directly affect the Viking Piper's operation. This paper discusses the interrelated capabilities and contributions of these particular vessels that form the core of the pipelaying team.

The Viking Piper

The Viking can install pipe of outside diameter up to 44 inches. The Ninian line is 36 inches in diameter and will terminate in more than 500 feet of water. Certain diameters can be laid in water depths of more than 1200 feet.

Forty-foot lengths of pipe are off-loaded from pipe-supply vessels by crane, and stored on deck the Piper. Facilities are adequate to store about 7000 tons of pipe, This permits continuity of pipelaying operations even when heavy weather keeps the resupply vessels in port.

Pipe sections are double jointed, welded, x-rayed and transferred to a central launchway. There they are welded to the main line, coated, and launched down a stern ramp. This ramp is in itself an innovation. Earlier pipelaying vessels used a long submerged pontoon, called a "stinger," down which the pipe was guided into position. One problem with the stinger was its susceptibility to damage by high seas and winds. The Viking Piper uses a new, giant stern ramp more than 300 feet long. The ramp is rigidly mounted on the stern and supported from the lower hulls. In survival conditions the pipeline can be abandoned and the ramp retracted to raise the tail above wave level.

In operation, the ramp supports the pipeline from the deck into the water, and, in conjunction with a pipe tensioning system (integrated with an abandonment and recovery system), controls curvature and stresses in the pipe to avoid buckling. Ramp curvature can be adjusted for different pipe sizes.

The Viking Piper has engines but no propellers to move her. Fourteen 2000 horsepower winches, deep in the bottom of the floaters, operate 3-inch steel hawsers attached to 20-ton anchors that pin the barge to the seabed. Tugs lift and move the anchors as required, and the winching system moves the barge. Maximum speed is 180 feet per minute with 300, 000 pounds tension on the pipe.

The computerized winching system is controlled by a single operator. The Automatic Winch Control system receives data from various control sensors and instrumentation. The system can be used in semi-automatic or fully automatic modes, and even a provision for manual control.

In the center of the vessel is a modern control tower housing some of the most sophisticated electronic equipment ever designed. The nerve center or heart of the Viking Piper control system is a unique, state-of-the-art computer system conceived by Viking's chief technical engineer and implemented by Norcontrol, a Norwegian computer company. The Norcontrol Data Bridge consists primarily of a computer/data processor. One of the most significant functions of the Data Bridge is the determination of the barge's position or deviation from the established right-of-way. This is the output to other computers which control the winches for the Viking Piper's movements.

The Lindinger Surveyor

Working closely with the Viking Piper is the M. V. Lindinger Surveyor, a 51-meter long converted Danish car ferry, with spacious facilities and good maneuverability. The Lindinger Surveyor provides an excellent platform for oceanographic investigation of the seabed.

A variation of the Norcontrol Data Bridge is also installed on Lindinger Surveyor, and provides navigation, data logging and ship's-position control for all phases of the pipelaying operation. Using radar and sonar and a variety of other electronic devices, it literally provides eyes and ears for the Piper's operation. It determines and charts where on the seabed the pipeline should run. By means of its sonar it helps monitor the proper location of the pipeline, and finally the as-laid position of the pipeline.

The Vickers Venturer and the Pisces

Working closely with the Viking Piper and the M. V. Lindinger Surveyor as an inspection vessel for BP, has been a third vessel named Vickers Venturer which serves as a mother ship for the small manned submarine.

The submarine's primary mission has been to make a visual survey of the bottom, determine the accuracy of the pipe lay, and check the route ahead. The submarine can operate at greater depths and cover a larger area in less time than divers working on the project.

The use of the submarine and subtender has required acoustic transponders, similar to sonar, emplaced on the seabed to position the small submarine. Experience to date with the Data Bridge systems and their input/outputs is proving that surface measurements are more than adequate to serve even the inspection function.

Electronics of Pipelaying

One of the features of the overall pipelaying operation is the utilization of a variety of complementary electronic systems that serve to determine where the pipe should be laid, permit positioning the laybarge to place the pipe precisely, and then provide means for checking the final location on the seabed.

The Norcontrol Data Bridge aboard the Lindinger Surveyor gives an excellent overview of the multiplicity of electronic inputs that characterize the three stages of operation. The Data Bridge is the master control and display point for all of the systems that contribute to navigation, data logging and ship's-position control.

The bank of controls to the right of the radar console gives some idea of the inputs that are available to the Data Bridge computer, and how the data are processed for use -- either to identify the ship's position or to control its course.

The portion of the panel labeled "Data Pilot," for example, is the portion of the system that interfaces with the standard ship's autopilot and takes over actual control of the Surveyor. The computer can provide automatic adjustment for heading, course and speed, and yet allows for complete manual control of the vessel from the panel, through the computer.

The Data Sailing portion of the panel permits data inputs to effect the desired mode of navigation -- course mode, preset track mode, or great circle sailing -- and includes provision for establishing path deviation limits, turning points, and offsets. Up to thirty turn points can be inserted.

The Data Entry block is the alphanumeric keyboard used for entering all data on course position, turning point coordinates, start and end points for lines to be run and any other factors affecting Data Sailing.

On the right side of the Surveyor's Data Bridge panel, the Data Position portion permits the selection and use of appropriate electronic positioning system inputs. The computer can optimize position accuracy by using individual systems or combinations of inputs; from Mini-Ranger, Loran, Satellite, Decca, and dead reckoning. The Mini-Ranger is the primary control instrument out to forty or fifty miles offshore. Satellite or Decca may be used beyond that but satellite parameters and other position accuracy factors are compared or calibrated within the Mini-Ranger area for application later, when other positioning systems are used.

The Mini-Rangers, on both the Piper and the Surveyor, are located on the right side of the Data Bridge. The Decca equipment and satellite receiving equipment are located to the left of the radar console.

Another way in which the different equipments are used in combination arises in connection with the use of Mini-Ranger for precise positioning within radio line-of-sight of land. The portable dual-channel satellite receiver is taken ashore to determine the coordinates of reference station sites for the Mini-Ranger system. This allows establishment of benchmarks quickly, at locations that give good geometry for accurate data logging and ultimate ship control, without incurring the time and expense of running a traverse from some existing benchmark miles away. This becomes a particularly effective combination of system capabilities because the satellite receivers provide a flexible and adequate means to let the extremely precise repeatability of Mini-Ranger to control all three vessels in a common and accurate frame of reference.

This so-called "teamwork" extends also to the vessels themselves. For example, the Piper with the aid of the Surveyor, using its narrow-beam echo sounder to locate the touchdown point of the pipe, have both made extremely effective use of Mini-Ranger's repeatability. In the initial stages, the Piper was able to lay its first two kilometers of pipe in 80 to 100 meters of water, in a figure "S" curve between rock outcrops and mounds, in a path only 15 to 20 meters wide. This is especially significant as most pipelaying is done by locating the barge and assuming the pipe is where you want it, or by having divers and/or manned submarines observing the pipe as it is laid. Water was too deep for divers, and heavy fog made use of the submarine tender impossible. Without the two Data Bridges and the use of the Mini-Rangers the barge would have had to wait for clear weather and the submarine to guide it. Subsequent visual inspection of the pipe on the bottom confirmed it was exactly as planned between the rocks, safely on the sand seabed.