



MATING OF THE *MOLIKPAQ* DRILLING RIG

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Introduction

For development of the Piltun-Astokhskoye Field in arctic waters offshore Sakhalin Island, Sakhalin Energy Investment Company Limited purchased the mothballed Canadian drilling rig *Molikpaq* and had it refurbished and converted to a drilling and production platform. This was contracted to Daewoo Heavy Industries Limited (DHI) at their shipyard in Okpo, South Korea. To make the platform suitable for the larger water depth at its new location, a steel substructure was built in Russia and towed to Korea for mating with the *Molikpaq*. In March of 1998, ARGONAUTICS Marine Engineering was hired by DHI to provide the Mating Superintendent, working closely with DHI Task Force Team leader In-Tae Kim, for this challenging marine operation, which took place in the last week of May 1998.



The Molikpaq

The original *Molikpaq* (meaning “giant wave” in the Inuit language) was a mobile, bottom founded drilling rig, designed to operate in arctic conditions. Its hull is an octagonal-shaped steel caisson structure, open in the center for the sand core. The plan view at the base measures 365 x 365 ft, reducing to 285 x 285 ft at the top. The caisson supports a 240 x 240 ft box girder deck structure, which carries the drilling and topside facilities, accommodation module and helideck.

As part of the conversion, new, larger wave deflectors were installed.

For the production mode, a process module, weighing 2,500 t, was constructed and installed by Daewoo at its Okpo Shipyard. An inclining test showed that the total weight of the *Molikpaq* in its mating condition was 43,000 t based on its 26.2 ft draft. Its vertical center of gravity was 60.7 ft above the keel.

The Spacer

Since the rig's new location in the Sea of Okhotsk is in deeper waters, a 50.5 ft high steel structure was designed by Sandwell Engineering Inc.¹ and Rubin Central Design Bureau for Marine Engineering, to increase the rig's hull depth. This "Spacer" was built in sections at the Amur Shipbuilding Plant and assembled in Bolshoi Kamen. The octagonal, donut shaped 15,000 t Spacer measured 361 x 361 ft and was outfitted with 3 stability towers. A 3.5 ft deep skirt protruded below the base line. On the top, a total of sixty four pedestals, each 6.5 ft in height, were to ensure that the support loads of the *Molikpaq* were guided from its transverse bulkheads into the Spacer frames. The maximum allowed misalignment between the Spacer pedestals and the *Molikpaq* bulkheads was 4 inch. Because of the uncertainties in the "as built" surveys of both structures, the lateral mating tolerance was specified to be half of this, i.e. 2 inch. Three steel stoppers were installed to assist with the alignment of the structures during mating.



The Spacer hull was subdivided into 8 main ballast tanks and 8 corner tanks. A hydraulic operated valve system was installed for gravity ballasting. Deballasting was effected by compressed air, provided by a bank of rental compressors, mounted onto a barge. The compressed air was forced through the vent pipes via a manifold. The Ballast Control Container was mounted on the center buoyancy tower, where the valves for the vent pipes and air manifold were also located.

Upon completion in Russia, the Spacer was towed to the Daewoo Heavy Industries, Ltd. shipyard in Okpo for final preparations, testing,

¹ *Spacer Design and Fabrication for Sakhalin II Project*, J.C. Bruce, et. al., OTC 1999, #10818

and last minute changes before the mating operation.

Mating procedures

A large number of procedures were developed by DHI, detailing every aspect of the mating operation. These were issued for review by all parties involved, commented on, revised, and reissued. The final set of approved procedures served as guidelines for each step of the operation. The two most important procedures dealt with the mooring system and the (de)ballasting of the Spacer.

A mooring arrangement was designed for the following purposes:

1. To moor the Spacer during ballasting, with the ability to survive a realistic design storm at all possible drafts;
2. To control the *Molikpaq* during mating and maneuver it in place against the Spacer stoppers;
3. To moor the mated units, with the ability to survive a realistic design storm.

A system consisting of 9 anchors was developed. Five anchors were connected directly to the Spacer, while the remaining four were connected to mooring barges. These barges were outfitted with two mooring winches at the stern for independent control of the Spacer and the *Molikpaq*.

The ballast procedure of the Spacer was the most critical part of the operation. Given the asymmetric configuration of the three buoyancy towers, stability was minimal once the Spacer's top deck submersed. Because of the limited instrumentation (full indicator lights for the main ballast tanks and level indicators for the corner tanks), final control was based more on behavior rather than actual tank levels. The original procedure was tested with a computer simulator designed by Sandwell Engineering Inc. Although this procedure did seem to work on the computer simulator, potential for water locks in vent pipes and free surfaces in some of the main tanks made this a very risky procedure. Based on the Mating Superintendent's extensive experience with ballasting ships and barges, combined with DHI's offshore experience, a safer procedure was developed and its feasibility confirmed with both the computer simulator as well as by Daewoo's inhouse stability calculations, using Ultramarine's MOSES software.

Deballasting the Spacer after mating required maintaining stability throughout the whole operation, including the transition through the pedestals. This 6.5 ft air gap needed to be transited gradually. A 3 deg heel combined with a 3 deg trim provided a workable solution.

Mating Schedule

The original mating schedule was set up early in the project and it showed a total of 13 days for the complete mating operation, from tow out of the Spacer to return of the mated units. Since offshore time is equivalent to exposure and potential delays, especially in an El Niño year, key to success was to reduce the offshore operations to an absolute minimum. The offshore tasks were reviewed and reduced or eliminated where possible. Examples of tasks eliminated are the full submersion test of the Spacer unit and the offshore welding of securings between the 2 units after mating. The submersion of the Spacer was the most critical part of the mating project. Since the ballast equipment was already tested before tow out, combined with the fact that it was a one time operation only (gaining experience for future operations was not relevant), it was considered safer to eliminate this test. Given a reasonable level of friction, it was demonstrated that the *Molikpaq* would stay in place on the Spacer even in moderate storms or in case of list due to damage of a Spacer tank. Welding offshore would mean unnecessary exposure.

Logical breaks were built in for survival of any bad weather periods. During the eight weeks on site, it became obvious that this year's weather was different than that of previous years and the changes of getting an uninterrupted 5 day calm weather window were slim to none. The new schedule allowed for the mating to be executed within a number of short discrete windows, with the critical operations scheduled for day light hours only. After completion of each task, the decision to stop or continue could be made basis the actual and forecasted weather situation.

Preparations

In addition to developing the procedures and the schedule, the preparations for the mating operation performed by DHI in advance and consisted of the following activities:

1. Survey of the proposed mating site;

2. Specification and selection of mooring equipment and assisting tug boats;
3. Testing of the Spacer ballast equipment (valves, level sensors, control panel, etc.);
4. Preparing the compressor barge;
5. Pre-installation of the anchors and mooring system;
6. Training of the yard's ballast crew;
7. Team building.

The proposed mating site was surveyed for depth, levelness, obstacles (including sub-surface), and anchor holding power. The required depth was such that if control over the Spacer during ballasting was lost somehow, it would end up safely on the bottom with its buoyancy towers still partly out of the water. The optimum location was 29.0 m deep, with a level and soft bottom surface.

For the mooring equipment, anchors, chains, and barges of opportunity were selected. Inspection trips to their various storage locations were organized. Same for the tugboats, which were selected from available boats in Pusan and Ulsan.



The Spacer was towed from Russia with blind flanges installed over its water inlets. Upon arrival at the Daewoo shipyard, additional 4" air operated valves were first installed in the 8 corner tanks, after which all blind flanges were removed by a diver. These 4" valves were installed to be able to better control the water flow in the corner tanks. During the preparation phase, it became clear that the 12" valves generated too large a water flow for accurate control of the corner tanks in the critical phases. Their delayed reaction time further increased their inaccuracy. During testing, two of the 12" valves failed to close completely and had to be



refurbished. Also the level sensors in the corner tanks had to be replaced.

The compressor barge consisted of a total of 12 trailer mounted rental compressors, hooked up to a central pipe line, feeding a high pressure air receiver which in turn fed a low pressure storage vessel. A set of 6 flexible air hoses connected the low pressure manifold on the barge with the air flow control manifold on top of the center buoyancy tower of the Spacer. This barge was also outfitted with a generator set (to run the compressors), portable office space and a mooring winch.



The mooring system required to moor the Spacer and control the Molikpaq during mating was pre-installed on the alternative mooring site. Bad weather frequently hampered the anchor lay operation. Once all anchors were installed, some failed the 100% pre-load test, requiring the piggy backs of large concrete blocks.

The shipyard's ballast crew was trained to ballast and deballast the Spacer. Theoretical background information on stability in general and that of the Spacer in particular was provided. The Spacer's ballast system was explained. The

ballast crew was involved in the testing of this system. The final ballast and deballast procedure was practiced with the computer simulator and "what if" scenarios were tested.

Team building sessions were organized to ensure that the various supervisors, which originated from different shipyard departments, were all fully aware of the procedures and were able to directly communicate with each other.

Mating operation

May 22, everything was ready to go and the weather looked promising. The Spacer was towed out to the mating site and connection of the pre-installed anchors and winch barges commenced. The compressor barge was towed to the mating site and hooked up to the Spacer's center tower. Pre-ballasting began and the freeboard was reduced to 6 ft. Completion of the mooring was not until late next day, which delayed the submersion of the Spacer with one day, as this was too critical of an operation to do in the dark. On May 24, the Spacer was slowly submerged by flooding the main ballast tanks while carefully maintaining trim and heel control with the pre-ballasted corner tanks. In spite of some problems with the level sensors and full tank indication lights, the critical ballast operation was successfully executed without ever losing control and the Spacer safely reached its full submersion draft (i.e. pedestals well under water) without touching the bottom. Once this draft was reached, the *Molikpaq* was cleared for tow out as the weather forecast for next day seemed favorable.

On May 25, the *Molikpaq* arrived at the mating site. The Spacer was ballasted further down to mating draft. Weather conditions initially looked favorable, but during final maneuvering towards the submersed Spacer, the horizon started to darken and a wind started to blow. The operation was temporarily aborted to see if this unreported front would blow over. White caps started to appear and wind speeds exceeding 20 knots were measured. The *Molikpaq* became harder to control by the attending tug boats and it was decided to tow her back to the yard and postpone the mating operation with one day (next day's weather forecast looked good). The Spacer was deballasted approx. 5 ft to bring it into survival mode. Later in the day, heavy seas caused the compressor barge to break loose, ripping 3 of the 6 flexible air hoses.



Early morning next day, the wind and waves were calm. The broken air hoses were replaced and the Spacer was ballasted down to mating draft. At 8:20, the *Molikpaq* was alongside and the green light for the mating operation was given. Slowly the unit was towed over the submersed Spacer, while one by one, the mooring lines from the winch barges were connected. At 11:54, at slack tide, all wires were connected and the tugboats discharged, but remaining standby close by. Final positioning was delayed by the breakdown of one of the winch control panels, which required some emergency repairs.

Positioning continued at 13:08 and 40 minutes later, the *Molikpaq* was in position against its three stoppers, as confirmed by the underwater cameras. The Spacer was deballasted some more to ensure firm contact, before the diver was sent down to physically measure the actual gaps, if any. Of the three stoppers, two were in solid contact and one showed a 3/16 inch gap, well within allowable! Deballasting continued, gradually going from the level mating condition to the required 3 deg heel and trim condition. Deballasting continued throughout the night and the *Molikpaq* was slowly lifted out of the water. Next morning at 6:22, all Spacer tanks were empty and the mated *Molikpaq* was at its sailing draft, ready for disconnection.

The mated units were unmoored and towed back to the Daewoo yard for welding of the *Molikpaq* bottom to the Spacer pedestal tops and completion of the refurbishing. Late August, the unit was towed to Sakhalin and successfully installed at its new location.

Conclusions and recommendations

The Mating Superintendent was presented with a custom built Spacer structure and preliminary mating procedures that were still to be fully developed. Within the given limitations, changes were made to improve the system and the procedures. The ballast and mating procedures were simplified where possible, and the offshore exposure time reduced. Contingency plans were developed.

The actual mating of the *Molikpaq* drilling rig onto its Spacer was extremely successful. The achieved alignment was well within the allowable limits. Frequent bad weather hampered the preparations and delayed the actual mating operation, but the procedures were designed to cope with this and safety was never compromised. Good cooperation between all personnel involved, representing many different companies and nationalities, was an important factor in the overall success of the operation.

For future operations such as this one, it is recommended to review constructability with the Contractor, such as DHI in this case, and to involve the Mating Superintendent at a much earlier stage, preferably at the design stage of the structures. Practical input early results in a better system and may prevent “last minute” problems and consequential expensive remedial solutions.

Acknowledgements

The authors acknowledge Daewoo Heavy Industries, Ltd. for being given this unique opportunity to supervise this challenging mating operation performed by DHI’s Task Force Team, under leadership of In-Tae Kim. Meng-Hoe Wong of MH Wong Marine Pte., Ltd. and the engineers of Plus International Company Ltd. are acknowledged for their excellent engineering efforts, for frequently working around the clock to get all procedures done in time, and for their continuous support during the preparations and the actual mating operation. On site representatives of Sakhalin Energy Investment Company, Ltd., Marathon Upstream Sakhalin Services, Ltd., and Global Maritime are acknowledged for their good cooperation and valuable input throughout the project.