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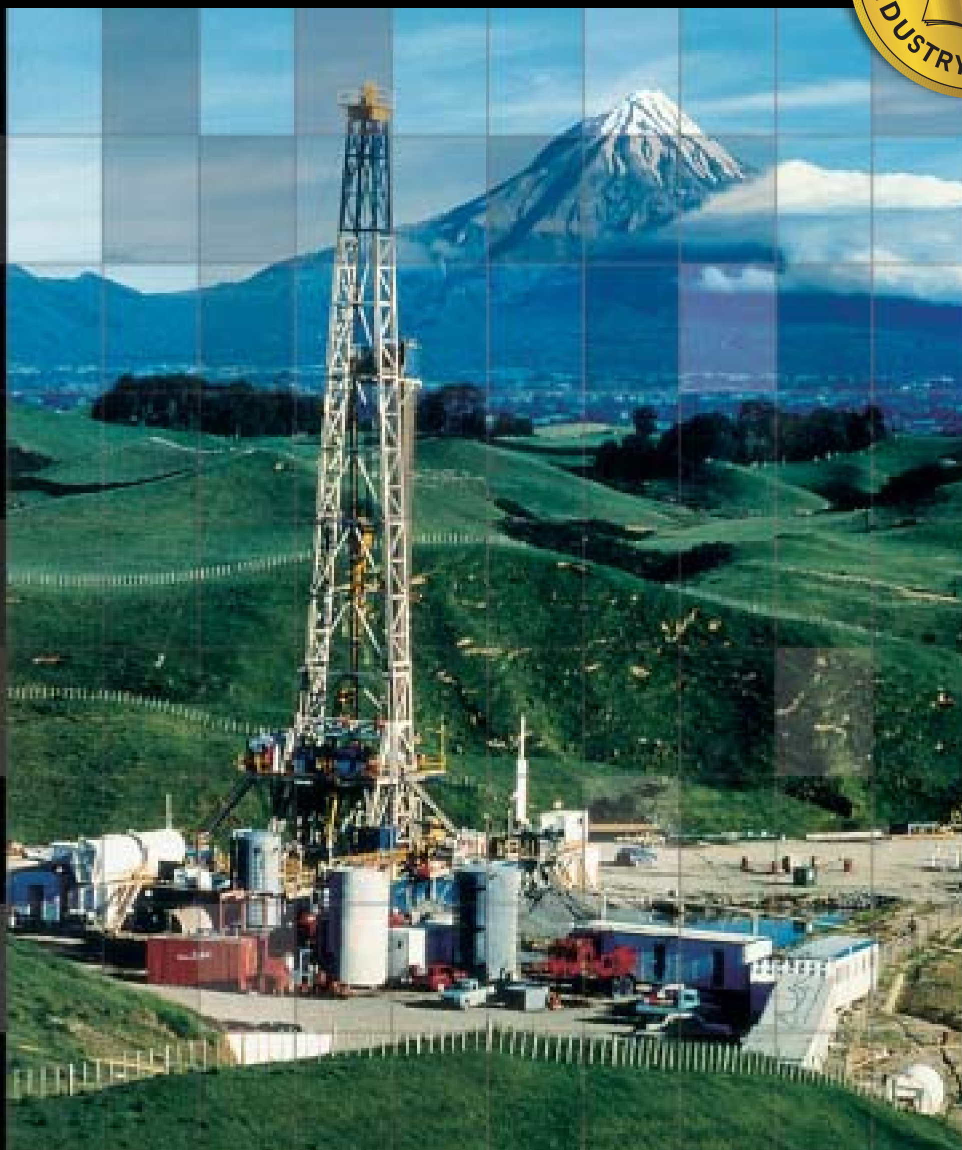
A CENTURY OF INDUSTRY LEADERSHIP 1902 2002

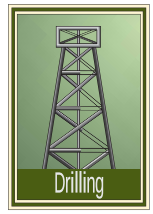


Frontiers of Drilling Technology

Will deepwater, Middle East oil supplies live up to expectations?
Meeting exploration challenges in Uganda's remote Albert graben
Deepwater trial tests low-dosage hydrate inhibitor
Effectiveness confirmed of inhibitor for pipeline internal corrosion

Extreme conditions, extended-reach wells govern land-rig design for Sakhalin

Mike Sumrow
Drilling Editor



Exxon Neftegas Ltd., a subsidiary of ExxonMobil Corp. and operator for the Sakhalin I consortium, plans to develop the northern part of the offshore Chayvo oil and gas field with wells drilled from onshore Sakhalin Island. The company expects to spud the first well in the fourth quarter 2002.

With planned horizontal displacements of 6-10 km and a reservoir TVD of 2,600 m (8,500 ft), company sources characterize the drilling operations as working at the edge of industry experience for extended-reach drilling (ERD). The wells may redefine the envelope of ERD technology.

The consortium expects ERD wells to reduce the overall cost of developing the offshore field. Drilling from onshore eliminates the need for an offshore facility in an area where sea icing in winter restricts ocean access and offshore activity.

To optimize oil recovery, the wells will produce from horizontal completions in Chayvo's Miocene sandstone reservoir oil column.

An arctic and seismic class land rig will drill the wells from a single location, with the wellheads spaced about 10 m apart. Houston- based Parker Drilling Co. has signed conrtacts to build and operate the rig, which it calls Rig No. 262, for the Exxon Neftegas-led consortium (OGJ, Mar. 25, 2002, p. 8).

As outside temperatures drop to − 40° C., the built-for-purpose rig will operate fully enclosed to maintain a comfortable "shirt-sleeve environment" for the crew and equipment, according to Denis Graham, vice-president of engineering for Parker Drilling, speaking to a meeting of the American Association of Drilling Engineers in Houston in April.

Engineers have designed the rig to survive earthquakes without catastrophic failure by essentially bolting it to the ground, reducing the mass of a typical drilling rig's derrick, and customizing the structure.

A specially designed pipe barn will allow efficient drilling operations, while drill pipe and casing are being run from horizontal pipe racks rather than being racked in the derrick.

The remote location and logistics of the project, the technologies required for drilling and completing the Chayvo wells, and the drilling rig's unique design, characterize drilling technology frontiers.

Sakhalin I project

Sakhalin Island lies off the east coast of mainland Russia, north of the Japanese island of Hokkaido (Fig. 1). The island is 948 km long from north to south and 27-160 km wide from east to west.

At about 52° north latitude, arctic conditions prevail with winter temperatures as low as −40° C. Sea ice occurs for 6-7 months/year, from December to June, essentially restricting ocean access to the island to the summer months.

The Sakhalin I project will eventually develop three fields on the northeast shelf of Sakhalin Island in 10-60 m water depth: Chayvo, Odoptu and Arkutun-Dagi (Fig. 2). In October 2001, the Sakhalin I consortium declared the project commercial, with Phase 1 operational schedule to begin in 2002.

According to company filings, the fields together contain estimated total recoverable reserves of 2.3 billion bbl of oil and 17 tcf of natural gas.

The first phase of Sakhalin I will focus on the Chayvo and Odoptu fields with first oil expected from Chayvo at the end of 2005 and from Odoptu in early 2008.

The consortium plans a Phase 1 oil production plateau of 250,000 b/d along with gas production to meet the island's domestic demand.

With the Chayvo oil and gas field 5-15 km offshore, the consortium will develop it from both onshore and offshore locations.

Sakhalin Island

Fig. 1

Source: ExxonMobil Corp.

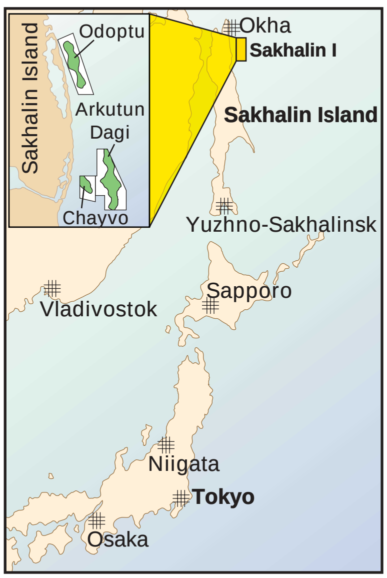
Chayvo field onshore wellsite

Fig. 3

Source: ExxonMobil Corp.

Sakhalin I project

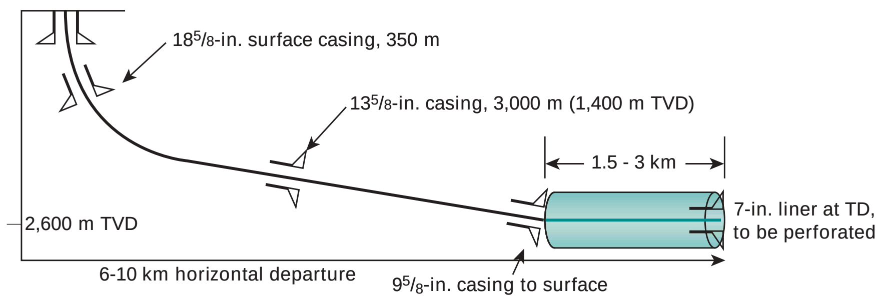
Fig. 2



Source: ExxonMobil Corp.

Planned Chayvo well completion

Fig. 4



Note: A surface controlled subsurface safety valve (SCSSV) will be set in the tubing at or below the $18^{5}/_{8}$-in. casing shoe.
Source: ExxonMobil Corp.

In addition to the land-based drilling operations, Exxon Neftegas will position the Orlan concrete island structure, after substantial modifications, on the Chayvo field in 15 m of water in 2004, where the rig is expected to drill up to 20 wells.

According to news reports, the Sakhalin I consortium will invest $750 million this year to develop the Chayvo field, installing onshore drilling equipment at Chayvo and upgrading the concrete island platform Orlan to serve as a drilling and production facility.

Reports say the consortium has invested $450 million in a 5 year evaluation-drilling program, with overall Sakhalin I capital investment to be $12 billion over 30-40 years.

Extended-reach land wells

Exxon Neftegas has chosen a drilling site, on the eastern side of the Chayvo Bay on an elevated portion of the shoreline, where the rig can drill the wells in roughly a radial pattern to the Chayvo field (Fig. 3).

The company plans to drill 10 wells from the site initially and has the space available to add more wells later. The consortium will determine the specific area within the field that each extended-reach well is to target for production and exploitation, even though the wells will originate from the same pad.

Fig. 4 shows the planned wellbore design and completion for the Chayvo ERD wells.

The sketch shows the build section beginning shortly after the wellbore exits the conductor casing, with the 18⅝-in. surface casing set at about 350 m, within the build section.

The rig will set 13⅝-in. casing at about 3,000 m MD, about midway in the sail angle toward the completion target.

Before drilling into the reservoir for the completion interval, the rig will set 9⅝-in. casing back to surface. Once the rig has set and cemented the 9⅝-in. casing, it will drill an 8½-in. horizontal section and run a 7-in. liner for the reservoir completion.

Company sources said they expected the perforated 7-in. liner would be an adequate completion technique, without the need for sand control.

Upon well completion, the rig will install a tubing string with surface controlled subsurface safety valve (SCSSV) set at about the same depth as the 18⅝-in. casing shoe.

Drilling best practices

To make the operation as safe as possible, minimize environmental impact, and control overall development costs, ExxonMobil has initiated several drilling project planning best practices through the land rig design and the drilling methods it will employ.

The company explained some of the concepts:

• Maximizing safe working environment. Creating comfortable working temperatures within all areas of the rig in the arctic environment and equipping the rig with a highly mechanized pipe-handling system to promote a safe working environment, are expected to minimize injuries, and enhance operational efficiency.

• Cuttings injection. The drilling mud system and mud processing equipment will allow cuttings removal, processing, and reinjection into a cuttings injection well. Cuttings injection into a nonproductive formation through a special drilled-for-purpose well will reduce environmental impact of the Chayvo field development.

• ERD and efficiency features designed into the land rig. Many of the rig's features are designed to accommodate ERD operations, including a high torque top drive, 7,500-psi-rated stand pipe, four large capacity 1,600-hp mud pumps, high-capacity shale shakers, and mud-cleaning equipment.

The project will use Range-3, 5⅞-in., XT-57 high-torque drill pipe. With 45-ft average joint length, it will make tripping operations more efficient and fewer tool joints will result in less pressure drop in the annulus of the hole during drilling.

The pipe barn and bucking machine will make up single joints of casing into doubles, offline, while other drilling operations are underway. All casing strings will be run in doubles during critical-path rig operational time, compared to most land rig operations that run casing with the rig in singles.

• ERD offset benchmarking, cost estimate, and learning curve models. The company says it plans to use offset benchmarking and learning curve models generated from industry statistics on other ERD projects such as the UK's Wytch Farm, Argentina's Tierra del Fuego, and Russian operations to drill 5-6 km step-out ERD wells in the North Odoptu field.

• Fast tracking land rig development and construction to meet accelerated drilling target. ExxonMobil fast tracked the design, construction, and delivery of the rig through Parker Drilling, with the project taking 1 year from initial design to loadout. Construction of the rig components was a global effort, with various components made in Canada, Denmark, Germany, and the US.

• Early focus on ExxonMobil proprietary technology in integrated-hole quality, quantitative risk analysis. The company used methods that it developed to review wellbore stability issues thoroughly during planning for drilling and completion of the Chayvo ERD wells.

• Use batch drilling for increased efficiency and lower cost. According to company sources, it plans to drill and complete the first well from start-to-finish and gather data to accelerate the learning curve, which it will use for benchmarking the ERD process at Chayvo.

According to the operator's plans, it will batch drill the remaining wells to maximize process efficiency. Designed for easy moves along the well bay area, the rig is expected to be well suited for batch drilling operations.

• Include quality engineering function on drill team. Due to the remote location and difficult logistics for acquiring equipment and materials, quality assurance takes on a much more significant meaning. The operator plans to staff the drilling team with dedicated quality assurance and quality control personnel.

• Purchase land rig to mitigate risk of project delays. Direct ownership of the rig by the consortium removes financial burden from the contractor and gives the operator direct control over the rig's disposition.

Seismic activity

Sakhalin Island is in a very seismically active location, lying in a region where four of the earth's tectonic plates converge: The North American, Pacific, Philippine, and Eurasian plates converge just south of Sakhalin, near Japan.

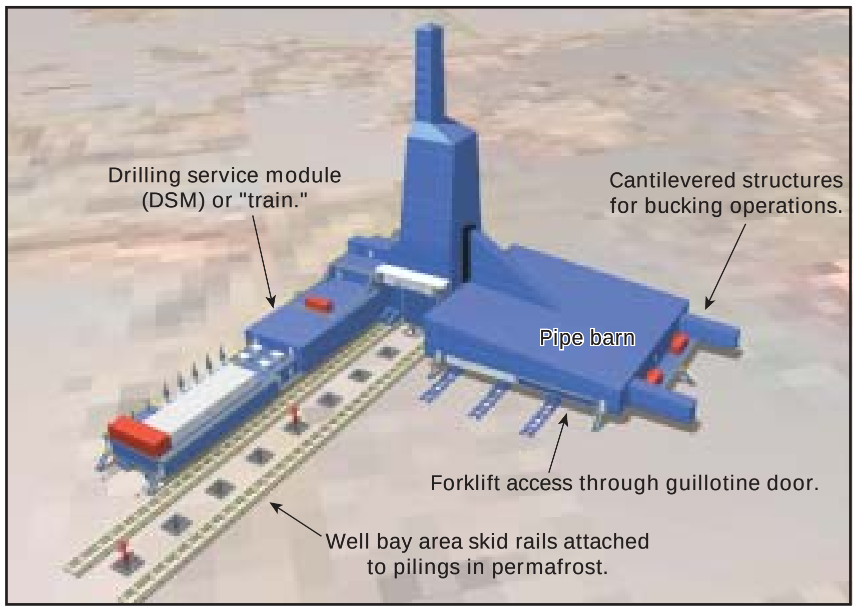
Sakhalin, in line with northern Japan, essentially straddles the North American plate-Eurasian plate boundary.

According to news accounts, a powerful magnitude-seven earthquake rocked the island in August 2000 but with no reported casualties or serious damage. The epicenter was near the center of the island. The earthquake caused a 4-m mudslide near the town of Makarov.

Russia's worst-ever earthquake, measuring 7.5 on the Richter scale, occurred on Sakhalin Island's north end in May 1995, killing 1,989 people in the town of Neftegorsk.

FULLY ENCLOSED SAKHALIN LAND RIG

Fig. 5



Source: Parker Drilling Co.

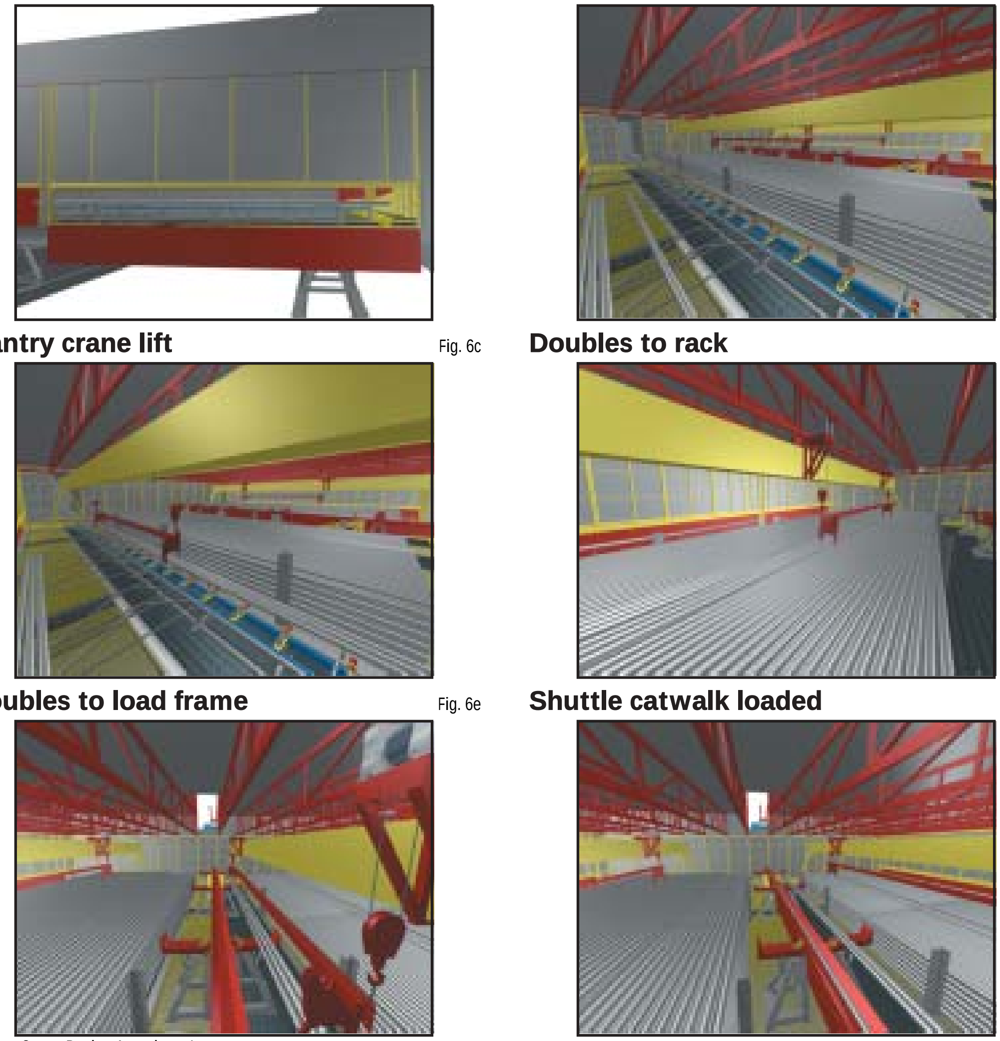
Exxon Neftegas and Parker Drilling say the significant design features of the land drilling rig for Sakhalin should allow it to survive serious seismic activity without catastrophic collapse of the mast or rig structure.

Parker Drilling's Denis Graham said the rig's mast is of a compliant design that could undergo plastic failure during a major earthquake but without catastrophic collapse, which would minimize possible injury to personnel.

Exxon Neftegas plans to install SCSSVs in the producing wells, not the normal practice for remote land-based wells, as a measure to prevent leakage in the event of damage to equipment during an earthquake.

PIPE-BARN LOADING AND BUCKING OPERATION

Fig. 6



Guillotine door — Fig. 6a
Roller table — Fig. 6b
Gantry crane lift — Fig. 6c
Doubles to rack — Fig. 6d
Doubles to load frame — Fig. 6e
Shuttle catwalk loaded — Fig. 6f

Source: Ocean Design Associates Inc.

Land rig design

Fig. 5 shows a 3D rendering of Rig No. 262, with the insulated panels enclosing the entire rig, including the drilling service module (DSM) to the left of the drilling package and the pipe barn to the right.

The exterior, with double-walled construction, will have 2 in. of insulation to allow heating of the entire rig and operation at arctic conditions down to −40° C. Designers intended the rig enclosure to allow personnel to work and transit throughout in a shirt-sleeve environment.

The skid rails, on either side of the well bay area, attach to pilings that are driven into the ground. Using clamps, the drilling module attaches to the skid rails and in turn to the pilings, a feature that is part of the rig design that allows it to withstand a severe seismic event and avoid catastrophic failure.

Secured to skidding beams that are placed on matting boards, the pipe barn and the DSM, also called the "train," will skid independently of the drilling package. The crew would leapfrog the skid rails to the front of the DSM and pipe barn, to follow the rig and move down the well bay area.

Pipe barn

The pipe barn allows the rig to perform tripping operations without racking pipe in the derrick, and it allows crews to buck drill pipe and casing into doubles offline or while the rig is doing other work. The barn also shelters and heats the tubulars that are actively in use and allows crews to move tubulars efficiently from racks to the drill floor.

The barn is equipped with two horizontal bucking machines. One is dedicated for drill pipe and one for casing.

The machine, dedicated for casing, can handle casing sizes up to 20-in. diameter.

The bucking operations are possible with the two-cantilevered structures on the aft end of the pipe barn (Fig. 5). Crews push a single of casing or drill pipe to the back of the barn into one of the barn extensions. The bucking machine makes it up with a second joint, resulting in a double.

As designed, the pipe barn will store about 11,000 m of 5⅞-in. drill pipe and 8000 m of 9⅝-in. casing. Designers made it capable of handling all casing sizes up to 30 in.

Fully enclosed, illuminated, and heated, the pipe barn in operation will protect the crews from arctic conditions for most of the pipe-handling operations.

The pipe barn will be 130-ft long by 134-ft wide, with an inside clearance height of 23 ft. The width doesn't include the cantilevered extensions for the bucking machines, which are 45-ft long.

Engineers expect the pipe barn, when fully loaded, to weigh 7 million lb.

Pipe barn operation

Crews align the center of the pipe barn with the center of the rig substructure's V-door during operation, which facilitates tubular transfer between the pipe barn and the drill floor. Engineers designed the pipe barn interior to be highly mechanized, but not necessarily automated.

1. A forklift loads or feeds drill pipe and casing through a side door. Hydraulically actuated guillotine doors allows rapid opening and closing to limit the exposure to the elements (Figs. 5 and 6a).

2. The pipe rack feeds Range-3 singles onto a roller table. Crews roll the joints into position for make up into doubles (Fig. 6b).

3. Once the bucking machine has made the pipe into doubles, a gantry crane picks up the doubles and puts them on the pipe rack. The gantry crane's claws operate hydraulically, eliminating the need for personnel physically to handle the pipe or rigging (Figs. 6c and 6d).

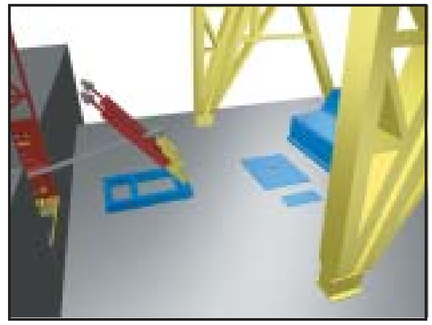
4. Crews perform the entire bucking operation upon initial set up of the barn and therefore pipe make-up is not on the critical path for drilling or tripping operations.

5. For moving tubulars to the rig floor, the gantry crane loads pipe onto the loading frames of the tubular shuttle (Fig. 6e). The loading arms hydraulically tilt forward to gravity feed the pipe into the tubular shuttle's pipe trough, with the tripper arm feeding one pipe double at a time (Fig. 6f). The tripper arm keeps the pipe separated on the loading arm.

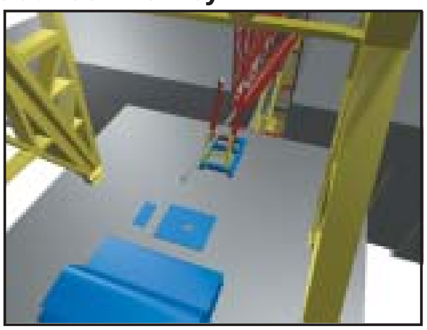
PIPE TRANSFER TO DRILL FLOOR — Fig. 7

Catwalk shuttle raised — Fig. 7a

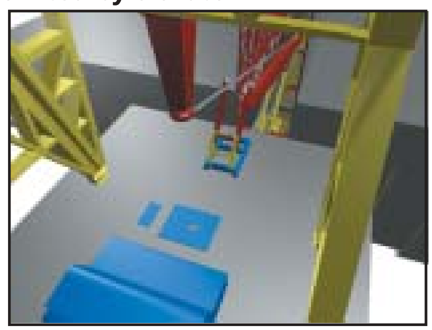
Push pipe to monkey — Fig. 7b



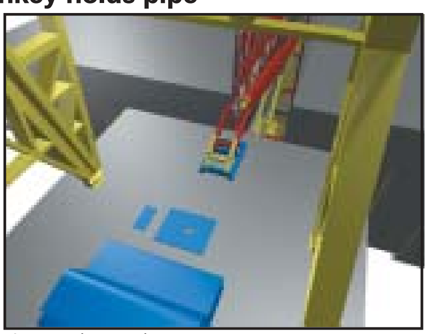
Pipe at floor monkey — Fig. 7c



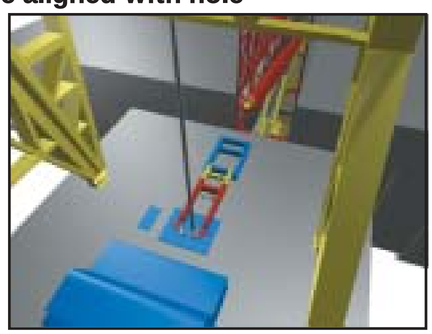
Pipe lifted by elevator — Fig. 7d



Monkey holds pipe — Fig. 7e



Pipe aligned with hole — Fig. 7f



Source: Ocean Design Associates Inc.

Fig. 7 illustrates the overall pipe transfer process, of moving pipe from the pipe barn to the rig floor.

6. The catwalk tubular shuttle rises up to align with the floor monkey and drill floor, with a 7.6-m vertical travel (Fig. 7a).

7. A skate within the tubular-shuttle trough pushes the drill-pipe double over the floor monkey's inner roller to align with the elevator (Figs. 7b and 7c).

8. The elevator from the traveling blocks or top drive latches onto the double pipe for hoisting (Fig. 7d). The red device at the top of the frame depicts the elevator, which is not drawn to detail.

9. The elevator lifts the pipe above the floor monkey's top rollers. The rollers close and support the pipe as it clears the tubular shuttle (Fig. 7e).

10. Floor monkey then swings pipe's end to the well center (Fig. 7f).

11. The telescopic arms of the floor monkey align the tubular precisely with the well center.

These hydraulic arms on the pipe monkey are set to index the position so that each presentation is at exactly the same place for each tubular.

The operation occurs in reverse when the rig is tripping out of the hole. The catwalk machine has a series of hydraulic arms that eject the pipe out of the catwalk machine back onto the loading arms.

Drilling package

The rig's drilling package is 35-ft wide by 230-ft tall and fully outfitted will weigh 2 million lb.

Fig. 8 shows a cross section of the rig through the middle. Engineers designed the shorter mast-assist structure to the right to improve torsional stiffness and strength over that of a conventional stand-alone mast.

Parker's Graham said, "A lot of thought and discussion about whether the rig should have a derrick or mast went into the design phase. The thought was that a mast would allow it to be rigged down and moved to another location, without bringing in rig builders.

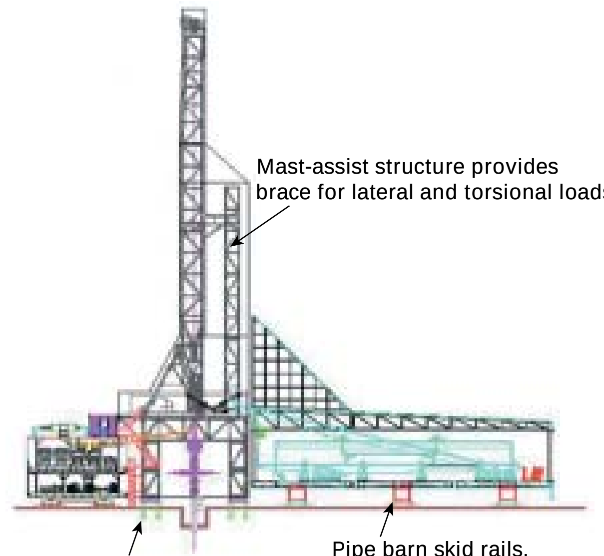
"To use a mast in a seismically active area, it must have something to reduce torsional load brought on by seismic moments. Attached to the mast, it provides bracing for lateral loads from both wind and seismic action."

Flared bottom boxes distribute the rig's load along skid rails that are welded to piles that in turn are driven into the ground (Fig. 8).

Part of the seismic design criteria, clamps attach the rig's substructure, along with the mast assembly, to the skid rails and driven piles (Fig. 9).

RIG CROSS SECTION

Fig. 8



Source: Parker Drilling Co.

As part of the seismic design criteria, clamps hold the rig's substructure to the skid rails that attach to piles driven into the ground (Fig. 9). Photo courtesy of Parker Drilling Co.

Engineers designed the mast for static rated hook capacity or casing capacity of 1.5 million lb, with 14 lines strung in the crown and blocks, and with a derrick setback capacity of 450,000 lb in seismic areas and 750,000 lb in nonseismic areas.

Fully winterized and with full setback load, the mast is rated to withstand 70-knot wind velocity and 93 knots with no setback load.

Graham said, "We have limited the mast's vertical racking capacity to 3,000 m of pipe. Only the bottom hole assembly and any culls (damaged pipe) that come from the horizontal racks will be set back vertically."

Avoiding the need to rack drill pipe in the derrick was part of the design philosophy for the seismically active area.

With ERD drilling operations requiring significant top-drive capability, engineers specified the Varco TDS-8SA AC top-drive system with 94,000 ft lb torque capability or 64,000 ft lb continuous load rating.

Since the top-drive system was not built for arctic conditions, the rig designers had to ensure the entire mast structure would be insulated and heated along with the rest of the rig.

Other major rig components include:

- OIME E-3000 drawworks that Parker had designed, with a 7838 eddy current brake.
- A Weatherford Power Frame iron roughneck.
- A Varco RST 495 rotary table.
- Varco PS 30 power slips.
- Weatherford bucking machines, in the pipe barn, for drill pipe and casing.
- Hydralift horizontal to vertical pipe-racking machine, in the pipe barn, with floor monkey, tubular shuttle, and gantry crane.

The rig designers equipped the rig with the Varco, MDT rig instrumentation system that will allow fully automated monitoring of the rig operation and performance and data transfer to any off rigsite location.

Configured to monitor all essential drilling equipment, the system will record the top-drive speed (rpm) and torque, rotary table speed (rpm) and torque, mud pump strokes/min, mud inventory, and the drawworks speed (rpm).

Graham said, "The crew complement will be 62-64. Of that, Parker expats will be limited to the supervision. We will have the superintendent and drillers, but majority of the crew will come from local Russian labor."

He added, "There will be a period of time when we have our own folks there, for training purposes, but once we get the Russian labor up to speed, we'll turn it over to them."

Drilling service module

Containing reserve mud pits, mud cleaning equipment, choke manifold, active pits,

Power distribution equipment sits above the power generation sets, during construction in New Iberia, La. The drilling services module or utility train contains 50 skid equipment packages that must stack together for the module to fit within a reasonable space at the drilling location (Fig. 10). Photo courtesy of ExxonMobil Corp.

Parker Rig No. 262 mast rests on scaffolding in the construction yard at New Iberia, La. The rig's drawworks will upright the mast from the scaffolding, which will be the rig-up method at the Sakhalin drilling location (Fig. 11). Photo courtesy of ExxonMobil Corp.

mud mixing equipment, mud pumps, power generation, air compressors, water tanks, and fuel tanks, the DSM or utility train consists of six modules and 50 skid equipment packages.

On location, the DSM will be 272-ft long by 45-ft wide and with its pits full of mud, will weigh 7 million lb.

Graham said, "In order to get all of this stacked up in a reasonable piece of real estate, we have to stack other equipment on top of the mud package."

Fig. 10 shows the DSM's power generators with the power distribution equipment stacked above.

Designers have given the DSM six Caterpillar 3516B diesel generator sets to power the main 600 VAC electrical bus.

Running together, the main generators will supply 9.759 Mw (13,081 hp) of power, which the rig will use partly for heating as well as the rig operations.

This compares with a typical 3,000 hp class land rig that would normally have 5.23 Mw of power generating capacity.

Extended-reach drilling operations require substantial mud pumping capacity because of the long distances involved and the task of transporting the cuttings from the drill bit and back to the rig through the drill pipe, wellbore annulus.

For this reason, the utility train will have four National 12P-160 mud pumps with 4½-in. liners that can deliver 7,500 psi to the rig's stand pipe, which is also rated for that pressure.

The DSM will have 9,000 bbl of mud storage capacity, with 2,000 bbl in the active pits, 2,000 bbl in the reserve pits, and 5,000 bbl of additional mud storage capacity.

Graham said, "All of these units are insulated, heated, agitated, and put into packages where the crew can manifold it to build an entire second system of mud while they're operating off of the active and reserve pits."

Rig designers have equipped the DSM with the following mud processing equipment:

- Two Swaco vacuum degassers with combined output of 1,500 gpm.
- A Brandt tandem scalping shaker.
- Four Derrick Hi-G dryer shakers.
- A desilter with 40-4-in. cones that yield 1,200 gpm of fluid output.
- Two decanting Derrick model DE-1000 centrifuges.

Construction, assembly

Vendors built the rig components worldwide, with the crew quarters built in Calgary, the bucking equipment in Germany, the tubular shuttle equipment in Denmark, and all of the drilling packages in New Iberia, La., or various locations in Texas.

Staging of equipment and fabrication of the rig has occurred in New Iberia, where crews are simulating rig-up operations that will occur at the Sakhalin Island drilling location.

Fig. 11 shows the Rig No. 262 mast resting on scaffolding in the construction yard at New Iberia.

Crews used the rig's drawworks to upright the mast from the scaffolding, which will be the rig-up method at the Sakhalin drilling location.

Clamps held the substructure to rails that were attached to 40 driven pilings to counteract the moment created by raising the mast.

A similar rig up will occur at the Sakhalin drilling location. Fig. 12 shows the mast fully raised following the procedure.

Logistics

For moving the rig to Sakhalin Island, Parker plans to load the rig out into a cargo ship.

Parker Rig No. 262 mast sits fully raised in the construction yard at New Iberia, La. Clamps hold the substructure to rails that are attached to 40 driven pilings to counteract the moment created by raising the mast (Fig. 12). A similar rig up will occur at the Sakhalin drilling location. Photo courtesy of Parker Drilling Co.

Offloading the rig at the drill site will require a beach landing with the rig packages.

A drive off ramp will allow trucks to move the loads to the drill site.

Graham said, "Every piece of equipment in every package has to be truckable. Even the pipe barn breaks down to a truckable size of 45-ft long by 12.5-ft wide. It all pins together; so the entire rig is a big erector set."

According to Parker, the rig will be loaded out by mid-July and should arrive at Sakhalin Island by mid-August.

With the ocean frozen from October to April, there are only a few months for equipment to arrive by ship or barge. ✥