ABSTRACT

The Sakhalin-1 project includes three offshore fields: Chayvo, Odoptu and Arkutun Dagi. Exxon Neftegas Limited is the operator for the multinational Sakhalin-1 Consortium of ExxonMobil; the Japanese consortium SODECO; affiliates of Rosneft, the Russian state-owned oil company, RN-Astra, and Sakhalinmorneftegas-Shelf; and the Indian state-owned oil company ONGC Videsh Ltd. Sakhalin-1 potential recoverable resources are 2.3 billion barrels (or 307 million tonnes) of oil and 17.1 trillion cubic feet (or 485 billion cubic metres) of gas. The project is being executed in phases. The initial phase develops the Chayvo field. The Odoptu and Arkutun Dagi fields will be developed as subsequent phases.

One of the major contractors for the first phase of the Sakhalin-1 project is Nippon Steel Corporation from Japan. In 2004 they awarded two major subcontracts for the offshore works to Van Oord Offshore: firstly, the installation and post-trenching of 20 km pipeline crossing of Tatar Strait, the narrow fairway between Sakhalin island and the Russian mainland; secondly, the trenching and backfilling for the 11 km long flowlines from Chayvo beach to the Orlan platform, including the construction of the landfall. This also included the installation of the multi-layered erosion protection rock around the Orlan platform, which was installed by another contractor.

Subcontractor Geocean from Marseille, France, carried out the pipeline installation offshore in Tatar Strait and the Australian subcontractor Subtrench developed the tailor-made post-trenching machine. The main contractor Nippon Steel did the pipeline installation at Chayvo. Both subcontracts were executed in 2005, but the work could not be fully completed, in large part owing to the short summer working window available in Sakhalin. As a result the last section of 2 km of pipeline, which was produced and stored on the seabed adjacent to the already laid pipeline, could not be pulled ashore in time and the operations had to be abandoned in late October 2005. The Russian contractor MRTS completed this 2-km section during the winter by working from the land-fast ice.

INTRODUCTION

The Sakhalin-1 project includes three offshore fields: Chayvo, Odoptu and Arkutun Dagi. Exxon Neftegas Limited is the operator for the multinational Sakhalin-1 Consortium (ExxonMobil interest 30%). Co-venturers include the Japanese consortium SODECO (30%); affiliates of Rosneft, the Russian state-owned oil company, RN-Astra (8.5%) and Sakhalinmorneftegas-Shelf (11.5%); and the Indian state-owned oil company ONGC Videsh Ltd. (20%). Sakhalin-1 potential recoverable resources are 2.3 billion barrels (or 307 million tonnes) of oil and 17.1 trillion cubic feet (or 485 billion cubic metres) of gas.
One of the major contractors for the first phase of the Sakhalin-1 project is Nippon Steel Corporation from Japan. In 2004 they awarded two major subcontracts for the offshore works to Van Oord Offshore: firstly the installation and post-trenching of 20 km pipeline crossing of Tatar Strait, the narrow fairway between Sakhalin island and the Russian mainland, secondly, the trenching and backfilling for the 11 km long flowlines from Chayvo beach to the Orlan platform, including the construction of the landfall (Figure 1). The latter subcontract also included the installation of the multi-layered erosion protection rock around the Orlan platform, which was installed by another contractor.

The project is being executed in phases. The initial phase develops the Chayvo field. The Sakhalin-1 Phase I Development Project will comprise several major facilities necessary for the drilling, treating, transporting and exporting of produced oil and gas from the Chayvo reservoirs located along the northeast coast of Sakhalin Island (Figure 2). These facilities will include:

- The Orlan Platform
- Chayvo Well Site with the onshore Yastreb Drilling Rig
- Chayvo Onshore Processing Facilities (OPF)
- Two pipelines (flowlines) from the Orlan platform to onshore processing facilities
- The Export Pipeline System: 206 km onshore and 20 km offshore 24" Oil Export Pipeline, westward across Sakhalin Island and Tatar Strait to the Russian mainland and then southwards to De Kastri
- Crude Oil Export Terminal and SPM Offloading Facilities at De Kastri
- The Chayvo Well Site will support drilling and production operations from 10 production wells located onshore and connected by horizontally deviating directionally drilled casings by the large Yastreb onshore drilling rig. Its location is approximately 500 m from the Orlan flowlines’ shore approach.

Key components of the site include drilling modules, power generation warehouse facilities and accommodations. It neighbors a temporary work harbor, used for the landing of a multitude of modules for the construction of the Well Site and the OPF (Figure 4).

**Work at Chayvo Field**

Production from Chayvo started on October 1, 2005. Current oil production is about 50,000 barrels (6700 tonnes) per day and gas sales through the winter have averaged about 60 million cubic feet (1.7 million m³) per day. Oil production is forecast to ramp-up to 250,000 barrels (33,000 tonnes) per day with the start-up of the Onshore Processing Facility (OPF) during late 2006. Domestic gas sales are expected to plateau at annual average rates of 270 million cubic feet per day (Figure 3).
The Orlan platform is an upgraded version of the Concrete Island Drilling Structure (CIDS) used in the Canadian Beaufort Sea. The facility will provide drilling quarters and production capability for the 20 wells planned for the development of the Chayvo Field. Upgrading required the replacement of the existing drilling rigs, the addition of a well bay module for 20 wells, production equipment, pipeline risers, pig receivers / launchers and refurbishment of quarters as well as other modifications. Oil properties are generally favorable with low wax content and containing no hydrogen sulfide (Figure 5).

The Chayvo OPF will process production from the Chayvo field offshore (Orlan platform) and from the Chayvo Onshore Wells and in addition will store and handle the Odoptu field production later. During Phase I of the development the Chayvo OPF will produce stabilised crude for sale and dry gas for re-injection into the Chayvo reservoir. Produced water will be treated for injection in disposal wells at the Chayvo OPF site (Figure 6).

Flowlines include various onshore and two offshore pipelines to transport the full well stream production between the Chayvo Well Site, the Orlan Platform and the OPF.

Figure 3. Layout of the Chayvo Field.

Figure 4. Overview of the Chayvo Well Site, which will support 10 production wells, with the Yastreb Drilling Rig.

Figure 5. The Orlan Platform is an upgraded version of the Concrete Island Drilling Structure (CIDS) used in the Canadian Beaufort Sea.
Flowlines also include the side tap assembly, pig launchers and receivers, valves, instrumentation and similar items to operate the flowlines at design conditions. The 36” (914 mm) diameter offshore full well stream flowline is a concrete coated (2.5”) pipeline for its offshore part of approx. 11 km. The 24” (610 mm) diameter gas re-injection flowline from Chayvo OPF to Orlan platform is a thick walled pipeline and is only epoxy coated.

The Oil Export Pipeline is a 24” (610-mm) outside diameter pipeline and concrete coated (3”) only when crossing the Tatar Strait from the landfall at Mys Uangi on Sakhalin Island till after the landfall at Mys Kamenny on the Russian mainland. Its total length is 226 km of which the Tatar Strait Crossing entails 20 km. Pipeline installation is by conventional S-lay from a dedicated barge, supplemented by two pipe pulls at the landfalls and one additional pull on the western tidal flats (Figure 7).

The Export Terminal at De Kastri includes the facilities and related control systems necessary for receiving, storing and handling crude oil for the loading of 110,000 DWT double-hulled (Afamax Class) tankers. The Export Terminal is located at a site on the north side of Chikhacheva Bay. The onshore facilities include a tank farm and loading control center, power generation facilities, measurement facilities, permanent housing, fire fighting, and warehouse-workshop facilities. The offshore facilities include a 6 km 48” pipeline to a bottom-founded SPM loading system.

TATAR STRAIT CROSSING

The Oil Export Pipeline crossing of the Tatar Strait is approximately 20 km in length, extending from Sakhalin Island at the Mys Uangi landfall westward, crossing 4 km of tidal flats near the shore and then crossing a 6 km navigable channel, followed by another 9 km across tidal flats to the westerly shore approach at Mys Kamenny on the Russian mainland (see Figure 2).

The pipeline specifications and dimensions are:
- Diameter 24” or 610 mm
- Wall thickness 15.6 mm
- Coating FBE
- Concrete coating 3” or 75 mm
- Weight underwater 128.8 kg/m’
- Weight above water 607 kg/m’
- Total length 19.7 km

The most demanding factor in the choice of the installation equipment for operations in Tatar Strait was the water depth at the very shallow tidal flats, where the available water depth during high water was 2 metres or less for over 6 km on the Russian mainland side. At low tide they were drying out for a large part. This required a very shallow draught pipe-laying barge and tugs, anchor handling equipment, crew boats, survey boats and auxiliary equipment with same.
It was accepted that the lay barge was at times bottomed out and pipe-laying production would suffer tidal delays.

Another determining factor in the planning and execution of the work at Tatar Strait was its very remote location and the absence of any local support infrastructure. As a result, working there required careful planning of crew changes and supply of materials and spares. Each piece of equipment needed to be well outfitted, well maintained and equipped with more than normal required spare parts to be able to function reliably at the work location. Since a total of 23 floating units were required to be mobilised, this was no small task. Most equipment was mobilised from Singapore together on a large submersible transport barge, the GIANT 3 (Figure 9).

The work at Tatar Strait further suffered from prolonged periods of exceptionally severe weather, which made the operation of the smaller work vessels particularly difficult. The utmost care had to be given to safe operations, crew changes and frequent boat-to-boat transfer of personnel, equipment and materials (Figure 10).

**Pipeline installation Tatar Strait**

The pipeline was laid in 2005 by conventional S-lay from a shallow draught barge, specially outfitted for this project in Batam, Indonesia, by pipe-lay contractor Geocean from Marseille, France. The line pipe was supplied by the main contractor to site on separate small barges and brought alongside the lay barge.

Gradual transfer by crane from transport barge to lay barge took place thereafter. Pipeline welding soon went well after the initial start-up problems and daily productions up to 1000 m were reached, well over the assumed average production of 700 m per day (Figures 11 and 12).
Pipe pull at Uangi landfall

Whilst the pipeline sections for the shore approaches were produced on the lay barge, these sections needed to be pulled ashore by a separate dedicated pipe pull barge. At the Uangi landfall the pipeline was pulled to KP 1.1 with a wire running from the “lay barge” via a sheave to the “pull barge”. Figure 13 shows the pull configuration at the start of the pipe pull. Prior to the pipe pull, pull anchors were tested. The configuration was designed for pull forces of maximum 150 tonnes. This means that the force on the holdback anchor would be maximum 300 tonnes. Ultimate Holding Capacity (UHC) of the 18 tonnes Stevpris holdback anchor was calculated as 680 tonnes.

In the original Pull Operation Procedure the lay barge was planned to reach KP 1.45 and pipe would be pulled from KP 1.45, but from a pull force point of view a pipe pull from KP 1.65 was also possible. As this reduced the tidal downtime of the lay barge in the pipe-lay operation (deeper water would be reached earlier), KP 1.65 was chosen as production station for the lay barge. The pull barge was stationed at KP 2.

Pipe pulling was performed by one of the two linear winches placed on the dedicated pull barge. The anchor was placed on the beach by the pull barge crane at high tide and pre-loaded. A total of 550 metres was pulled ashore on Sakhalin Island to KP 1.1 at the Uangi shore, with the lay barge at KP 1.65. The soil consisted of silty sands. Start-up pulling forces rose to a maximum of 140 tonnes. Continuous pull forces were never higher than 65 tonnes. The pull barge was equipped with two 300-tonne linear pulling winches and numerous cable reels with 92 mm diameter steel wire rope (Figures 14 and 15).

Pipe pull on Kamenny flats

At the Kamenny shore a 2 km pull was planned into a pre-dredged trench. Prior to
this approx. 3.5 km was pulled from the lay barge and lined up with the end of the already laid pipeline. Subsequently an in-water tie-in was required because of available water depth and the lay barge not being able to lay the last 4 km directly as a result of available water depth.

Near the Kamenny landfall the pipe has been pulled with a wire running from the lay barge directly to the pull barge. Towards the shore the pipe has been installed in a curve with an offset of 30 m towards the south. This was necessary to allow the last 2 km pipe string to pass the already installed pipeline in order to enter the pre-dredged trench in a correct manner. The submerged weight had to be reduced from 130 kg/m to 70 kg/m by means of attaching inflatable buoyancy bags.

The efficiency of the top of pipe-installed buoyancy was tidal dependent. Figure 16 shows the seabed profile at Mys Kamenny. The Kamenny flats are a very shallow long area. The soil consisted of silt to sandy silt and clayey silt. At times pull forces reached up to 280 tonnes at start-up and up to 225 tonnes during continuous pulling.

**Pre-dredging the trench for the last 2 km**

Pre-dredging for the last 2 km was carried out by an excavator mounted on a small barge, the DN17, with two spuds and a dredge spread consisting of a hopper (container), a jet-pump, a dredge-pump, a generator and related piping. During start-up several changes in the hopper jetting system were made, but at times the soil appeared to be too sticky to be pumped and frequent boulders were delaying the progress. Subsequently the working method was changed to a combination of side-casting and rainbowing (Figures 17 and 18).

After changing the work method the production increased but also the forces in the pontoon’s spud system whilst side-casting. These forces caused cracks in the spud poles and needed to be repaired. Quantities of boulders, stones, rock and shells were found in the 2 km trench, which caused some delays because of cleaning and repairing hopper and grid, but most of the cleaning and repairing happened during the shifting of the barge.
Pipe pull for the last 2 km string

After the finish of the pipe pull to KP 18.4 the pull barge started to install the pull wire for the pipe pull of the last 2 km string towards the shore into the pre-dredged trench.

The barge DN17 was in the meantime converted to small pull barge with a 150 tonne linear winch installed with a 64 mm pull wire (Figure 19). By this time it was mid October and well beyond the working window originally foreseen. Subsequently a tie-in at KP 18.4 had to be made between the already installed pipe and 2.0 km pipe string at KP 18.473.

The 2.0 km pipe string had to be pulled in three stages to KP 20.4:
- Stage 1: From KP 14.85 to KP 17.346 or 1500 m with the Pull Barge.
- Stage 2: From KP 17.346 to KP 18.4 or 1100 m with Pull Barge.
- Stage 3: From KP 18.4 to KP 20.4 or 2000 m with DN17.

First two stages were completed with many delays owing to very low tide (not enough water depth), frequent bad weather and the consequences thereof. Pull-out forces exerted by the pull barge for the string of 2000 m after it had been stored for a couple of days on the seabed, appeared to increase well beyond the DN17 pulling capacity. Since all this happened towards the end of October, with temperatures regularly below zero at night and ice building up on the dry tidal flats, the decision was taken to abandon these final operations for safety reasons and leave the pipe string on the seabed. The whole equipment spread then demobilised from the site at Tatar Strait. This section of 2 km was ultimately completed by Russian contractor MRTS during the winter of 2005 by working from the land-fast ice.

Post-trenching of pipeline

According to requirements, the pipeline had to be buried with a cover varying from 1.5 m to 2.2 m over the top of the pipe (TOP) when crossing the navigation channel. For environmental reasons the burial method by post-lay trenching (Figure 20) was chosen over conventional trench dredging, with the exception of the last 2 km at Kamenny, which would be pre-trenched.

Development and testing of the tailor-made post-trenching machine was done by a subcontractor in Australia. The machine was tested prior to shipment to Sakhalin in an abandoned quarry, which could be partly flooded to simulate operating conditions. As an add-on it was decided to

![Figure 19. The barge DN17 was converted to small pull barge with a 150 tonne linear winch.](image1)

![Figure 20. The post-trenching machine at work in the Tatar Strait.](image2)
install vertical cutting chains at the front end of the machine (Figure 21).
In hindsight, this proved to be a wise decision. Performance of the trenching machine varied considerably with changing soil conditions. At the Uangi side of the Strait many obstructions in the form of boulders and logs were encountered as well as unexpected hard soils in which side slopes were at an angle of 60-70 degrees.

At the Kamenny side trenching went rather smoothly, but because of delays in the pulling operations as a result of bad weather, the trenching of the pipeline to the required depth in some places could not be fully achieved. This required coming back in 2006 to complete the work.

Figure 21. The post-trenching machine with vertical cutting chains in the front end.

Pipeline-lowering work during 2006
As a result of the limited amount of further pipeline-lowering work a different dredging vessel was mobilised in 2006: the Coastal Worker, a small self-propelled suction dredger with one suction pipe, dredge pump and jet pump. The vessel was transported from Ijmuiden, the Netherlands, to Korsakov, Sakhalin, and back on a heavy lift cargo vessel. Pipeline-lowering operations went satisfactorily and work was completed by the beginning of July 2006 (Figure 22).

Pipeline rock protection installation
Tatar Strait (2006)
Apart from pipeline remedial lowering in places during the 2006 work window, certain areas of the pipeline in the shipping channel needed to be covered with rock for protection against ice scour and dropped anchors. A total of 19,325 tonnes of rock was placed in two gradations, filter rock and armor rock. This was done by the rock placement vessel Jan Steen using the same rock transport spreads as was used at Chayvo. This is further discussed below under “Chayvo offshore pipelines”.

Figure 22. The Coastal Worker, a small self-propelled suction dredger, was mobilised for the remaining pipeline-lowering work in 2006.
Personnel accommodation vessels
The Trinity Supporter was “home” for contractor’s personnel and client representa-
tives on site during the project execution. The vessel provided accommodation for up
to 125 persons, craneage and sufficient space for stores. The number of beds was
increased during preparation for mobilisation to 150. Good communications, which
included email and Internet use, were ensured by a permanent satellite up-link.
From the outset the whole construction crew was made aware of the remoteness of
the work location. Despite this the morale on board was good, which was ensured by
good western standard catering services, a well equipped gym and free availability of
internet on board amongst other amenities (Figure 23).
Locating a suitable vessel was not easy and became one of the critical activities,
because of the process for the flag dispensation required for entry into the
Russian Federation. In the end two suitable vessels were found. The other vessel, “Beta”,
was used by the pipe lay subcontractor and provided accommodation to all pipe laying personnel, which amounted to
approx. 200 people.
During 2006 one smaller accommodation vessel, the Russian ship named Akademik
Shokalskiy, was used in conjunction with the Jan Steen and Coastal Worker
operations to accommodate another approx. 20 passengers, including the
diving crew, client and Russian authorities representatives (Figure 23).

CHAYVO OFFSHORE PIPELINES
The Chayvo Offshore Pipelines work involved the trenching and backfilling for the 11 km
long flowlines from Chayvo beach to the Orlan platform, the installation of the
cofferdam at the landfall, and the installation of the multi-layered erosion protection rock
around the Orlan platform, which was installed by others mid July 2005 (see
Figures 1 and 2). The pipe pulls of both flowlines to shore were carried out by the
main contractor. Special dredging tasks were the dredging of the access pit for the
pipe spools and two glory holes for the platform’s cathodic protection system
anodes.

Landfall construction
Since the pipe pulls of the flowlines were scheduled during early July this meant that
cofferdam construction needed to start during the winter season. A 150-m
cofferdam with two wing walls was constructed amidst snow walls was
constructed amidst snow and ice (Figure 24).
The commercially most attractive solution was to import all the equipment and all
sheet pile materials on a temporary basis into the Russian Federation. It arrived in
Korsakov, Sakhalin, onboard a coaster from Europe.
Particularly demanding were the conditions of the roads during transport of the heavy equipment and sheet piles to the Chayvo landfall site. To a large extent these transports suffered from an early thaw when road conditions became difficult and at times impossible. Also the roads on site were giving similar problems. With substantial additional efforts the cofferdam was nevertheless completed in advance of the pipe installation operations.

As can be seen from the aerial photo (Figure 25), the cofferdam works coincided with installation of beach erosion protection for the Chayvo Well Site north of the landfall site and the deepening of the temporary work harbor further to the north.

**Pipeline trench dredging and backfilling**

*Near shore dredging*

An access channel approx. 2 km long from the open sea towards the cofferdam had to be dredged to provide access so that the main contractor’s pipe-lay barge Korushio 2 could perform two pipe pulls. The dredging was done by the self-propelled cutter suction dredger Aquarius connected to a 500 m floating discharge line with a moored spray pontoon, which delivered the dredged soil into the designated temporary storage areas (Figure 26).

The Korushio 2 then performed the first pipe pull of the 36” flowline and laid the pipeline to a position approx. 1200 m offshore. It then returned to pull the 24” flowline into the cofferdam structure and subsequently laid the line all the way to the Orlan Platform. Finally the 36” flowline was recovered offshore and also laid towards the platform. In the meantime the cofferdam could be closed and the laid pipelines could be pressure tested. Also the main contractor could start tie-in operations to the valve station of the onshore pipeline infrastructure (Figure 27).

*Offshore trench dredging and backfilling*

Trench dredging and backfilling was performed by a number of trailing suction hopper dredgers, including the Volvox Asia, Kaishuu and Amerigo Vespucci, assisted at times by cutter suction dredgers Aquarius and Leonardo Da Vinci (Figure 28). A total of 1.3 million m³ was dredged and the sediment discharged in designated temporary storage areas for later use as backfill sediment. Burial requirements for the flowlines necessitated dredging to a trench depth of up to 5 m in places in water depths ranging from 8 m to 20 m. Side slopes were generally 1 in 4 and the seabed consisted of dense to very dense sand.

Backfilling constituted around 1.0 million m³. Backfilling was required to be done by pumping back through the suction tube rather than by large mass disposal through the bottom doors to avoid shifting of the pipelines. Special operations performed were the dredging of the access pit (pipeline interface) for the two spools to the Orlan platform, two anode pits for the Orlan platform cathodic protection system components and some seabed levelling prior to the Orlan platform set-down operations on July 15 2005.
Pipeline de-burial operations
Because the installation of the two pipe spools between the laid pipeline and the Orlan platform could not be achieved during the 2005 work season, the pipeline ends had been covered with backfill sand at the end of the season. For the start-up of pipe spools installation these pipe ends had to be uncovered. To do this the trailing suction hopper dredger HAM 312 was mobilised from Dubai to Sakhalin. The vessel was converted and equipped with a mass-flow device at the end of the suction pipe. By pumping water back through the suction pipe, a rather large flow with sufficient pressure could be directed towards and very close to the seabed. This mass flow eroded the backfilled sand and brought it into suspension. The tidal currents then transported it away from the dredged area. The pipe was lowered to a position not less than 2 m above the pipeline(s) to avoid the draghead touching the pipe(s).

This system performed successfully in removing some 20,000 m$^3$ of sand, but became, as expected, less effective the deeper the trench became. It was foreseen that the mass flow system could not remove all sand directly around the pipelines. This caused the main contractor to mobilise a submersible pump frame on their construction barge to remove minor quantities of sand.

ORLAN PLATFORM
Erosion protection installation (2005+2006)
The Orlan platform’s steel base with skirts measures approx. 90 x 90 m and is installed in 15 m of water depth on a large sand ridge. Within days following its installation, substantial scour effects occurred caused by the relatively strong tidal currents around the platform. This required unscheduled remedial work and additional rock and caused many deviations from the planned work right from the start.

The general erosion protection design showed two rock layers (D- and C-type rock) with a coarser armor layer (B-type rock) added at the corners of the platform base (see Section D in Figure 29). In order to protect the pipeline interface location on the northeast side of the platform against ingress of large amounts of sand, an artificial channel was created by placing two rows of containers out from the platform in the pre-dredged pit. This created a channel with fixed width in which the pipe handling equipment needed to be located later. The containers were filled with coarse gravel (D-type rock) for stability and rock berms were built against the containers.

The design of the pipeline interface erosion protection was extensively tested in a model basin in Ottawa, Canada. The design is shown in Section A in Figure 29. Large 5 to 7 tonne blocks (type A rock) will form the top layer of the erosion protection in this location.

Erosion protection rock types and amounts
Table I shows the gradations applied in the erosion protection design, the cover on the anode pits and pipeline interface, as well as over the pipeline corridor close to the platform. A total of approx. 80,000 tonnes of rock was placed in 2005, including the additional amounts for urgent remedial work caused by the occurrence of scour holes around the platform immediately after its installation in the field. Another approx. 60,000 tonnes was placed in 2006 at Chayvo.

Operations around Orlan of other work spreads (DSV Seaway Hawk and platform supply boats) required regulation of the frequent simultaneous operations (SIMOPS). Initially the diving support vessel was given priority in installation of anode cabling around the platform, but later the erosion protection installation activities were given free access to the platform perimeter as much as possible. The platform, understandably, could not function without regular offloading of supplies from the

Table I. Gradations applied in the erosion protection design.

<table>
<thead>
<tr>
<th>Type</th>
<th>From (Mass)</th>
<th>To (Mass)</th>
<th>From (Size)</th>
<th>To (Size)</th>
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<tbody>
<tr>
<td>A</td>
<td>3750 kg</td>
<td>6250 kg</td>
<td></td>
<td></td>
</tr>
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<td>325 kg</td>
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<td></td>
<td></td>
</tr>
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<td>C</td>
<td>10 kg*</td>
<td>325 kg*</td>
<td>200 mm</td>
<td>600 mm</td>
</tr>
<tr>
<td>D</td>
<td>4.75 mm</td>
<td>125 mm</td>
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</tr>
</tbody>
</table>
large platform supply vessels (Figure 30). The organisation of this at times difficult task lay in the hands of the Offshore Installation Manager on the platform. This was organised by introducing a strict reporting system, whenever a vessel needed to enter the 500 m zone around the platform.

As a result of various and frequent weather delays and the inevitable short summer working window at Chayvo the two pipe spools (24” and 36”) could not be installed during the 2005 work season. Figure 31A shows the situation achieved at the end of the 2005 construction season. In addition to this protection an additional temporary protection was placed over the pipeline interface area, consisting of large 3 m³ sandbags and D- and C-type rock. This influenced the 2006 operations, since this temporary protection needed to be removed before remaining construction operations could resume. The second drawing (Figure 31B) shows the final situation expected at the end of the 2006 season.

**Installation methods and spread**

For the execution of the rock placement services the DP Class 2 rock placement vessel Jan Steen was used both during 2005 and 2006. The Jan Steen is equipped with side-stone placement facilities on both sides of the vessel and for this project was equipped with a 20 m retractable steel fall pipe. Moreover using her onboard crane, she is able to place the large 5 to 7 tonne individual rocks (A-type rock).

Transfer of rock from the transport barges to the Jan Steen is done while both vessels are alongside each other at sea at a distance of about one nautical mile from the Orlan platform. Adequate fendering between vessels is provided. The vessel is equipped with state-of-the-art survey equipment (e.g. multi-beam echo sounders and profilers) and operates with a 3D-rock placement model in which each change or planned addition to the erosion protection is monitored and logged (Figure 32).

For the transport and storage of rock material, two large submersible barges with a DWT of 24,000 T were used. During 2005 these were the rock barge Giant 3 with tug Smit Luzon and rock barge Ocean Seal with tug Hua An. During 2006 Rock barge Giant 3 with tug IOS Glory and Rock barge Giant 2 with tug IOS Victory were used (Figure 33).

All barges were outfitted with a concrete layer as deck protection and a 2.5 m high coaming to contain the rock. For rock transfer operations each barge was further equipped with two large excavators and two wheel loaders. The rock material was produced at a quarry near the harbour of Vostochny near Vladivostok and shipped from there. Barges were loaded by driving trucks directly onto the barge via a heavy-duty ramp and tipping on the deck. A stockpile of approx. two barge loads was kept on the quayside at the loading location.

Figure 30. The platform could not function without regular offloading of supplies from large icebreaking platform supply vessels such as this.

Figure 31. **A**, A drawing of the erosion protection status at the close of the 2005 season. The two uninstalled pipe spools and the pipeline with ends uncovered are circled. **B**, A drawing of the erosion protection when finished in 2006.
delays and under good weather conditions. Local support infrastructure is very minimal, if not absent, on site and limited in the capital of Sakhalin, Yuzhno-Sakhalinsk. Any spares coming from abroad usually spend 2 to 3 weeks in customs.

**Visa and related matters**

During the preparations for the construction phase of the Project in early 2005 it became clear that seaman’s books alone for the marine crew were no longer accepted as entry documents into the Russian Federation. The Russian Border Guards required formal entry visas for all crew, including all marine crew of all supporting vessels. This became known in February with a May-start on site in view. The result was a huge number of visa applications, since applications for back-up crew also needed to be processed in time. All in all over 1200 visas were applied for (including both Chavyo and Tatar Strait). Apart from the time involved, a cost of over 800,000 Euros was incurred for handling personnel and direct visa costs.

Furthermore, all foreign personnel seeking multiple entry visas were required to submit the results of an HIV test. In addition, the operator of Sakhalin-1 facilities required a drug and alcohol test for every worker prior to going to work in Sakhalin. Also noteworthy is that this contractor was not the only party wanting to start working in Sakhalin during the summer window of opportunity in May 2005. At times there were over 1500 applications per week being presented. The visa bureau in Yuzhno-Sakhalinsk has only a limited number of personnel and the personnel was only able to register and produce 50 invitation letters per day for 6 days per week at best.

**Permits and licences**

Last but not least, a project of this magnitude anywhere in the world, but in particular in Russia, requires a long, labourious and time-consuming process to obtain the required permits, licences, approvals and concurrences from national/federal, regional and local governmental authorities.

Whilst most of the activity to obtain these approvals lies with the operating consortium the vessels, requiring careful planning of crew changes and supply of materials and spares. A typical journey from the Netherlands to Tatar Strait required a flight of over 12 hours, a train ride of 12 hours, a 2-hour bumpy ride in a four-wheel drive truck and a journey by crewboat of 8 hours. All of this excluding

**LOGISTIC CHALLENGES**

**Crew changes and supply of materials and spares**

Both work locations Tatar Strait and Chayvo are very remote. Very long journeys are required for all foreign personnel to get to...
of the oil and gas facilities, the main contractor and the major subcontractors were required to provide their specific input into the documentation in time. They also needed to take care of those licences, permits and approvals that were required for conducting their own business in the Russian Federation, e.g. the Contractor’s Construction Licence or Gostroy Licence.

Without trying to be complete, an idea is given below of the long permit application process:

• The Project was commercially announced at the end of 2001. This enabled the Project to a transition from explorations to development stage.

• The project received positive conclusion of the State Ecological Expert Review (SEER) in July 2002 for both the Extended Reach Drilling and the Phase 1 Development Justification of Investment (JoI). In October 2002 the Gladvesexpertiza of Russia approved the JoI for the Sakhalin-1 Project. Favourable conclusions had previously been received from the Ministry of Natural Resources and the Ministry of Development and Trade. This was a key milestone and allowed the Project to proceed to the next stage, that of the TEOC or Technical and Economic Substantiation of Construction.

• In April 2003 the Authorised State Body approved the Development Programme and Budget for the Sakhalin-1 Project.

• In February 2004 the Ministry of Natural Resources of the Russian Federation approved the positive conclusion of the SEER-Panel on the TEOC for Phase 1 of the Development of the Sakhalin-1 Project. This Panel, comprising 49 leading Russian experts from the Russian academia, technical and environmental organisations of the Russian Federation. In April 2004 the Russian Federation approved the TEOC for Phase 1 of the Sakhalin-1 Project. This approval is the key milestone that allows the operator to commence construction.

Each of these major approvals required literally hundreds of other approvals and concurrences as pre-requisites from tens of Russian federal and local government agencies. Further permits and documentation entailed:

• Land Allocation Permits;
• Permits to Construct Landfalls;
• Construction Permit for a Subsea Pipeline and for the ORLAN platform (or: Offshore Installation Permit);
• Water Use Licence and Water Use Agreement, including a fish damage simulation study and cost calculation;
• Permission for temporary import of foreign flag construction fleet/Cabotage Permit (also called the ‘Flag Waiver’);
• Development of project Detailed Design Documentation in accordance with Russian rules, regulations and legislation;
• Development of an Oil Spill Response Plan and facilities, integrated with main contractor and client;
• Marine Mammal Protection Plan (including the last 100 Western Gray Whales);
• Navigation Safety Plan for both work sites at Chayvo and Tatar Strait (shipping lane);
• Severe Weather Plan (typhoons during the autumn);
• Medical Evacuation Plan, integrated with main contractor and client;
• Waste Management Plan (for vessels);
• Air Emission Permit; Waste Disposal Permit;
• Development of environmental reporting on air emissions, waste management, WUL compliance, socio-economic statistics of employed persons and so on;
• Execution of pre- and post-construction environmental surveys, as well as monitoring during construction;
• Inspection and Test Plans; Development of the project As-Built and Commissioning Dossier;
• and numerous ‘Akts of Transfer’ of the facilities to the Russian Authorities.

CONCLUSIONS

The Sakhalin-1 Project in the Russian Far East was a many-faceted and challenging project involving several co-venture partners each working within their areas of expertise. The cooperation amongst these partners was essential to the successful completion of the task. During the dredging, trenching and rock placement works, several challenges specific to the remoteness of the project and the severe weather conditions were encountered. The remoteness of the site in the Far Eastern part of Russia meant that transporting crews and other personnel to the area required carefully designed logistics, allowing time both for extensive travel and for obtaining the necessary legal documentation.

The extreme distances that foreign personnel had to travel to get to the vessels demanded precise planning of crew changes. It also meant providing satisfactory accommodations on vessels nearby the work areas.

The absence of any local support infrastructure on site meant that working there also required planning of the delivery and presence of supplies of materials and spares. Each piece of equipment needed to be well outfitted, well maintained and equipped with more than normal spare parts. The ability to replace parts and make repairs in a timely fashion was essential to avoid unwelcome, costly delays.

The magnitude of this challenge was enhanced by the inevitable short summer working window in Sakhalin which lasts from June to October. Winter ice clears during the end of May and in October the typhoon season starts with ice returning in November. This tight window did indeed hinder the completion of certain aspects of the operation which had to be postponed until summer of the following year.

The completion of both Tatar Strait crossing and Chayvo offshore pipelines works were continued in 2006 with the Tatar Strait crossing being finalised during July and at Chayvo the final work at the base of the Orlan platform being installed in August and the completion of the erosion protection rock over these spools being completed during October 2006.

The enormity of such an offshore project in a severe climate demands flexibility and innovative organisation regarding crews, vessels and materials. The satisfactory completion of the dredging works emphasizes the significant contribution the dredging industry makes to the development of maritime infrastructure for offshore resources.