OKHOTSK SEA & SEA ICE, MOMBETSU, JAPAN, 24-28.2.2002

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ABSTRACT

Ice as an environment creates a great challenge to oil and gas exploration and production. The additional requirements compared to the open water operations are considerable. The fleet in ice around a drilling/production platform has to be able to bring the supply of equipment to the platform, take away the drilling waste, break ice around the platform (ice management), help the export vessels in coming in and mooring, to be an emergency response vessel and handle rescue operations for people and the environment.

Ice conditions are different in every frozen sea and thus the composition and quality of the supply fleet may differ considerably. The vessels today in supply operations in ice are multifunctional (traditional icebreakers only broke ice assisting cargo vessels).

This paper describes the operations in the Caspian Sea; how the fleet has been developed and what is to be expected in the near future. Also the possibilities in other areas are discussed with examples of possible vessel concepts.

HISTORY

Ice operations historically have been related to import and export transportation of materials and goods to/from ports. The transportation is carried out by cargo vessels which are assisted by icebreakers. The icebreakers have been owned by governments in each individual country and the escort has been provided as service. This type of operation has been the practice in Canada, Finland, Russia, Sweden and the United States. In the late 1970ies interest in year-round operations in the Arctic started and many projects for ships intended to operate in the Arctic wintertime were started. At the same time offshore oil exploration and later production in the North Sea started and new kind of ships were needed.

In Russia the winter traffic to Yenisei River (Dudinka) started in 1978. The transportation was namely bringing in equipment, fuel and food the export local raw material. The fleet consisted of icebreakers (Arktika and Sorokin Classes, and ice strengthened cargo vessels (20000dwt, class UL). Everywhere else in the Arctic all operation was restricted to summer season.

In the 1980ies exploratory drilling started first in Canada, Beaufort Sea and later in USA, Alaska. The last decade has been in many ways breakthrough in operations in icy environment. Development in the Caspian Sea (Kazakhstan) has lead to a major discovery of oil (Kashagan) and the exploration has started the development of a whole system with drilling platforms, supply vessels and barges designed for ice operation. Simultaneously in the Sea of Okhotsk on the shelf of Sakhalin Island seasonal production has started. In the north (Russia) plans for development have been continuing already over ten years and still the realization of the projects see to be in far future. The two major interests are both in the Barents Sea region; Prirazlomnoye oil field in the Pechora Sea in 20 meter of water and Shtokmanovskoye gas field in the central Barents Sea in over 300 meter water depth.

In the following chapters there is a brief review of operational experience in the different areas so far.

Experience in the Beaufort Sea

The key operators in the 1980ies in Canadian Beaufort Sea were Dome Petroleum (Canmar) and Gulf Canada. Both built their own fleets. Canmar was more aggressive and started to build supply fleet on experimental basis having in focus large oil tankers and projects for both escort icebreakers and tankers were done. The Gulf Canada fleet consisted on two icebreakers (Terry Fox and Kalvik) and two supply icebreakers (Ikaluk and Miskaroo), see Figure 1. The key vessels in Dome fleet were; first Canmar Kigoriak and then Robert Lemeur, see Figures 2. However, the discoveries in the Beaufort sea were not that encouraging, specially as the oil price started to sink. Anyhow the experience gained during those years built a foundation and knowledge for the future possible operation in the area and gave as well guidelines for other areas as well. Typical ice environment in the Beaufort Sea is the existence of multi-year ice that basically breaks loose at the edge of the Polar Pack and drifts southeast to the area.

In the Beaufort Sea the drilling sites are not very far from the main base Tuktoyaktuk and thus the vessels can be constructed more to cope with the ice than transporting large volumes of cargo.

Figure 1, Gulf Canada Fleet in winter harbour.

Figure 2, Canmar Kigoriak and Robert Lemeur.

Experience in Newfoundland

The eastern coast of Canada has mainly one major hazard; ICEBERGS. The icebergs are drifting to the south from Greenland/Baffin Bay and the oil fields being at the Grand Banks the oil drilling/producing platforms are just on the route of the icebergs. The main unconventional supply operation is to tow the icebergs (deviate their drift) away from getting collided with the platforms. This operation requires a good forecast system for detecting the bergs and making prognoses for where the bergs are headed to be able to decide whether the ice bergs are to be towed away or not. A tow of an iceberg is far from easy operation and requires several powerful vessels and experienced crew, see Figure 3.

Figure 3, An iceberg under tow

Experience in the Caspian Sea

The newest area in the icy offshore world is the Caspian Sea. The northeastern Caspian Sea freezes almost every winter. This area is very different from any other offshore area; very shallow water (under 7 m), thin ice drifting fast with changing speed and direction and ice is piled up in shallow areas forming rubble piles with freeboard up to 10 m, Figure 4. Ice piles up against any drilling platform as well, Figure 5.

Figure 4, An ice rubble pile in the Caspian Sea

Figure 5, Ice piled up at a drilling site

The present operation is concentrating on the gigantic Kashagan oil field, which is in water depth 4-7 m. The supply base is in Bautino, Figure 5, some two days trip from the drilling site. Part of the supply distance is open water. In the future when more oil discoveries are explored there might be a need for a supply base at other locations as well. Today the AGIP consortium of Kashagan field operate two Icebreaking supply vessels, Arcticaborg and Antarcticaborg (Figure 6), and three small tug boats (not designed for ice operation, Figure 7). The operation started with the above mentioned fleet.

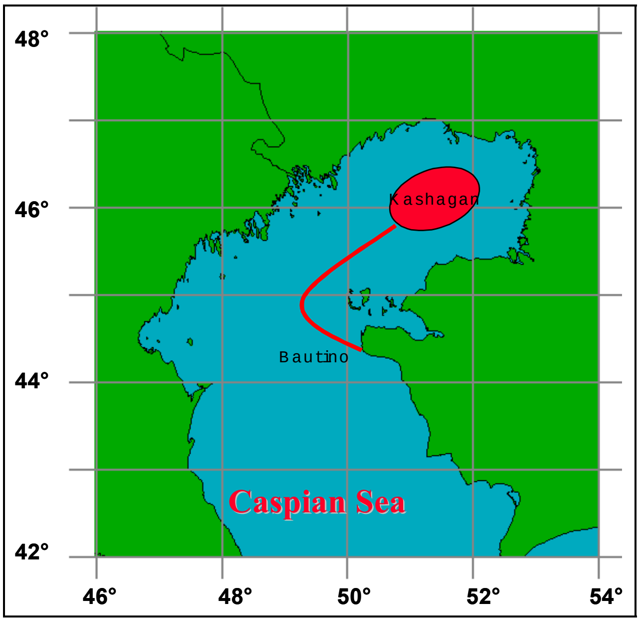

Figure 5, Caspian operation area

Figure 6, IBSV Antarcticaborg

Figure 7, Small tug towed and a barge towed by IBSV

The design of the IBSVs for Wagenborg Kazakhstan B.V. started in 1997 taking into consideration the special requirements of the operation area, namely.

- Icebreaking capability, level ice 0.9 m
- Operation in shallow water, draft of the vessel to be 2.9 m
- Ability to break apart grounded rubble piles
- Considerable supply distance
- Etc.

In the design phase the knowledge of Wagenborg Shipping B.V. and Kvaerner Masa-Yards Arctic Technology were united in harmony and the ships were successfully delivered after 16 months from the start of the project. The project is in more detail described by in reference 1. In the time when the operation started at the Kashagan site there were no ice capable barges available for transportation purposes and mission dedicated barges were to be designed, see reference 2.

This way the fleet is getting more and more complete partly on the basis of learning by doing. However, during the process there have been some key issues that have not been taken into consideration in full, namely.

- Rescue operations
- Standby duties
- Access to the platform at all times

The original rescue system is based on Arktos vehicles, which have a covered shelter at one end of the platform behind a gate. The problems in this arrangement are: ice may be piled in front of the escape gate, the Arktos vehicle seems to be unstable when moving partly on ice (one unit capsized in tests). The Arktos gates are to be kept ice free at all times, which is something the present fleet is not the best to do. In Figure 8 the Arktos gate is ice free and in Figure 9 the Arktos vehicle is at the gate.


Figure 8, Arktos gate.


Figure 9, Arktos vehicle

By the time the IBSV:s were designed there was no word about acting as a standby vessel with rescue duties. However one of the IBSV:s has been acting as a standby vessel, which she is not suitable lacking quarters for rescued people and proper fire fighting equipment.
The platform is placed on a rock perm and protected by vertical piles (6 m apart). Ice tends to pile up between the piles and the platform and furthermore extending the rubble pile outside the

pile line. In all supply operations the vessels and barges are to be docked next to the protective pile line and no ice is to remain between the vessels and the piles (the cranes on the platform cannot reach the cargo).

Experience in the Barents Sea

The operations in the Barents Sea still wait to be started and no winter supply operations have taken place. The exploratory drilling has been limited to summertime and ice operation has not started as no year-round facilities exist. However, some plans and designs for the supply fleet have been made.

Experience in the Sea of Okhotsk

During the last three years seasonal production has started on the north east shelf of the Sakhalin Island. The exploration platform Molikpaq was installed in 1999 and since then oil has been pumped through a loading buoy (SALM) to a tanker. The supply base is on the southwest side of the island and the supply distance is very long. The vessels used are former Gulf Canada supply icebreakers (Ikaluk & Miskaroo). Presently, when the operation is growing, work is done to study the possibility to establish a supply base closer to the drilling sites.

Experience in the Bohai Bay, China

The Bohai Bay is relatively shallow and especially in the northern area the sea freezes. Today the China National Oil Company has production in the area year-round. Ice is moving quite heavily and makes a threat to the stationary platforms, especially of jacket type. The ice management and supply operations are handled in ice by a couple of icebreakers and an supply icebreaker (former Robert Lemeur).

DEDICATED VESSELS

As can be clearly noticed from the above short summary, in most of the cases the fleet is not originally designed for operation in the area in question. Only in Caspian Sea the fleet is being designed and built for continuous operation in the area. Even the vessels in the eighties in the Beaufort Sea were more like experimental in nature than real work horses. This means that most of the vessels operating today are far from optimum both economical and technical respect.

Safety and operational feasibility as basis for fleet design

When dedicated vessels for specific area and specific operation are designed, the design should always be seen as a part of a fleet. No single vessel can do all the required tasks and still be feasible. On the other hand, there are tasks that cannot be neglected for the sake of feasibility. The fleet must be designed to carry out all the necessary task under any environmental condition or the operation has to be designed with the possibility for down-time to maintain human and environmental safety.

To design a feasible fleet, one should first list all the basic tasks that need to be done. Typically these should include:

- delivery of the supplies to the platform
- transportation of the possible waste from the platform
- transportation of people to and from the platform
- maintenance of production facilities, including sub-sea equipment
- transportation of products from the platform

In addition to the basic tasks there are also the tasks related to safety. Typically these include:

- firefighting
- rescue and evacuation
- oil spill response

It seems that the normal practice is that the basic tasks lead the decision making in the development of the fleet. This is somehow understandable in open water conditions, since there are several proven options for safety functions. However, in ice the situation is different. A vessel, which is fully capable to operate in all ice conditions, in poisonous or explosive atmosphere (worst case) and is capable to perform firefighting or evacuation tasks as well, will be probably the most expensive vessel in the fleet. There are not many options to solve the problems related to the safety functions. To avoid unnecessary down time at the platform, the best way would be to start the design with safety analyses and base the fleet development on fact that the vessels resulting from such an analyses are a must.

Sakhalin East-Coast as a case

The environmental conditions offshore Sakhalin East-Coast are very demanding. Level ice thickness is above 1.5 meters and ice ridges can easily be up to 30 meters thick. In addition, the risk of having grounded rubble around the platform in the shallow water areas is obvious. With certain flexibility in the regularity requirements the basic tasks can be handled with even the existing powerful icebreaking supply vessels or similar designs, but for safety functions, where there is no flexibility, new and more capable designs are required. When these designs exist, it is a question of optimization to set the requirements for the supply fleet.

The basic requirements for the Emergency Response Vessel could be as follows:

- Ability to approach the platform under any conditions
- Capability to evacuate up to 150 people
- Firefighting class 2 or 3
- Initial oil spill response capability

In addition this vessel can also have other functions as long as they do not endanger the main task. These could be related to offshore maintenance work. Additional requirements would then be:

- Capability for ROV support
- Capability for diving support
- Capability to give icebreaking assistance for transportation vessels
- Dynamic positioning

This type of vessel would have some 16-20 MW propulsion power. To ensure the 24 h stand-by capability, two vessel of this type would be required. Again it is a question of optimization. The second vessel could be designed for lower performance in ice and assume that she would be used only during the summer period. The question is, would this vessel find work to do in ice free areas during the winter time? In figure 10 there is an example of a vessel tested for conditions of Okhotsk Sea

For the basic task, the supply operations, the requirements will be dependent on flexibility of the entire supply chain. In case no downtime is allowed, the performance requirement will be the same as for the Emergency Response Vessel. On the other hand, if the ERV exists and is designed to work as an assisting icebreaker for the supply vessels, the requirements for supply vessel performance can be lowered.

Figure 10, A vessel in ice rubble

The requirements could be typically:

- Deadweight capacity 3000-5000 tons
- Propulsion power 12-16 MW
- Ice strengthening for the heaviest conditions
- Firefighting class 1

FUTURE

The operators, in most of the icy areas, are today using secondhand vessels designed for other areas and duties. The operators are eventually finding out what are the real requirements and margins in their operation. Also, most of the present vessels are getting old (nearly 20 years) and they need to be replaced. This gives the opportunity to naval architects, designers, researchers and shipyards to further develop the skills and services.

In the future the design of the fleet should be based on careful risk assessment of all the operations. The work carried out today gives valuable background information for the safety planning as well as for the feasibility analyses of the whole supply chain.

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