

# ARCTIC OFFSHORE TANKERS OPERATIONS

*Paper discussed problems relating to marine oil transportation in Arctic by specialized tankers designed for operations in high geographical latitudes at extremely low temperatures and ice conditions. Such sophisticated kind of vessels was built specifically for Arctic oil export terminals operating in extremely harsh climate. Special types of vessels were introduced to cover rescue operations in Arctic.*

## INTRODUCTION

They are two remaining areas on Earth which have unexplored resources of fossil hydrocarbons. First of them, Antarctic is protected by Protocol on Environment Protection to the Antarctic Treaty which entered into force on January 14th, 1998. Under this international agreement any activity relating to mineral resources, other than scientific research is prohibited. Second polar region, Arctic is lacking such protection and open for exploration and mining of mineral riches. Accordingly US Geological Services assessment Arctic Ocean lies on vast resources of oil and gas. Graphic below depicts Arctic hydrocarbons endowment:

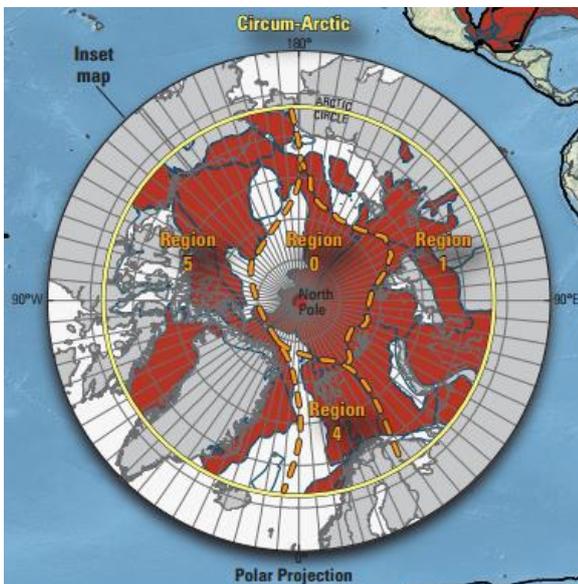


Fig. 1. Arctic oil and gas deposits assessment modified from [3]

Today, in many locations in Arctic oil and gas is produced at offshore fields. For time being, offshore fields are located outside permanent ice limit when navigation in first-year ice is much easier. Gas is transported by subsea pipelines to shore facilities but oil in some installations is exported by purpose built Arctic shuttle tankers. First Arctic tanker was S/S "Manhattan", modified large crude oil carrier with strengthened hull and ice breaking bow. In 1969 she made epic voyage crossing Northwest Passage. After initially successful navigation in ice covered waters she sustained damage to her cargo tanks and required icebreaker escort. Thoughtfully, her tanks were filled with sea water during this trip. She never resumed

her service in polar waters. Idea of marine oil transportation in Arctic was put on hold for several years. In 1982 through 1996 Panarctic Oils Company Ltd operated Bent Horn export terminal at Cameron Island in the Canadian Archipelago, using double hulled tanker for oil export during summertime only. After closure of Bent Horn there were attempt to create another oil terminal in Canadian Arctic but plans were met with fierce opposition from local population and politicians had to scrap them. Technological advance in shipbuilding resulted in 2002 with first double-acting Aframax size tanker M/T "Tempera" for year-round operations in Baltic Sea without icebreaker assistance. She was equipped with Azipod propulsors which became standard kind of propulsion for modern icebreakers and Arctic bound vessels Era of modern offshore Arctic shuttle tankers has begun in 2008 with commissioning of 49597 gross tonnage shuttle M/T "Vasily Dinkov" for Varandey terminal services. Fleet of similar vessels follow suit and currently several of them are engaged in active operations in Arctic for crude oil carriage.

## 1. OFFSHORE ARCTIC TERMINALS

### 1.1. Barents Sea terminals

First large scale Arctic offshore oil exporting terminal began its operation in 2008 at east corner of Barents Sea, 22.5 km from shoreline. This place also is known as Pechora Sea. named after Pechora River estuary. Position of Varandey oil export terminal is marked on map below with red triangle and number 10:

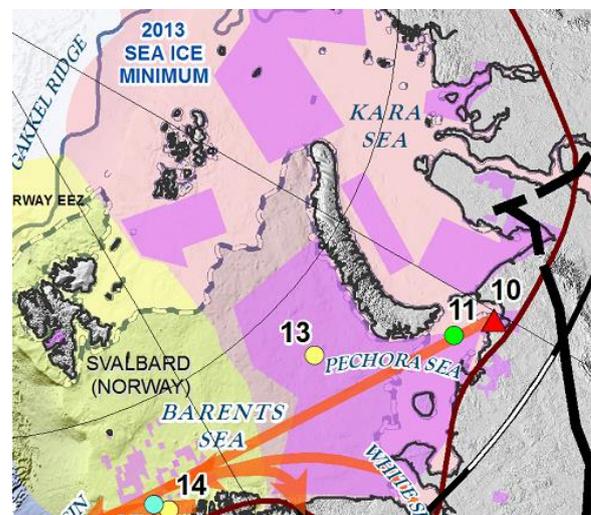


Fig. 2. Geographical position of "Varandey" terminal, marked as red triangle, modified from [6]

The terminal is built as a steel caisson structure consisting of a base piled to the sea bottom, living quarters, and rotary upper structure called Mooring and Loading Arrangement (MLA). It is designed to withstand pressured of rafted ice with thickness to 2.7 m. Oil from onshore storage tanks is delivered through 2 pipelines with 812 mm diameter. Maximum offloading capacity is 8,000 m<sup>3</sup>/h. Terminal is served by purpose build shuttle tankers "Vasily Dinkov" class, transporting oil to storage and export facility near never freezing port of Murmansk. Image below shows M/T "Timofey Guzhenko" loading at "Varandey" terminal in ice conditions:



Fig. 3. M/T "Timofey Guzhenko" loading at "Varandey" terminal [7]

Shuttle tankers designed for "Varandey" terminal can move on their own through ice 1.5 m thick but mooring and loading operations are supported by icebreakers for safety reasons.

Second Arctic oil terminal in Barents Sea came online in 2014 as "Prirazlomnaya" drilling, oil-producing and offloading oil platform. Figure 2 shows position of this rig as green circle. Installation is located 60 km from shore and about same distance west from "Varandey" terminal. It is designed as gravity base steel caisson resting on sea bottom at depth 20 m. Its environmental design criteria are similar to "Varandey" terminal structure. Export hose is handled by loading arm to keep hose away from water and ice. Winter and springtime operations require icebreakers assistance to clear ice rubble accumulated around platform. Two special purpose icebreakers are on stand-by near platform as part of emergency response plan, including oil spill containment and clean up in Arctic conditions. Produced oil is being offloaded to Arctic offshore shuttle tankers "Kiril Lavrov" class, built specifically for this terminal. Oil is discharged at "Belokamenka" floating, storage and offloading unit (FSO) near Murmansk.



Fig. 4 M/T "Mikhail Ulyanov" loading at "Prirazlomnaya" terminal [4]

## 1.2. Sea of Okhotsk terminal

International Maritime Organization defines boundary of Arctic waters as approximated by circle at 60° North with line running across Barents Sea, excluding waters warmed by Gulf Stream. Almost the whole Sea of Okhotsk lies outside those boundaries but navigation there is difficult in wintertime due to ice and very low air temperatures, reaching even -35° C. In 1996 large reservoirs of oil and gas were found offshore of Sakhalin Island and oil companies began development of Sakhalin I, II and III projects in harsh conditions similar to Arctic. Produced oil is exported from "De-Kastri" oil terminal located in Tatar Strait, close to mainland shore of Khabarovsk Krai. Installation lies at latitude 51° North, but winter navigation requires ice-class tankers and assistance of icebreakers. Terminal went online in 2006 and quickly became one of the major hub for oil export in Far East. Installation is designed to handle Aframax size tankers, 110,000 deadweight tonnage (DWT) in year-round operations. Design loading capacity is 8,000 m<sup>3</sup>/h. Position of "De-Kastri" terminal is marked on map below with red triangle and number 8:

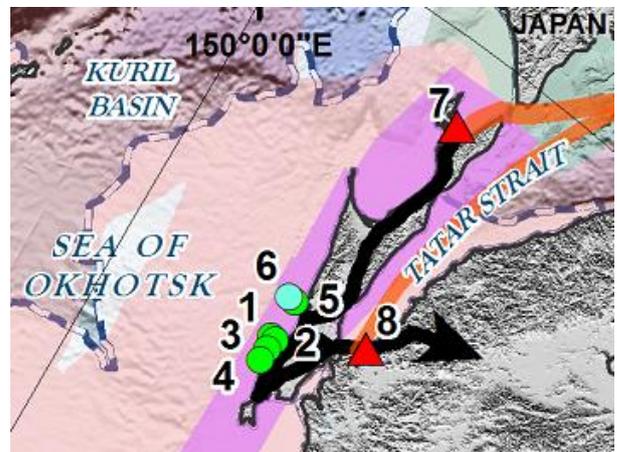


Fig. 5. Geographical position of "De-Kastri" terminal, marked as red triangle, modified from [6]

Terminal has been designed as Single Point Mooring (SPM) to moor a dedicated Aframax size tankers in ice conditions and temperatures as low as -35° C. Vessels are required to have ice class 1C. Offloading arm prevents export hose from contact with water or ice at all times. Rotating head with hawser allows for export tanker to weathervan freely. Position of rotating head, control of hose and hawser winches, operation of valves can be done remotely from the tanker or shore base. Figure below shows Aframax tanker at De-Kastri terminal in light ice conditions:



Fig. 6. Aframax size tanker loading at "De-Kastri" terminal [8]

SPM tower is protected against ice pressure by ice-breaking cone. Installation is designed to withstand on its own pressure of level ice with thickness 1.5 m and 2.0 m for ridged ice. Offloading operations with moored tanker are limited to ice thickness 0.55 m. This is the biggest SPM terminal in Far East.

## 2. VESSELS

### 2.1. Arctic shuttle tankers "Vasily Dinkov" class

This class of vessels have been designed for transferring oil from Arctic terminal "Varandey" to FPSO "Belokamenka" near always ice-free port of Murmansk for export with, occasional Atlantic trips. Their general specification is based on Panamax size vessel. With draught (loaded) 14 m, length 256 m and breadth 34 m they have gross tonnage (GR) 49,597 and cargo carrying capacity 71,294 tons. Hull form is compromise between ice-breaking capability and good open water performance and seakeeping. Underwater hull lines are based on double-acting icebreaker and ice-breaking tanker M/T "Tempera". In light ice conditions vessel moves forward, using her bow to break an ice and to push it aside.. When ice becomes too thick, vessels reverses her movement and uses spoon shaped stern for icebreaking. Impact resistant steel propellers help to break large ice chunks and thus reduce friction resistance. Pronounced skegs forward and aft act as protection against large floes going under the hull. Driven by two Azipods, each 10,000 kW, vessel has open water service speed 16 knots and can move astern at 3 knots through first-year ice 1.2 m thick. Accordingly to design criteria vessel is able to sail astern in ice 1.5 m thick without icebreaker assistance. Installed dynamic positioning system is capable for operations in ice conditions. Hull friction against ice is reduced by coating with Teflon® based paint with very low friction coefficient. Main power source are 2x Diesel-driven generators 11,600kW, 6.6 kV AC and 1x generator 4,350 kW. Vessels have polar class PC 6 in accordance with International Association of Classification Societies (IACS). It is typical class for today's offshore operations in Arctic. This class allows vessels for unassisted summer and autumn operations in medium first-year ice which may include old ice inclusion. All their equipment is designed for operation at air temperature falling to -40°C. At bottom of the page is graphic showing Arctic shuttle tanker "Timofey Guzhenko" moored at "Varandey" terminal, with hull outlines.

### 2.2. Arctic shuttle tankers "Kiril Lavrov" class

For platform "Pirazlomnaya" similar class of Arctic shuttles has been designed and built. Their principal dimensions are almost the same with length 257 m, breadth 34 m, draught (loaded) 13.6m and gross tonnage 49,866, cargo capacity 70,053 t. New improved design resulted in better fuel economy. With almost the same size and hull form they have same open water speed and ice breaking ability with 2 smaller Azipod drives, each 8,500 kW only. Power source consist of 4x Diesel generators 6,525 kW each. Working in the same Arctic region they have also polar class P 6 like their predecessors. They are running mainly between oil field and FPSO "Belokamenka" but can cross Atlantic if such need arises.

### 2.3. Sea of Okhotsk tankers

Vessels operating at Sakhalin terminal "De-Kastri" are dedicated Aframax tankers with maximum cargo carriage capacity around 110,000 t. Their hull form is typical for tankers of such kind and designed for good seakeeping and open water performance. Designed for log trips with good fuel economy they are powered by slow speed Diesel engines. For operations in Sea of Okhotsk ice condition vessels are obliged to have ice class 1C in compliance with Finnish-Swedish Ice Class Rules. Such vessels can operate independently in ice covered waters with ice thickness 0.4 m without icebreaker assistance. It is compromise between cost of construction and navigation in ice performance. Initial plans called for ice class but 1C was found satisfactory for operations at "De-Kastri" terminal. Tugboats built for this terminal have ice-breaking capabilities sufficient for winter operations. Terminal works only with tankers with bow loading manifold to avoid export hose contact with water and ice. All tanker equipment must operate in temperatures as low as -35° C. Vessels loading at "De-Kastri" terminal are not required to have dynamic positioning systems and mooring operations are always supported by tugboats.

## 3. RESCUE IN ARCTIC

### 3.1. Arctic Search and Rescue Agreement

In 2011 member states of Arctic Council signed international treaty Agreement on Cooperation on Aeronautical and Maritime Search and Rescue in Arctic providing legal base for Search And Rescue (SAR) operations. Arctic has been divided into SAR areas with clause that such delimitation is not related to any boundaries between the states. Figure below shows agreed SAR regions limits:



Fig. 7. Arctic SAR regions [2]

Treaty entered into force in 2013 and vessels navigating these waters may expect much better SAR response, including personnel evacuation in polar harsh conditions, similar to rescue services

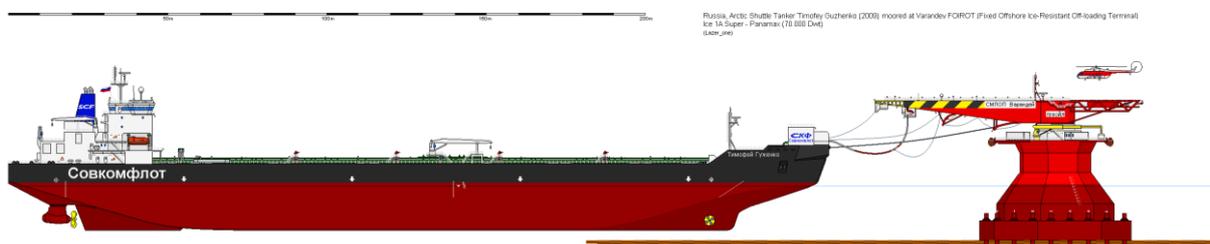


Fig. 8. Drawing of Arctic shuttle tanker "Timofey Guzhenko" at "Varandey" terminal, showing hull lines of double-acting icebreaker [9]

available in areas covered by earlier international agreements.

### 3.2. Polar Code

International Maritime Organization (IMO) adopted in 2014 International Code for Ships Operating in Polar waters (Polar Code) covering wide range of design, construction, search and rescue, equipment, training and environment protection matters. Purpose of this code is to supplement existing regulations as polar navigation exposes vessels to number of unique risks and may threaten clean polar environments. Code is scheduled to enter into force on 1<sup>st</sup> January 2017. New regulation pays special attention to crew survival in case of evacuation to the water, ice or land. In order for crew to survive in extreme polar conditions, vessels need to carry personal and group survival equipment sufficient for necessary protection during maximum expected time of rescue.

### 3.3. Arctic rescue vessels

Offshore installations, oil terminals and regular shuttle tankers operations in Arctic called for design and building of new class of multipurpose vessels capable to conduct rescue mission in polar conditions if such need arises. Such requirements are now fulfilled by Multifunction Ice-Breaking Supply Vessel (MIVBS) with polar class PC 6. Fully winterized they can operate in temperatures as low as -35°C. Crewed by 52 persons vessels can accommodate 195 survivors, allowing evacuation of whole crew of offshore installation. Powered by two 6.6 MW each Azipods, they are excelled tugs with bollard pull 128 t. Double acting with powerful Diesel-electric propulsion MIVBS can operate independently in 1.7 m thick ice and penetrate consolidated 20 meters ice ridges. Her design includes tasks as:

- supply operations, carrying variety of packaged and bulk cargoes
- icebreaking, escorting vessels and ice rubble removal
- ocean towing
- offshore firefighting
- oil spill recovery in polar conditions
- offshore polar rescue and recovery operations.

Such vessels are in active service in Arctic and more are scheduled to be built in operations in Sea of Okhotsk. Figure 9 below shows outline of such vessel with typical icebreaker hull:



Fig. 9. MIVBS hull outline [1]

### 3.4. Oblique icebreakers

Further development of double acting multipurpose Arctic vessels brought design of oblique icebreaker with asymmetric hull. In addition to breaking ice with bow or her stern, vessel can move sideway at large angle of attack to clear in ice channel with width

slightly less than icebreaker's length. Main idea behind this concept was use of small, compact icebreakers for clearing passages for large merchant vessels. First vessel of this new type entered service under name "Baltika" and classified as emergency multipurpose and rescue vessel. Although designed for service at Baltic Sea she went for trials in Arctic and river Ob estuary to test her performance in fresh water strong ice. Results of trials exceeded design parameters both in ice and as oil spill recovery vessel. With length mere 76.4 m she performed in ice as icebreaker with twice powerful propulsion. Driven by three Azipods, 2.5 MW each, she can continuously move bow first through ice 1.2 m thick and achieve in such conditions 3 knots when moving astern. Using oblique movement she can break 50 m wide channel in ice 0.65 m thick. During oil recovery operations in open waters and ice infested areas, her almost vertical side acts an arm pushing oil along hull to stern hatch where contaminated water is being sucked inside the recovery unit. Vessel has polar class PC 6 and dynamic positioning system. Figure 10, below, shows "Baltika" during Arctic trials:



Fig. 10 Oblique icebreaker "Baltika" during Arctic trials [5]

## CONCLUSION

Offshore Arctic operations of oil tankers began as early as 1969 but they were not successful. Presently they became routine due development of oil installations and oil terminals. Severe climatic conditions require specialized class of crude oil tankers with icebreaking capabilities and complying with necessary ice class. International community has introduced new regulations related to safety of shipping in harsh polar environment. For search and rescue in Arctic new generation of highly advanced vessels have been designed and built.

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### Arktyczne operacje tankowców offshorowych

*W artykule omówione zostały zagadnia związane z przewozem ropy naftowej przez tankowce specjalnie zaprojektowane do żeglugi w wysokich szerokościach geograficznych,*

*przy ekstremalnie niskich temperaturach i zalodzeniu morza. Ten nowoczesny typ statków został zbudowany dla obsługi arktycznych terminali naftowych, działających w ekstremalnie trudnych warunkach. Powstały też specjalne statki do przeprowadzania operacji ratowniczych w Arktyce.*

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