MINISTRY OF TRADE AND INDUSTRY, FINLAND
(KTM)

GROWTH Project GRD2-2000-30112 "ARCOP"

# TECHNOLOGY AND ENVIRONMENT

WP6: WORKSHOP ACTIVITY

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# Technology and Environment

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## DELIVERABLE SUMMARY SHEET

| **Short Description** |
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| The Workshop 4 report consists of the presentation abstracts and slides, a record of the discussions as well as the conclusions and recommendations. |

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## DISCLAIMER

## PREFACE

The oil and gas resources of the Arctic regions in Russia are the world's biggest energy reserve outside the OPEC countries. Due to their geographical location they are an important source in meeting the energy need in Europe.

There are a number of alternative routes for conveying oil and gas: direct pipelines, shipments across the Baltic Sea and direct carriage by ships along the Western part of the Northern Sea Route. All of these alternatives must be further developed to increase security of supply and cost-efficiency. The ARCOP project aims to develop an alternative that will make use of the Northern Sea Route.

Arctic Operational Platform ARCOP is a research and development project co-funded by the Directorate General Energy and Transport of the European Commission under the 5th Framework Programme for Research and Technological Development. The project coordinator is Kvaerner Masa-Yards. The project consists of six parts:

- Development of collection methods for ice information and ice forecasts in view of choosing transport routes (WP1)

- Assessment of the rules and regulations on transport by sea and of insurance and payment systems (WP2)

- Development of an integrated transport system for Arctic oil and gas transport (WP3).

- Development of the environmental impact assessment method and the environmental hazard management system (WP4)

- Trial in practice of the solutions developed and recommendations given during an actual transport assignment (WP5)

- Organisation of expert meetings between industry, authorities and representatives of technology to direct the project, to assess the results and to give recommendations (WP6)

The ARCOP project organises three workshops during every year of activity (2003-2005). Representatives of industries, authorities and scientific organisations are invited to discuss the topical issues of Arctic transportation. The workshops give guidelines for the project and also evaluate the results. During 2004, 102 participants, representing 55 organisations from all over the world, attended them. The workshops are arranged by the Ministry of Trade and Industry of Finland.

The fourth workshop of ARCOP, Technologies and Environment, was held in Brussels in June 2004. The first day of the workshop focused on the integrated transport system, the economics of transport and the supporting infrastructure such as the ice information and traffic management systems. The second day focused on the environmental impacts, oil spill countermeasures and socio-economic impact of the oil transportation.

The report consists of the presentation abstracts and slides, a record of the discussions during the event as well as the conclusions and recommendations. The conclusions and recommendations have been compiled by the project coordinator and the workshop organisers based on the presentations and the discussions heard during the workshops. The recommendations have been written after the three midterm workshops in order to include all the views and guidelines presented by the workshop participants.

We wish to thank the chairmen, speakers and commentators for their valuable input to the successful and interesting fourth ARCOP workshop.

In Helsinki, 1.12.2004

Liisa Laiho

Piia Rahikainen

Kimmo Juurmaa

**WORKSHOP 4: TECHNOLOGIES AND ENVIRONMENT**

## CONTENTS

# EXECUTIVE SUMMARY

## ARCOP Workshop 4 “Technologies and Environment”

The main topics of the workshop dealt with transportation systems and related technical solutions, training for arctic navigation, environmental safety and oil spill countermeasures.

The ARCOP project was started in the beginning of year 2003 and now, as the project has reached its midterm, the participants gathered to discuss the first results achieved. 37 representatives from industries and research and administrative organisations from a total of 12 countries participated the meeting.

By increasing its oil production, Russia has become the worlds leading oil producer this year. Further increase in the production is limited by the scarcity of export capacity, even with the rising capacity of Primorsk oil terminal (50 million tonnes this year) and the investments by oil companies to repair the old terminals and build new ones on the Gulf of Finland, the White Sea as well as the Pechora Sea. Both the highest administrative bodies of the Russian Federation and the oil industry are demanding for new export routes.

The strongest contender for a new oil terminal location is now proving to be Indiga, situated in the Nenets Autonomous Region, which is strongly promoted by the state-owned oil pipeline monopoly Transneft. A pipeline from West Siberia to Indiga would be economically favourable in comparison to Murmansk pipeline and it could be built in less than two years. Compared to Murmansk, the disadvantages of Indiga as a location for an oil terminal include the ice conditions of which the participants presented contradictory information in the ARCOP workshop. The decision upon the location of the new oil terminal is expected during the year 2005.

Transport equipment suitable for the ice conditions in Indiga and Varandey oil terminals has already been developed. Economical efficiency, however, calls for optimisation of the fleet. Large-scale oil transport lays new demands to ice breakers as well; the traditional icebreakers are not capable of assisting large oil tankers efficiently. Alternate technological solutions were presented in the meeting. The economy of these solutions is analysed during the project.

The shallow shores of the Russian Arctic make demands for loading facilities. Loading of large vessels is carried out at sea in offshore terminals, to which the oil is transported via submerged pipeline. These pipelines are a threat to the environment due to moving ice ridges. The requirement specifications for designing and constructing pipelines and loading facilities are under study in ARCOP.

The majority of collisions and accidents at sea are caused by the human factor. This was the case in the numerous damage incidents in the Baltic Sea during year 2003. According to the study conducted for ARCOP, the training for acting in the arctic conditions is incoherent and insufficient. Recommendations for organising the training are needed.

The environmental safety of marine transports has been brought up in the public discussions as a focal concern. In ARCOP, the procedures for environmental impact and risk assessments of arctic navigation are formulated. The studies conducted so far show that the biggest risk is an accident caused by drifting. To eliminate the damage the tankers need sufficient ice reinforcement. The probability of a tanker’s sinking due to a fire or a collision is estimated to be 0,5% during 20 years time.

The effect of oil spills on arctic marine ecosystems is evaluated in ARCOP. The flora and fauna under the ice, on the surface and within the ice pores are particularly vulnerable. The oil spill countermeasures to be studied within ARCOP include oil collection methods, in-situ burning and biodegradation processes.

In the ARCOP midterm assessment meeting the experts considered the work to have been allocated correctly. The questions related to training and its importance should anyhow be looked into, for example by analysing the available accident statistics.

| PROGRAM | |
|---|---|
| **June 8th 2004** | **Integrated transportation system for Arctic oil and gas** |
| Chairman: Kimmo Juurmaa, Kvaerner Masa-Yards (KMY) | |
| Opening address:<br>Goals and progress of Workpackage 3 | Kvaerner Masa-Yards (KMY),<br>Kimmo Juurmaa |
| Design of cargo vessels for the Arctic | Kvaerner Masa-Yards (KMY),<br>Sami Saarinen |
| Assisting large tanker in ice | Hamburg Ship Model Basin (HSVA),<br>Karl-Heinz Rupp |
| Loading facilities for Arctic areas | Tecnomare,<br>Giovanni Busetto |
| Traffic management systems – basic requirements | Technical University Hamburg-Harburg, Maritime Logistics (ISSUS),<br>Jens Froese & Karsten Bruns-Schűler<br>*Comment: VTT Technical Research Centre of Finland, Jorma Rytkönen* |
| Training for arctic navigation | Wagenborg Shipping (WS),<br>Anniek Platzer<br>*Comment: Maritime Safety Training Centre Meriturva, Leif Baarman* |
| Impact of climate change on transportation environment | US Arctic Research Commission,<br>Lawson W. Brigham |

| PROGRAM | |
|---|---|
| **June 9th 2004** | **Integrated transportation system for Arctic oil and gas** |
| Chairman: Karl-Ulrich Evers, Hamburg Ship Model Basin (HSVA) | |
| Goals and progress of Workpackage 3 | Hamburg Ship Model Basin (HSVA),<br>Karl-Ulrich Evers |
| Ecological safety of oil transport and terminals in the Baltic Sea | RF Ministry of Transport, State Marine Pollution Control,<br>Natalia Kutaeva |
| Characteristics of shipping and navigation in the northern seas<br><br>Characteristics of shipping and navigation in the northern seas in Environmental Risk Analysis (ERA) perspectives | Central Marine Research and Design Institute (CNIIMF),<br>Vsevolod I. Peresypkin<br><br>Alpha Environmental Consultants,<br>Odd W. Brude |
| Oil weathering and oil spill countermeasures | Hamburg Ship Model Basin (HSVA),<br>Karl-Ulrich Evers &<br>SINTEF, Hans Jensen |
| Biological degradation on oil in sea ice | Alfred Wegener Institute for Polar and Marine Research (AWI),<br>Birte Gerdes |
| Sea ice Biota | Finnish Institute of Marine Research (FIMR), Johanna Ikävalko<br>*Comment: David Thomas, University of Wales-Bangor* |
| Social Impact of Arctic transportation | University of Lapland / Arctic Centre (AC), Nina Messhtyb<br>*Comment: Administration of the Nenets Autonomous Okrug, Jana Kislyakova* |

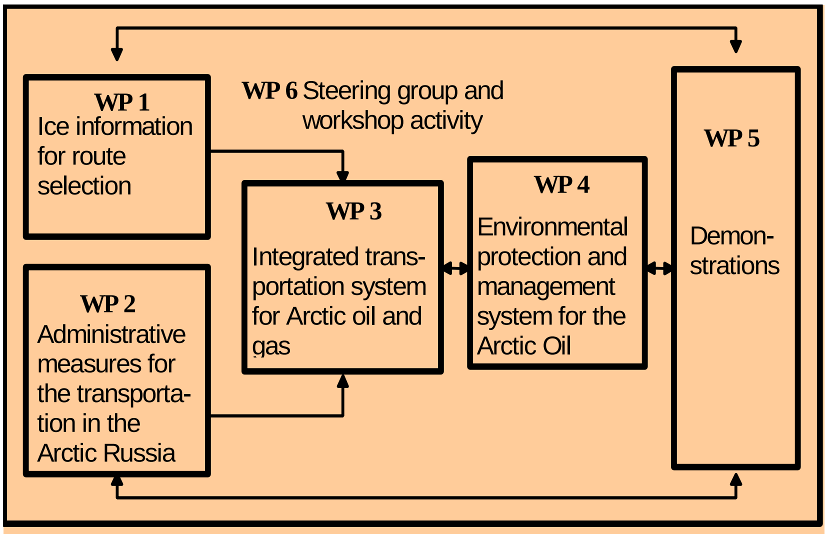
# 1. GOALS AND PROGRESS OF WP 3, INTEGRATED TRANSPORTATION SYSTEM FOR ARCTIC OIL AND GAS

*Kimmo Juurmaa*

*Kvaerner Masa-Yards Inc.*

**Abstract**

ARCOP is an R&D project. But it is also aims to be an Operational Platform for Arctic marine transportation. This means that within the project we will do research and development work, which helps the parties, involved to make operational decisions when trying to develop the marine transportation in the Northern Sea Route. The research and development work aims at showing what modern technology can provide for the transportation and environmental protection. It also aims at showing the cost structure of the transportation system and how the cost level depends on the technology applied and on the rules and regulations that regulate the traffic. The technology evaluation covers the cargo vessels, the icebreakers, the loading facilities as well as the supporting infrastructure like the ice information service and the vessel traffic management system. The workshops during the project aim to create an online discussion between the parties involved throughout the project. The approach will be the use of a realistic scenario as an example. The results and especially the recommendations should however be applicable to the NSR traffic more widely.




***Structure of the ARCOP project***

WP3 concentrates on the transportation system including the supporting activities that are required. The first task (WP3.1) was to define the scenario, that is, what to transport, where and in which conditions. This work has been completed and the results have been published in three reports:

D3.1.1: Report of the oil and gas fields in the area of interest.

D3.1.2: Description of the transportation tasks.

D3.1.3: Design Basis for the transportation system.

The next task was to develop alternative cargo **vessel designs (WP3.2**) based on the requirements presented in the scenario.

This work is well in progress and the designs selected for the comparison are presented in a separate paper during this workshop. The documents to be reported including the specifications and performance estimates will be reported in accordance with the original schedule at the end of this year. The main idea is to compare vessels based on different technologies and of different size to show the sensitivity of costs to the different parameters.

**The design of the icebreakers (WP3.3)** is proceeding simultaneously with the cargo vessel design. Also here the idea is to compare the cost of icebreaking with different technologies. This work has been delayed from the original schedule, but actually the results are not needed before the economic comparisons start at the beginning of the next year. The draft of the report has been circulated among the participating organisations for comments. The alternative designs are presented in a separate paper during this conference.

The work for the design of the **loading facility (WP3.4)** has also been started and the first draft report on the design bases has been circulated among the participating organisations for comments and additional data requests. The idea is to show what the loading facility will cost, how this cost is depending on the loading rate (vessel size) and the allowable down time during the extreme conditions. In the economic evaluation phase (WP3.5) this is then converted into cost per barrel value on early bases. Today the presentation of the loading facility will concentrate on the design of the sub-sea pipeline part of the facility. This work has been delayed, and results will be available at the end of 2004.

**The economic evaluation of the transportation system parameters (WP3.5)** will be started when all the design work for system components have been completed. According to the original schedule this will be early next year.

The purpose of the economic evaluation is to show how the overall transportation cost depends on the decisions made in the design of the components of the system. In addition to this the economic model that will be developed here will be used to evaluate cost data coming from other work packages. Typically these are such as the cost for the environmental protection from WP4 and the influence of different fee systems from WP2. All the costs will then be combined to produce the average cost per transported volume of the oil over the whole lifetime of the oil fields selected. This figure can then be compared to the costs of other modes of transportation.

In addition to the ships and loading facilities needed for a specific transportation task, there must be certain supporting infrastructure in the area for all the transportation. And the transportation system for a specific task must also carry it’s share of the costs of the general infrastructure. Within ARCOP we will look at the costs coming from the vessel traffic management and information system (WP3.6) and the required training system (WP3.7). This work is planned for 2005.

The work for the **vessel traffic management and information system (WP3.6)** has been started, but there are some delays due to change in the personnel responsible for the work. There will nevertheless be a separate presentation of this subject within this workshop. Within the system developed there will be also a link to the ice information system, which is being developed in the WP1.

The costs from **the training system required for the Arctic marine transportation (WP3.7)** does not necessarily need to be carried by the transportation on the NSR, but certainly it will be a cost for the shipping companies operating there. The work to develop the recommendations has started and the two first report drafts have been circulated among the participating organisations. Also this subject will be presented in a separate paper within this workshop.

The integrated transportation system with the selected scenario will form the core of the platform on which all related questions will be raised, all proposed solutions will be evaluated and all recommendations given will be based on. Thus we should see the system as widely as possible and raise all related questions all though they would not directly be relevant to the selected scenario, but would be relevant to some other areas and tasks along the Northern Sea Route. We hope that at the end of the project we have well documented facts about parameters influencing the cost of the marine transportation in the Arctic and good recommendations for decision makers, both industrial and political, on the ways how to further develop this mode of transportation.

## Discussion

In the presentation it was said that one of ARCOP's goals is to lower the transportation costs to 15 USD/ton, from 70 USD/ton experienced during ARCDEV[1]. It was questioned whether the transportation cost of ARCDEV project, 70USD/ton, was comparable to ARCOP's target value, 15 USD/ton.

The figures of ARCDEV come from actual costs of a transportation voyage. The tanker that was used was a small size oil product tanker. Therefore the cost, 70USD/ton, is the actual cost of transportation from Ob bay to Rotterdam. The route in the ARCOP scenario is somewhat shorter, but it is assumed that it will only be a small factor.

Discussion continued with a question on the mentioned alternative transportation schemes that are to be evaluated within ARCOP. The transportation of crude from Varandey to Rotterdam is the primary scenario that is to be compared with other transportation systems, for example pipeline transportation. Varandey-Rotterdam transportation system scenario will include a study on fleet alternatives with different types and sizes of icebreaker and transportation vessels.

[1] ARCDEV (1998-1999) is an applied research and demonstration project conducted under the Waterborne Transport Programme of the European Commission. Final summary report can be found at http://www.cordis.lu/transport/src/arcdev.htm

# 2. DESIGN OF CARGO VESSELS FOR THE ARCTIC

*Sami Saarinen and Matti Arpiainen*

*Kvaerner Masa-Yards Inc.*

## Abstract

### Design considerations

When designing a cargo vessel there are a number of decisions to be made. One has to decide the size, speed and degree of flexibility. In Arctic areas the factors driving the decisions are mainly the same as for any other area. The main difference today is the uncertainty of the environmental conditions and their influence on the design. Open water designs are influenced by hundreds of years of experience where as arctic designs are based only on a few decades of experience and a very limited number of vessels in operation. This means that the design of an Arctic vessel is a big challenge.

### Selection of size

Basically in all kinds of transportation the selection of the size of the vessel is driven by two factors. One is the parcel size in the trade the vessel is operating. The other is the economics of scale; the bigger the better. In oil transportation the parcel is varying. Crude oil is generally sold in packages of 60 000, 90 000 or 120 000 tons. To reach the best economic result from the transportation the 120 000 tons of cargo would be most favorable.

In any specific trade the actual water depths in the area limit the size of the vessels to be used. If there are no limitations the vessel size can be increased up to the technological limitations, which today is somewhere around 500.000 tons. In Russian Arctic the waters in general are shallow and the water depths in the most potential terminal areas are around 20 to 30 meters. This allows vessels with draft of 12 to 15 meters to enter the terminals.

But draft is not the only limiting dimension. The other is the beam of the vessel. In open water areas the beam does not play an important role. But in the Arctic there is a question of icebreaker assistance. The size of the icebreakers available may set a limit to the size of cargo vessel.

### Selection of speed

The optimum speed depends on the economics. With cargoes where the delivery time is important, the vessel is designed to meet the requirement of that demand. With raw material a steady flow with economic speed is more desirable. But here the Arctic conditions bring a new problem. To reach a steady flow of transportation in summer and winter conditions is not possible. The requirement for regularity should be seen as one factor in the economics. The irregularity in the performance of the vessel during summer and winter can be compensated with increased storage.

The selection of the speed of the cargo vessel in different conditions should be based on the assessment of overall economics. When evaluating the economics, the ice conditions over the whole route and throughout the whole year must be considered. Also the variation in the conditions during different types of years must be taken into account. For this reason reliable data is extremely important.

**Hull strength**

When the size and the required speed for the vessel have been decided, there still remain a number of questions to be answered. In the Arctic areas the vessel will experience additional loads due to ice. The level of hull strengthening that is needed to avoid damages depends on the conditions and modes of operation. It is important to know, which condition and which operation creates the critical loading.

There are several ways to define the required level of strengthening. The simplest one is to just select the ice class from some classification rules. It should however be noted that a suitable ice class can be defined only through experience. In new areas and types of operation there is in fact no basis to select the correct ice class.

Another method is direct calculation of the loads to be expected and doing the dimensioning based on the acceptable stress level in the different parts of the structures. This method is more demanding and good understanding on the loading phenomena is required. Quite often these two methods are combined so that the ice class is selected based on the calculation of the actual loading and the ice class will serve as a reference.

**Hull form**

The selection of the hull form for an icebreaking vessel is complicated because the optimum form for open water conditions is different for ice. There are several ways to overcome this dilemma, but quite often the end result is a compromise. What kind of compromise is feasible is a question of economic evaluation. And this evaluation can be done only when there is adequate information on the actual conditions of the route.

**Propulsion machinery**

Propulsion machinery giving the vessel the required thrust to make the vessel move is one of the key elements in the design. Also, since the fuel costs and the exhaust gas emissions are depending on the size and type of the machinery, this part of the design should be done carefully.

Contradictory to ‘other tankers’ an arctic tanker will inevitably travel at slow or very slow speed due to the thickness of ice for long periods of time, which puts special requirements on the propulsion. Despite the slow speed the machinery should be able to maintain the maximum power, which is not the case with ‘normal’ machinery on large tankers. They have usually a slow speed diesel engine directly coupled to a fixed pitch propeller. The rpm (rotation per minute) and power of this arrangement will go down when the ship speed is reduced. This is why a fixed pitch propeller is not at all recommended for ice-going tankers and a controllable pitch should be used instead. Loss of propeller rpm when ship’s speed decreases can be avoided by reducing the propeller pitch, in which case the engine maintains both rpm and power. Propellers of this size and power with heavy ice strengthening are anyhow almost non-existent today, either fixed or controllable pitched.

Best options for propulsion machinery for the Arctic are those which have the capability to maintain power even when the rpm goes down, which means that the torque has to be increasing simultaneously. Both gas and steam turbines have this capability, and both of them also enjoy increased efficiency in the low ambient temperatures. Especially good in this are the electric machineries, because of the excellent characteristics of the electric propeller motor. If the electric power is produced by diesel engines, we are talking about diesel-electric machinery, which is used onboard most of the icebreakers. Diesel-electric machinery has a high efficiency and a high torque but also a high weight and cost.

A special component worth mentioning is the ducted propeller. The performance of an ice-going ship is greatly depending on the thrust of the propeller and use of a duct around the propeller allows for substantially extended thrust. A large tanker with a deep submerged large diameter high-powered propeller in the aft end of a long vessel may suffer of ice intrusion to the duct only a little. The duct increases ice resistance and may have problems if ice enters in the area. In the most difficult ice conditions when the maximum thrust would be needed the ducted propeller arrangement may be loosing the thrust.

One further characteristic to be attributed here is the manoeuvrability. Any vessel will loose steering capability when the surrounding ice cover grows thicker and tankers with long vertical sides will suffer the most. In practice they are not able to turn in thick ice at all but travel straight ahead only. Assistance of icebreakers is needed when turning.

An important issue to be considered is the use of ‘Double Acting’ concept, an innovation that has been available during the last ten years. Double Acting concept means a new operation method in which the icebreaking or operation in ice is done astern, stern first. The concept is developed on the fact that the ice capability, even icebreaking performance of the stern can be done as well or better than that of the bow, and consequently the bow no longer needs to be an icebreaking bow. Compared to an icebreaking bow a bulbous bow designed for fair open water performance contains much more displacement which means that the vessel can be built smaller, or the same size vessel can have more deadweight and transport more cargo. More important is that the power requirement for the open water speed will decrease reducing the machinery size, power and fuel costs throughout the service life of the vessel. Depending on the proportion of open water operation and of the speed of the vessel the possibility to have a bulbous bow for an arctic vessel might have tremendous financial results.

In addition to the sound open water efficiency a capable ‘Double Acting’ machinery will improve the ice navigation capability to a level of making icebreaker assistance unnecessary and save the icebreaker fees. In fact the Double Acting concept may turn a cargo vessel to an icebreaker that is most efficient when the ice conditions are at the worst, in heavy ridges and even in ice compression. However, it is not cheap to have an independent Double Acting vessel, and depending on the icebreaker due system it must be considered separately for each individual case if it is more profitable to let the cargo vessel do the icebreaking herself or to let the icebreaker do it.

Selecting the Double Acting concept also selects the machinery: the Double Acting concept always relies on electric propulsion, which is an optimum solution for icy arctic conditions. In the Double Acting concept the electric propeller motor or motors are located in the azimuthing propeller pods. This arrangement allows the vessel optimum manoeuvrability and steering capability simultaneously, both ahead and astern, in open water and ice conditions.

One aspect of the Double Acting concept to take into consideration is the sea keeping. An icebreaking bow form is not very sea keeping friendly, and it will become even worse when developed for extreme ice capability. A Double Acting ship is not a compromise between icebreaking capability and sea keeping form because a proven open water bow form can easily be adopted. The sea keeping issue grows more important if much of the vessel's time is spent in open seas. For ships coming from the Arctic this usually means the North Atlantic.

Generally it can be said that all distances in the Arctic are long, and due to the thick ice even high-powered vessels proceed slowly. This means that during the voyage a large amount of fuel is consumed which in turn means that the useful payload of the cargo vessel is reduced. In other words, the chance to make profit decreases while costs increase. This is why the icebreakers of the Soviet Union era are nuclear powered, and also the ice capability of any vessel operating in the area should be good enough to limit the increase of the fuel storage. Today even the number of operative icebreakers is reduced, and the big nuclear icebreakers are of 11meter draught so that they can enter just two of the ports in the Russian Arctic, Murmansk and Pevek. Most of the ports are shallower and consequently another icebreaker with shallow draught may be needed to reach the port. So to have icebreaker assistance for some route or destination may not be guaranteed. It must be contracted well in advance, but may still cause delays anyhow. Capability for independent navigation, use of icebreaker assistance and availability of icebreakers today and in the future must be considered before deciding requirements of an arctic vessel.

Especially when ice navigation is considered, unforeseen incidents may happen. This should be remembered when expecting a regular transportation. To achieve regular service, more independent vessels with higher power, performance, redundancy and margins should be selected, and still have ample icebreaker assistance available.

**Design conditions**

The design conditions with the main parameters affecting the design of ARCOP's vessels are presented in the Design Basis. Important parameters of the transportation task, fleet/vessel alternatives, ice conditions and open water conditions are defined in the Design Basis. The following information is originated from the Design Basis for ARCOP's transportation system. The transportation route selected for ARCOP is presented in Figure 1.


***Figure 1. The transportation route in ARCOP***

According to Figure 1, the vessels will transport oil from Varandey offloading terminal to Murmansk, where it can be distributed and for example reloaded to other vessels for transportation to Western markets. The maximum daily volume is assumed 330 000 bbl/day.

Climate related parameters for the loading area of ARCOP transportation system is presented in the Table 1.

***Table 1. Environmental parameters for the Varandey area.***

| Environmental parameter | Average value | Maximum value |
|---|---|---|
| Air temperatures (°C) (Varandey HMS) | -19.2 (January)<br>8.9 (July) | -44 (January)[2]<br>32 (July) |
| Frequency of wind >15m/s (%), (Varandey HMS) | - | 3.4 (February) |
| Speed of gusts (m/s) (Varandey HMS) | - | 38 (November) |
| Height of snow cover (cm) | 30 (April) | - |

[2] Minimum value is presented

The ice conditions used in the design of ARCOP vessels are presented in the Table 2.

***Table 2. Design ice conditions.***

| Parameter | | Average value | Maximum value |
|---|---|---|---|
| Ice period duration | days | 240 | 275 |
| Ice concentration | % | 95 (winter)<br>40 (summer) | 100 (winter)<br>100 (summer) |
| Drifting level ice thickness* | m | 0.7 | 1.5 |
| Drifting rafted ice thickness | m | 1.1 | 3.0 |
| Uniaxial comp. strength, vertical (level ice) | MPa | 2.3 | 3.0 |
| Uniaxial comp. Strength, horizontal (level ice) | MPa | 1.8 | 2.5 |
| Flexural strength (level ice) | kPa | 270 | 500 |
| Ice ridge width | m | 20-30 | 70 |
| Ice ridge sail height | m | 2.3 | 4.9 |
| Ice ridge keel draft | m | 7.0 | 14.0 |
| Ice ridge porosity | % | 20-30 | 35 |
| Ice ridge consolidated layer thickness | m | 2.0-3.0 | 6.0 |
| Uniaxial comp. strength, vertical (ice ridge) | MPa | 1.6 | 2.0 |
| Uniaxial comp. strength, horizontal (ice ridge) | MPa | 1.3 | 1.8 |
| Flexural strength (ice ridge) | kPa | 240 | 300 |
| Total ice drift speed | m/s | 0.25 | 1.05 |
| Prevailing ice drift direction | degrees | 90-135 | - |
| Tidal ice drift speed (by directions) | m/s | 0.20 | 0.34 N, 0.22 NE,<br>0.25 E, 0.45 SE,<br>0.28 S, 0.20 SW,<br>0.23 W, 0.50 NW |

## Operational principles

Same principles of operation, which are presented below, may apply to vessel types other than tankers when evaluating the differences and consequent pros and cons of 'traditional' icebreaking tanker design versus Double Acting one. However, tankers in the Arctic would probably be crude carriers of large sizes due to the economies of scale. This may be even more important in the Arctic because the costs of the transportation will be much higher than in open water. A large size brings extra problems for navigating in arctic ice, problems that are different for 'traditional' and 'Double Acting' vessels.

## Conventional Ice-Bow Tankers

Conventional tankers operating in the Arctic will be provided with an 'ice bow' which may be designed for icebreaking or operation in broken ice. The operation is 'bow ahead', and according to traditional thinking it depends always on icebreaker assistance. A further option is to consider an independent 'conventional' icebreaking tanker that would operate independently as an icebreaker even in 'traditional bow ahead mode'.

Today the breadth of a vessel, that is assisted by icebreakers is normally considered the same or a little larger than that of the escorting icebreaker. This would limit the breadth of the tanker to about 30 meters maximum and the 'size' of the tanker to some 35000 tons deadweight, consequently, because the largest existing icebreakers, the large nuclear icebreaker from the Soviet era, are only around 28 meters wide. This size arctic ice going and icebreaking tankers have not been built yet, so there are few or no references available when the Arctic is considered.

For larger vessels the alternative, which is discussed by experts, is to use two or more icebreakers to assist one large size vessel. Large tankers perform routine ice voyages only in the east part of Gulf of Finland during winter. Some preliminary tests have been done also at Sakhalin Island but not in the Arctic. The only 'real' tanker test voyage so far in the Arctic was the 'Manhattan' experiment in 1969 from US East Coast to the north slope of Alaska via the Northwest Passage.

Winter 2002-03 was a difficult 'ice winter' for navigation in the Gulf of Finland and almost all shipping to the eastern ports was halted because of lack of icebreaker assistance. The two brand new Double Acting tankers of the Finnish oil company Fortum Oil and Gas were the only vessels that could keep the scheduled traffic. In fact they were assisting the other cargo vessels waiting for icebreakers each time they would pass by. All the other vessels in the area, large ice class tankers included, had to wait days and even weeks for icebreakers. The Sakhalin test voyage consisted of escorting an ice strengthened tanker to an ice covered DeKastri terminal with two icebreakers. From the results of the test voyage mixed opinions prevail. The 'Manhattan', a twin screw turbine tanker of 31.6 MW shaft power, 106000 dwt with 273 m length and 44.5 m width was fitted with over ten thousand tons of extra steel constructions in an effective ice bow and inclined double sides. The test voyage was run with altogether 5 icebreakers taking part during the arctic 'summer' in 1969. The test was deemed successful, as the Alaskan oil could have been taken out with icebreaking tankers but instead a decision was made to build the Trans Alaskan Pipeline to export oil.

So the relevant references are few or non-existent when this kind of operation in the Arctic is considered. Experience suggests that an ice-bow tanker will need icebreaker assistance, probably at least two icebreakers per each tanker. A large export volume means a number of large tankers, which fix a double number of icebreakers. Costs of the icebreakers must be included in the economic calculations. The availability and performance of them should be guaranteed; otherwise the transport will stop when facing difficult ice conditions.

An alternative to icebreaker assistance is to design the ice-bow tanker with enough power and performance for independent operation. Depending on the desired route and performance this may require much power to be installed, and in the end the icebreakers may have to be used anyway.

As already mentioned about the propulsion of an arctic tanker, one should choose machinery that is able to maintain the power when the speed of the vessel goes down. The ‘normal’ machinery option of a large tanker with direct coupled fixed pitch propeller driven by a slow speed diesel engine is the worst selection, because when the propellers rpm and the ship’s speed is reduced, power is lost to large extent. A controllable pitch propeller is much better because the loss of the ship’s speed, due to ice, can be compensated by reducing the propeller pitch, and the engine can maintain constant rpm and consequently high power.

A characteristic, which may be worth attributing in the ‘ice context’, is maneuverability. Any vessel will loose steering capability when thick ice surrounds the hull. Tankers with very long vertical sides cannot turn at all and can only go straight ahead in thick ice.

**Double Acting Tanker**

As for the ‘conventional’ counterpart, the operation experience from large Double Acting tankers in the Arctic is still missing. In non-arctic ice covered seas the principle has been used successfully since 1990 in the Baltic and Caspian Sea with excellent operational performance and experience.

Unlike the ‘ice bow’ tanker which is considered to operate with icebreakers assistance although possibility of independent operation may not be totally ruled out, the Double Acting tanker is considered to have a reliable ‘independent operation option’ readily available. Of course icebreaker assistance can be used also as a supplement or when conditions exceed the design definition.

The Double Acting principle includes providing the tanker with electric propulsion machinery that is an optimal solution for operation in ice. Generators driven usually by diesel engines produce electric power, but turbines may also be used. Electric propeller motors located in azimuthing propeller pods can run equally and without limitations in both directions, which allow the vessel excellent maneuverability and steering both ahead and astern. A ‘normal’ vessel provided with ‘normal arrangement of propeller and rudder’ cannot be steered when reversing, and in ice the rudder prohibits astern operation totally anyway.

The Double Acting principle allows the vessel to be designed with a bulbous bow for open water efficiency, because heavy or heaviest ice operation is best done astern. Provided with a bulb the vessel can hardly proceed ahead in ice conditions and is using normally astern operation any time in ice, both in thin and thick ice, in rubbles and ridges. Of course the achieved speed in easy ice conditions will be high in astern operation also, but will decrease when the conditions get more difficult, and finally the vessel will proceed at slow creeping speed in the most difficult ridges or other problematic ice formations. The astern operation does not need ramming if the vessel stops for a while because the ice is destroyed and removed by the propeller. For most cases the power needed for open water speed will be enough to allow for remarkable capability in ice conditions as well, especially when the required open water speed is high.

The regulations have not been defined to recognise the Double Acting principle and may require much higher power for a given ice class. In practice the performance is not equal to the class and the desired performance can be achieved with a lot less power than stipulated by the class of the rule. In this case an exception is needed to gain the specified class.

The bow does not need to be open water one; an efficient ice bow form may be adopted if large profits depend on high speed in thin ice. This may be the case if open water performance is not important, and the vessel seldom operates in open water. This type of Double Acting vessel is normally operating in ice using ahead mode but turns around to use the highest performance of the stern and astern operation mode when the ice conditions grow really bad.

Already mentioned some times above, in the real world selecting between independent and assisted operation may not be a question of performance only. The government and the icebreaker owner are eager to exercise their reign and dominance, maintain cash flow, and even finance the development of the future icebreaker fleet which may make the adoption of independent operation more difficult than it should be.

**Examples of future Arctic vessels**

Two examples of the designs of Arctic vessels are presented below. First one is the 200 000 $m^3$ LNG vessel proposed for the operations also in the Kara Sea. Kara Sea is in the Eastern side of Novaja Zemlya (see Figure 1), where the ice conditions are typically harder than in the Pechora Sea (Varandey area).

The main parameters for the Arctic LNG vessel are presented in the table below and the general arrangement of this is presented in Figure 2.

| | |
|---|---|
| Length oa. | 328.0 m |
| Breadth | 50.0 m |
| Depth | 23.4 m |
| Draught | 12.0 m |
| Propeller Power | abt. 35 MW |
| Double Acting (with bulbous bow for open water) | |

This vessel is designed to meet the requirements of trading between the Yamal Peninsula and USA. In addition to the heavy ice conditions in the Kara Sea the vessel must be able to operate in heavy open sea conditions in the Northern Atlantic.

One estimate for the transportation volume of LNG from Yamal is 20 million tons per year. To be able to maintain a steady flow throughout the year, a total of 20 to 22 of vessels of this size are needed in the fleet. This will be one of the major challenges for the European shipbuilding industry in the future.

The second example is the Arctic Container intended to operate in the ice conditions, which can be very severe in certain seasons. The GA-drawing is presented in Figure 3 and the main parameters below.

| | |
|---|---|
| Length b.p. | 153.7 m |
| Breadth | 23.1 m |
| Depth | 14.2 m |
| Draught (in arctic) | 9.0 m |
| Propeller Power | 13.0 MW |

Bow designed for effective ice breaking (i.e. “Ice Bow”)

This vessel is intended to operate independently without assistance from icebreakers between Dudinka and Arkhangelsk in most of the conditions. The design of the vessel was a challenge. The experiences from the ARCDEV voyage were utilized when defining the performance requirements for the ship. The design of the transportation system without icebreakers is dependent on the capability to do efficient ice routing. The experience from ARCDEV gave justification to assume that an efficient routing system exists in the future. In this respect the expectations towards the IRIS project and the WP 1 of ARCOP are quite high.

**Tanker alternatives for the ARCOP scenario**

The selected crude-oil tankers for further studies in ARCOP are presented in more detail below. As defined in the ARCOP’s Design Basis, all of the tankers will be designed to operate in the Barents and Pechora seas. The design service speed of all tankers will be approximately 15 knots.

The propulsion machinery of Conventional Arctic Tankers consists of two low-speed diesel engines coupled to a single screw. The pitch of the propellers will be controllable (CP-propellers).

The machinery of the Double Acting Tankers will be diesel-electric consisting of four diesel engines driving main generators, that feed the propulsion network and one frequency converter controls one azimuthing propeller unit. Propeller will be FP -type.

The GA-drawings are presented at the end of this paper.

***Table 3. Main parameters of Conventional Arctic Tanker***

| | | | |
|---|---|---|---|
| Deadweight (t) | 60 000 | 90 000 | 120 000 |
| Length over all (m) | 234.0 | 260.2 | 286.8 |
| Length Lpp (m) | 225.0 | 250.0 | 278.9 |
| Breadth (m) | 32.0 | 40.0 | 44.0 |
| Draught (m) | 12.7 | 13.5 | 15.5 |
| Depth to main deck (m) | 19.0 | 21.3 | 23.5 |
| Propeller Power (MW) | 21.0(* | 23.0(* | 25.0(* |
| GA-drawing | Figure 4 | Figure 6 | Figure 8 |

*) Preliminary estimation

***Table 4. Main parameters for the Double Acting Tankers.***

| | | | |
|---|---|---|---|
| Deadweight (t) | 63 000 | 90 000 | 120 000 |
| Length over all. (m) | 219.5 | 252.0 | 289.0 |
| Length Lpp (m) | 202.0 | 228.0 | 268.0 |
| Breadth (m) | 34.0 | 40.0 | 46.0 |
| Draught (m) | 13.0 | 14.0 | 15.0 |
| Depth (to main deck) (m) | 17.0 | 19.0 | 22.0 |
| Power (approximation) (MW) | 14.5(* | 18.0(* | 22.0(* |
| GA-drawing no. | Figure 5 | Figure 7 | Figure 9 |

*) Preliminary estimation

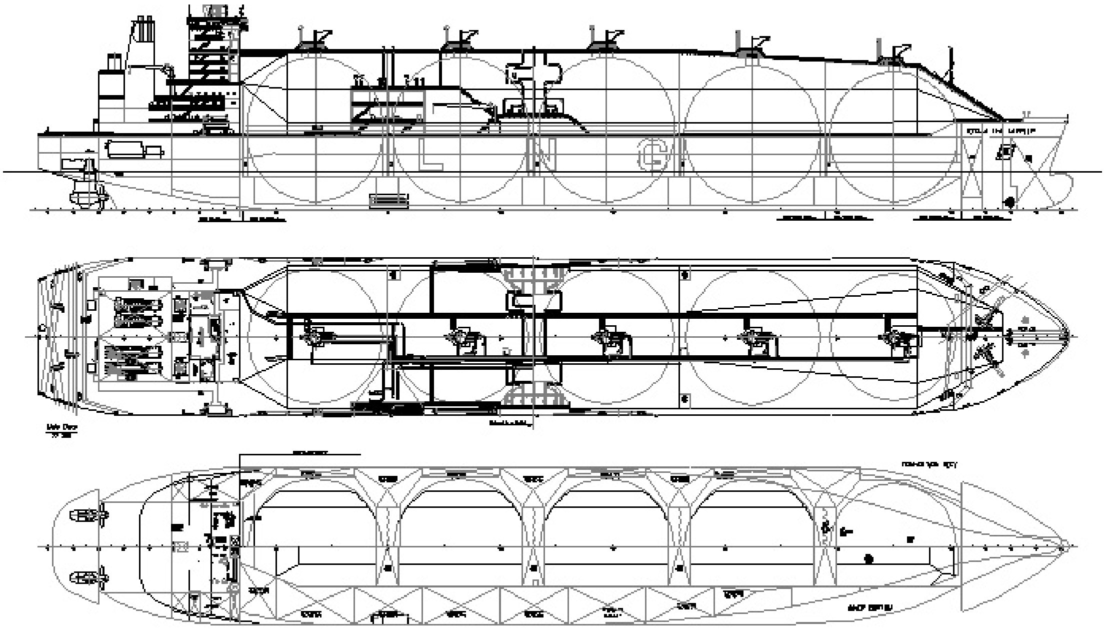


*Figure 2. Arctic LNG Tanker*

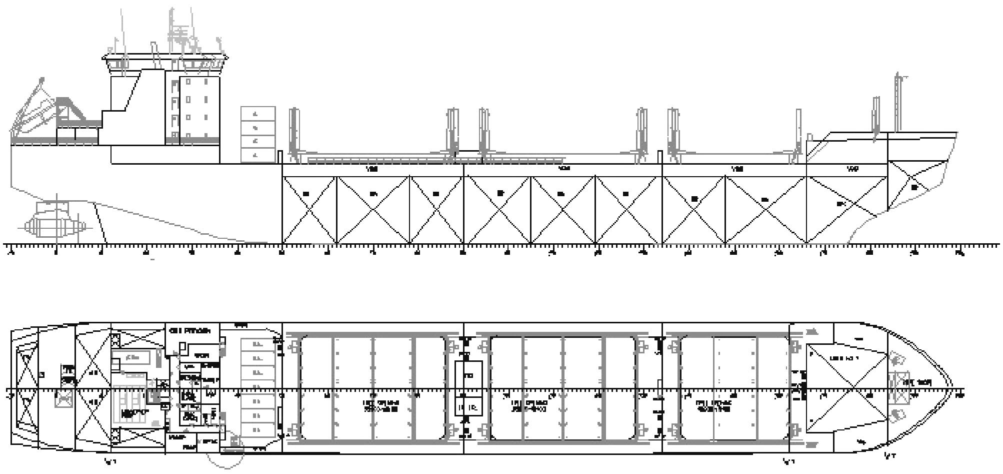


*Figure 3. Arctic Container*

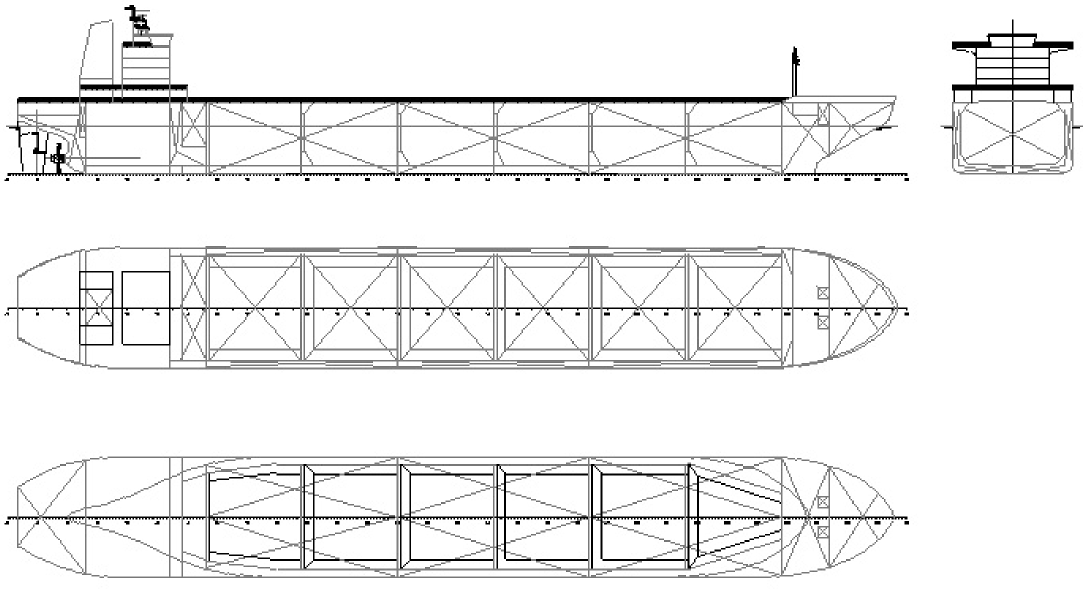


***Figure 4. 60 000 dwt Conventional Arctic Tanker.***

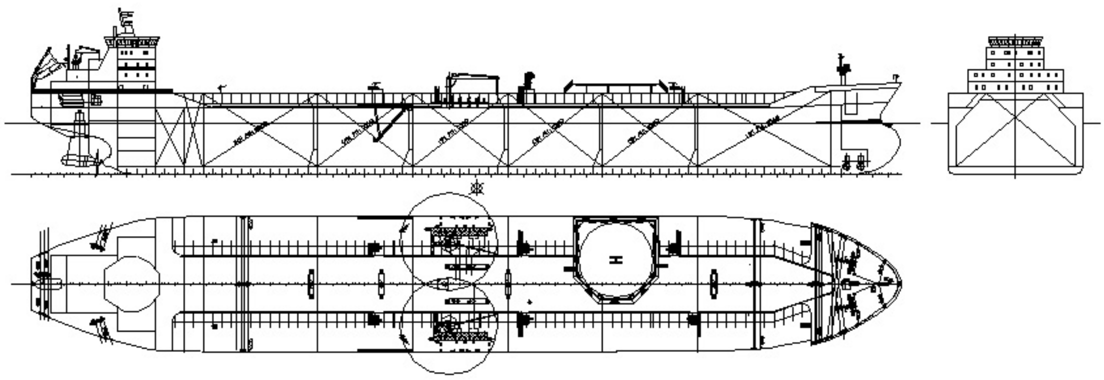


***Figure 5. 63 000 dwt Double Acting Tanker.***

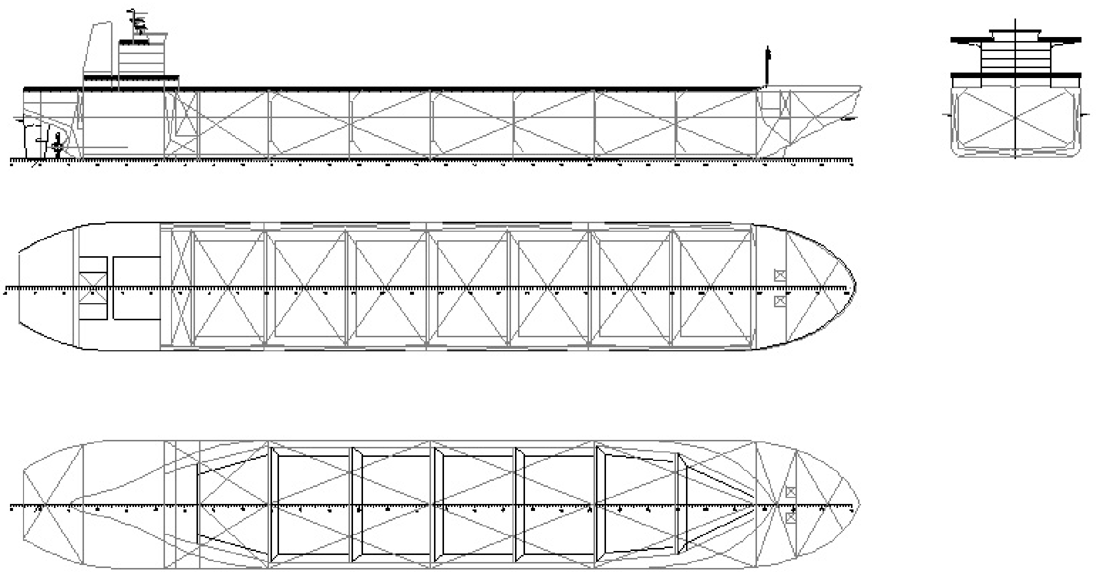


*Figure 6. 90 000 dwt Conventional Arctic Tanker.*

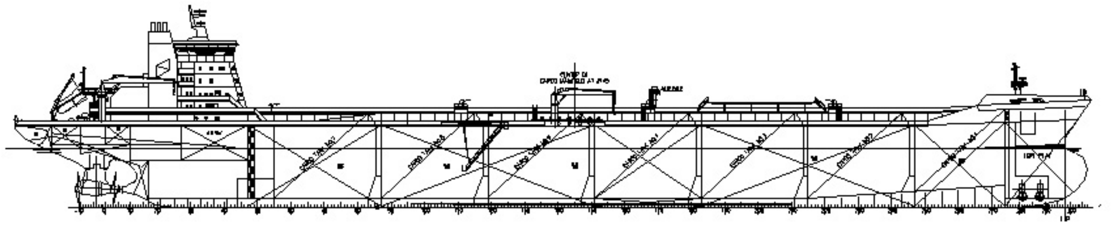


*Figure 7. 90 000 Double Acting Tanker*

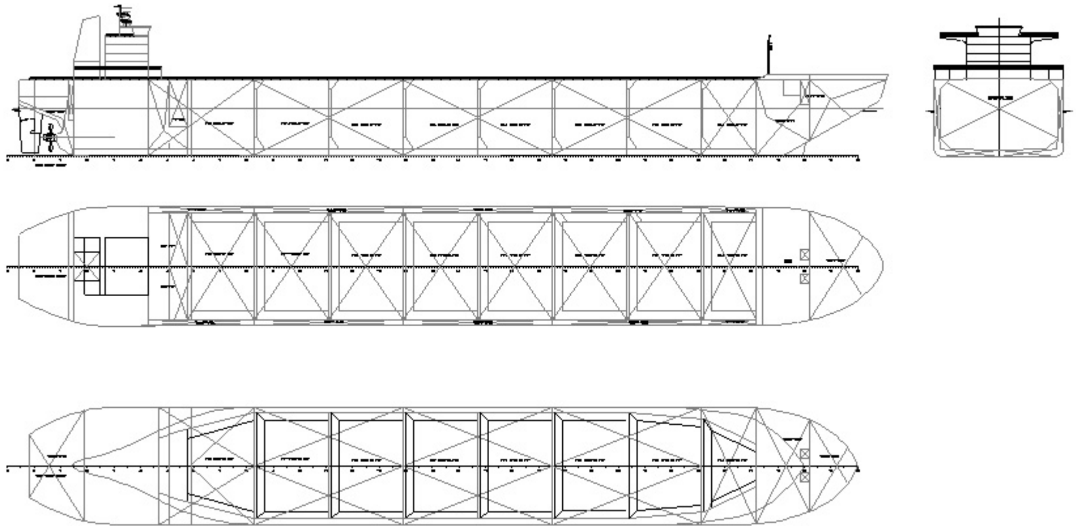


*Figure 8. 120 000 dwt Conventional Arctic Tanker*

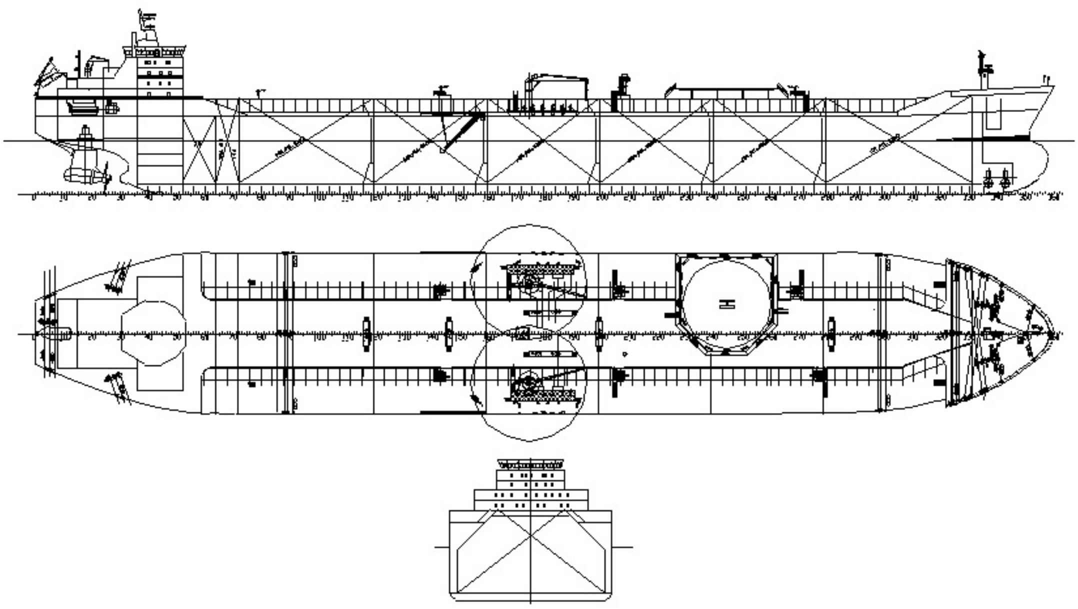


*Figure 9. 120 000 dwt Arctic Double Acting Tanker*

### Discussion

The discussion started with questions regarding the tanker sketches. The preliminary sketches of a 120 000 dwt tanker had only six tanker compartments. Compartments were criticized to be quite large and to possess an environmental and economical risk. The sketches are at the moment in a preliminary stage and will mature as the project progresses and the environmental and regulatory considerations are integrated in the design.

Calculation methods for hull strength for specific vessels were discussed. There have been operations of up to 100 000 dwt tankers, so there is some experience available that can be utilized. Russians also have experience from about 40 000 dwt vessels. From these extrapolations can be driven.

Mr Saarinen stressed that the designs that have been made are not intended to match any specific ice-class. In the case of the designs presented the ice class was from ICE-10 to ICE-15 (DNV) corresponding to ice class LU 5-6 of Russian Maritime Administration.

Cost estimation between conventional and azimuthal vessels of 120 000 dwt was brought up. Azimuthal propeller is more expensive than the conventional with equal power source (20MW), but the power required for double-acting (azimuth propeller) is lower, only approximately 16 MW.

The manoeuvrability of a Double Acting tanker in heavy ice conditions was brought up. One practical advantage of a Double Acting tanker is, that the captain has the possibility to see better the most difficult ice conditions and to manoeuvre around them.

The propellers' surviving under the loads caused by the tanker backing in thick ice was discussed. At the moment there are ongoing designs to battle the problem. In ARCOP tankers the azimuthal propellers are actually very deep in water and avoid almost all of the ice collisions.

The tanker designs focus now to Pechora Sea conditions, but the work on NSR and Kara Sea is being extended and added.

## 3. ASSISTING LARGE TANKER IN ICE

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### Abstract

The task of the assisting fleet is to guide large tankers through ice-covered waters to a port or loading terminal.

Assisting ice strengthened and relatively low powered vessels in ice-covered waters with the help of icebreakers has a long tradition. The vessels follow the icebreaker in the broken channel. If that is not possible, due to more severe ice conditions or other reasons, the icebreaker tows the vessel. In this case the beam of the icebreaker must be wider than the beam of the towed vessel.

Using large tankers in ice with a beam much wider than the beam of existing icebreakers the tactic in assisting and / or the icebreaker must be changed.

To increase the width of the broken ice channel the first approach is to increase the beam of the icebreaker. The examples show the shape of such icebreakers and the ice breaking performance in level ice. Another approach is to break ice with the side of the icebreaker to perform a wide broken channel.

The second approach is to use two icebreakers that break close together two parallel ice channels. The new wide ice channel for the large tanker consists of the channels of the two icebreakers and the distance between them.

Different engine power and propulsion systems are presented. With the good manoeuvring behaviour of icebreakers with azimuth propulsion the guiding of tankers will be improved.

### Discussion

Mr Rupp presented calculations conducted on different bow types, stating that a wide bow type with the same power would break 50% more ice than the presented normal bow type.

It was argued that energy-wise it is difficult to comprehend how the same power will break more ice than a normal bow. Mr Rupp explained that in case of a wider bow the open water performance will be less efficient. The new design simply breaks ice more efficiently and the power requirement between the two bows is identical in ice.

The secondary use of the assisting fleet was brought up and it was recommended that detailed design would include enough deck space; containers, recovery vessels and some free space in bow and stern in case of need for equipment for oil spill countermeasures. Adding tanks to existing vessels is quite difficult but some equipment can be put on the deck.

The type of ship plays a large role in designing the vessels. Multi-functional vessels can earn additional money, but they are normally bigger and more expensive. In cost-estimations it’s possible to specify the costs and earnings rising from additional features.

# 4. ARCTIC OFFSHORE PIPELINES, DESIGN AND INSTALLATION CHALLENGES

*Giovanni Busetto*

*Tecnomare S.p.A.*

**Abstract**

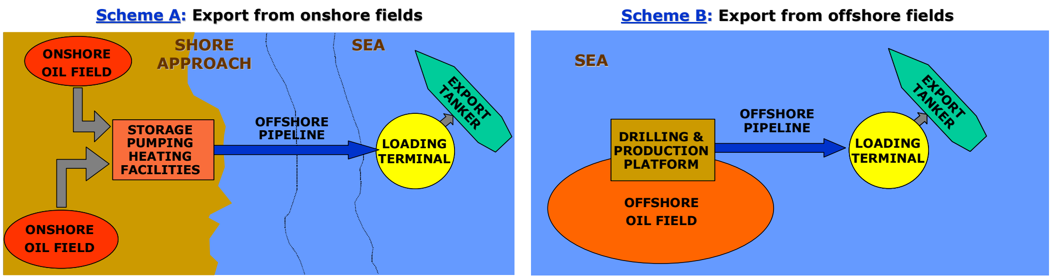
The challenging efforts for the development of a transportation system for hydrocarbon export from the Arctic fields must necessarily consider the aspects relevant to the design, installation and operation of the offshore pipelines.

They are a link of the maritime transportation chain as they are used to convey the hydrocarbons to the export terminals:

- from the offshore fields, where production platforms are located,
- from the onshore production fields, via storage and pumping stations.

In the former case, the distance to be covered is quite limited, in the order of two to three kilometres and generally the water depth is not subject to significant variations. The distance is determined by the extension of the manoeuvring area of the tanker, safe distance from the production facility and ice rubbling, as well as keel clearance requirements.

In the latter case, the transport of oil from the shore, particularly if large size vessels are utilised, calls for medium to long distances to be covered, of tens of kilometres, due to the bathymetry of the gently sloping shallow water areas characterising the Russian Arctic offshore, at least in the western part of the Northern Sea Route.




A significant experience has been accumulated for the design, installation, inspection maintenance and repair of offshore pipelines in general, but due to the fact that the Russian Arctic oil and gas offshore infrastructures still need to jump to industrial exploitation scale, the engineering and technological effort still needs a boost.

The experience, gained in the last three decades, in the installation of pipelines in the U.S. and Canadian cold regions, as well as in the south and west of the Yamal Peninsula, represents a proof that the available equipment is adequate also for a safe emplacement of offshore pipelines in the Arctic environment and that the body of knowledge to engineer, fabricate and operate them is ripe. Nevertheless, careful evaluations must be made of the specific features of the environmental scenario of interest and of the viable alternatives, as the economics of a project and sometimes its feasibility can be significantly affected by the involved development and operational costs.

## Design aspects of Arctic offshore pipelines

The general design data of an offshore pipeline foresees the definition of:

- chemical composition of the transported fluid, accounting for the changes during the design life,
- flow rates of the transported fluid,
- maximum and minimum pressures at the downstream end,
- maximum and minimum temperatures at the upstream end,
- locations and heights of the end points and bathymetric profiles,
- geotechnical parameters relevant to the seabed crossed by the pipeline,
- meteocean data,
- any known constraints (politics, environment, obstructions, human activities) of the route.
- In addition to the normal design aspects that the pipeline engineer must account for an effective non-Arctic application, specific considerations of vital importance for the system are to be made when dealing with a high latitude environment. Such aspects are relevant to the environmental loading on the pipeline.

To maximize the capability to withstand extreme environmental loading, playing with configuration and materials is obviously of paramount importance.

The environment of the Timan-Pechora Sea is a good example of how a decisive factor it is for the pipeline design.

Several environmental phenomena are unique to the Arctic environment and the major loads applicable to the pipeline system are those caused by:

- Ice gouging
- Permafrost thaw settlement
- Strudel Scouring
- Upheaval Buckling.

*Ice Gouging*

When the sea ice piles up at some location creating pressure ridges, they can periodically contact the seabed and form gouges into it. To avoid pipeline damage due to ice keel contact, it is necessary to bury the pipeline. Appropriate design requires that the maximum ice gouge depth be established along the pipeline route. The pipeline must also be analysed for bending strain caused by soil movements beneath the keel of the gouged ice.

If it is not possible to select a straight route from shore to the loading terminal, it may be convenient that the part closest to the coast runs parallel to it, shoreward of the zone affected by grounded ice formations, such as stamukhi. This permits to avoid the area where there is the highest intensity of ice gouging. The areas with stable landfast ice permit the best opportunities for installation and repair during the winter season.

A considerable number of studies have been carried out in the recent years by Russian Institutes to determine the optimum burial depth of pipelines, to avoid the effects of ice gouging on the pipes and the surrounding ground.

*Thaw Settlement*

If the soil underlying the pipeline route contains permafrost and the pipeline operates at higher temperature, the heat losses can thaw the frozen water in the surrounding soil and this can result in settlement of the soil. A similar situation occurs for the onshore segment of the pipeline, when the air temperature rises, during the summer season, and the load carrying properties of the underlying permafrost will change. When the thaw occurs, the pipes are no longer supported vertically and deflect into the void created by the settlement. Strain is thus induced in the pipe wall. This phenomenon is common at shore crossings and at shallow water depths.

*Strudel Scouring*

Strudel scours in the sea floor are formed if any river water overflows the bottom fast ice near the coast during the ice break-up in spring. The water can then drain through discontinuities of the ice sheet and if the drainage rate is high and the water depth shallow, scouring of the seabed can occur. The majority of the strudel scouring is circular, but linear scouring can be created by drainage through elongated cracks. Strudel scours are hazards only if certain conditions occur:

- be located above the pipeline route,
- exceed the bottom of the pipeline (otherwise the pipeline remains supported by the soil),
- have a horizontal extension exceeding the design span length.

*Upheaval Buckling*

This phenomenon is not specific of Arctic regions, but its extent and consequences may be more serious in the Arctic environment, as the pipe may become exposed to ice gouging. The phenomenon occurs if the pipeline was buried and installed at a lower temperature than the operating temperature: the axial thermal expansion is prevented by the surrounding soil and the pipe may arch either upwards out of the seabed forming a raised loop which may project several meters, or snake sideways if it is buried in very weak soil. This effect can overstress the pipe wall and can lead to excessive hydrodynamic loads if the line projects up into the sea.

**Types of configurations**

The basic distinction is between rigid and flexible pipe.

The most common application is the single wall rigid pipe, consisting of a steel pipe, with external and internal corrosion coating. Internal cladding is necessary for products with corrosive content, but this is not the case for a pipeline dedicated to export oil, assuming that prior treatment has been made to permit loading on export tankers.

A single wall pipeline is formed by joining together short lengths of pipe termed joints. For economic reasons, carbon-manganese steels are used whenever possible for fabrication, unless a corrosive service is expected. In most cases, the joints conform to API 5L Specifications, which covers the selection and use of seamless, longitudinal welded and helical welded pipe. The steel grade, defined by the yield strength, varies from X42 to X80, corresponding to 42 to 80 ksi yield strengths.

In general, high strength, ductility, fracture toughness and weld ability are needed for the low temperatures envisaged during construction and operation stages. The prime factor driving the need for good weld ability is economic, because the largest percentage of the cost of a submarine pipeline is the installation, due to the high cost of operating a lay barge. Therefore the faster the pipe is welded, the shorter the time of use of the lay barge.

If control and monitoring functions have to be assured for the offshore terminal, an umbilical will be associated to the pipe, in the form of an external bundle line. In this case a single installation and burying operation can be carried out.

The pipe-in-pipe rigid solutions consist of an inner product pipe, spacers or frames with rollers, insulation and external pipe. This structure has been suggested for the gas pipeline construction in the eastern coast shelf of the Baidaratzkaya inlet crossing in the Kara Sea. Such a solution was intended to prevent defrosting of permafrost, caused by the positive gas temperature in that part of line. The space between the inner steel pipe and the outer concrete pipe will be filled with thermo insulating material.

Bundles of pipes are not considered in the context of pipelines ending to loading terminals, because they mainly refer to pipelines from offshore facilities to shore. Separate laying operations can, in any case, be performed for multiple lines.

A flexible pipe combines low bending stiffness with high axial tensile stiffness, which is achieved by a composite pipe wall construction. A typical cross-section shows an alteration of collapse resistant, hoop strength and tensile strength steel layers with fluid barrier and anti-wear polymer extruded layers.

Material and full-scale qualifications for low temperatures have shown acceptability of the flexible pipes for a low temperature scenario, although the Arctic experience has highlighted handling and installation difficulties. It has been suggested that for an improvement in the application of the flexible pipe for Arctic areas would call for:

- a reduction of the conservative design derived for its use in underwater applications,
- a reduction of the capital costs for materials and end fittings through customisation, where the basic pipe design, properties and capabilities are preserved,
- development of cost effective shipping practices.

**Installation Techniques**

Construction methods for summer and winter must be evaluated to identify the best candidate method with respect to many factors, such as:

- size and length of the pipeline,
- duration of ice free and ice coverage seasons,
- bathymetry and ice features of the crossed area,

- type of shore approach,
- underwater soil type,
- cost and time schedule of the operations,
- mobilisation costs,
- available logistics,
- available equipment.

**Summer construction**

Summer construction season can take place when the waters are ice-free. In the considered Pechora Sea scenario, this occurs from July to late October.

Construction activities and their timing during the summer season are affected by considerations for environmental protection. Work should be planned in order to avoid bird nesting and feeding areas as well as water-borne activities may be restricted to avoid water quality changes affecting wildlife.

Trenching

Several trenching techniques could be used during the water-open season. Some are applicable only to pre-trenching, before the pipeline is installed, whereas others are best suited to post-pipelines installation. These methods include:

- conventional excavation
- hydraulic dredging
- plowing
- jetting
- mechanical trenching.

*Conventional Excavation*

Hydraulic backhoes and clamshell buckets can be used, operated from a flat-deck barge. Conventional excavation is a proven, but time-consuming method. The reach of an extended or long-reach backhoe is limited to a water depth of approximately 10m. Replacing excavated material in the trench after the pipeline is installed can create slurry, which could make the pipeline temporarily buoyant, unless it is sufficiently heavy to resist the uplift forces.

*Hydraulic Dredging*

The most common hydraulic dredges are cutter and suction dredges. The cutter dredge excavates the trench with a rotating cutter head on the end of a ladder extended to the seabed. Pumps transport the soil through a pipe up the ladder and through a discharge pipe. The dredge advances longitudinally using spud piles. Because of the sweeping motion of the vessel, the trench tends to be wide. A medium sized cutter-dredger with a dredging depth of 20m, required a water depth greater than 5m. Suction dredges excavate the trench by lowering a suction head to the seabed and pumping slurry into a hopper in the vessel’s hull. It requires a water depth greater than 10m. Hydraulic dredging is useless when the material dredged is liquid-like (e.g. fine sand), as it flows back into the freshly excavated trench.

*Plowing*

Plows can be used to lower the pipeline into a trench after it has been installed on the seafloor. They are attractive tools especially if the pipeline route is long. The plow is advanced over the seabed by pulling it with a tug. Several plows have been fabricated for various projects and may be available for lease or purchase. The pipeline would be laid along the route and the plow would be pulled along the pipe, using the pipe as a guide. Generally the plow tends to be quite large (above 250 t) so that a large tow force is needed, with an associated high cost to mobilize appropriate pulling tugs.

*Jetting*

A sled is pulled along the pipeline after it has been installed. High-pressure water is used to liquefy the soil, and air is used to lift it from under the pipe. The pipeline lowers itself to the bottom of the trench as the jet sled advances. To achieve a depth of cover of almost 3m in most soil conditions, the jetting sled would have to be towed over the pipelines several times, increasing the risk of damage to the pipeline. This method would require a trench barge, anchor-handling tugs, and a survey vessel. This method is useless if very hard clays, mixed with gravels and cobbles, are met along the route. So a good knowledge of the soil is needed.

*Mechanical Trenching*

The trenches are made by an underwater vehicle. The trencher has the capability of operating on already laid pipe. The locomotion on the seabed is by hydraulically driven tracks and guidance arms that follow the pipe to be buried automatically control the steering. The vehicle is linked to the surface vessel through an umbilical, which provides the hydraulic power and control functions. Trenching vehicles have been designed by Tecnomare in the past years and as an application for a typical Russian offshore environment, featured to bury pipelines with a diameter as wide as 1.5m in trenches 3 meters deep.

Except for the low-pressure guiding arm, no contact occurs with the pipe. This is to assure the integrity of the pipe and its coating in any conditions. The digging device is a very efficient chain, resulting from a combination of two positives actions: soil digging and soil lifting over the seabed.

*Directional drilling for shore approach*

This technique requires that a rig with a suitable inclination is positioned close to the coastline and a pilot hole is drilled, according to a design path that is in the direction of the lay vessel. After completing the drilling operation, the drill string is pulled back and fitted with a reamer to enlarge the hole as needed. By using a drill pipe and a swivel, the pipeline head follows the reamer until it reaches the rig. By adopting this technique, the environmental impact of the pipeline is minimal and an adequate protection is assured against coastal ice hazards.

*Installation*

The possibilities are:

- installation with lay vessel
- installation by towing and pulling.

*Installation by lay vessel*

The most common and widely adopted lay vessel is the conventional vessel with a stinger: the pipeline is fabricated during lying by using welding stations fitted on board. Generally the vessel moves along the pipeline route by means of an anchoring system. Anchor-handling vessels are needed to help reposition the anchors so the vessel can advance. The lay barge can carry a limited amount of pipe sections on its deck and vessel or barges carrying additional pipe sections are needed. Because of its large draft, a monohull or a semi submersible lay barge would not be able to operate in the water depths at Timan-Pechora. However, if flat-bottom vessels are used, a minimum operational depth of 10m can be achieved.

For pulling the pipeline to the shore, a shore-based winch directly connected to a pulling head on the first joint of pipe at the lay barge is used, or large diameter sheaves permit to reeve the pulling cable and to use the vessel's winches.

This method is typical of areas with ice-free calm water.

An alternative to the lay vessel with stinger is the reel vessel, fitted with a large diameter spool where the continuous length of pipeline is stored. The reel vessel can be a self-propelled ship-shaped vessel, fitted with vertical reel, or a flat deck barge, with a horizontally mounted reel.

This method is suitable for deepwater applications, such as the central areas of the Barents Sea, for connecting platforms to floating storage vessels to export terminals.

This latter method is not suitable for pipe diameters larger than about 20".

*Installation by towing and pulling*

These methods foresee that the sections of pipe are assembled together by welding, to form a complete pipeline. The design of the total weight of the pipeline during the pull is such that the total force required to pull the pipeline must not exceed the capacity of the pulling equipment. The pipeline is usually post-trenched after it has been installed in this manner.

In the bottom tow method, the pipeline rests directly on the seabed and a tug pulls it along.

The pulling is sometimes done by fixed winches, and sometimes by a pull barge. Pontoons may be added to reduce the submerged weight and make the line easier to pull. The longest single length of pipeline installed by this method is 30 km long, in Iran. There are several difficulties associated to this method, among them the abrasive effect of the seabed on the pipeline and the need to find a tow route free of obstructions.

An alternative method consists of towing complete lengths of pipeline while they are kept at a controlled distance above the seabed. In this method chain-buoy assemblies are often connected to the pipe, which permit to maintain the vertical equilibrium depending on the amount of chain resting on the seabed.

**Winter construction**

In areas where the ice is land fast and/or grounded, the pipelines can be assembled completely on ice and either lowered through an ice trench or towed to their final location.

The ice must be thickened so that it can bear the weight of the construction equipment during pipeline installation.

Several alternative installation methods during the winter season have been studied and applied in the Alaskan and Canadian Beaufort Sea, as well as in the Russian Arctic for bay crossings.

Installation by laying through the ice foresees the assembly of the pipe by using mobile welding stations on the ice cover and laying in a similar manner to laying from a vessel, i.e. using a stinger. A large wheel cutter prepares the trench on the ice. If the preassembled pipeline is entrapped in the ice, an ice stinger can be utilized by progressively cutting two ice sides adjacent to the pipeline.

An alternative method is to utilize towing and pulling under the ice through holes that are drilled through the ice along the route. Using a remotely operated vehicle, guide cables are passed and connected in advance from hole to hole before the pipe is laid on the seabed.

**Reference data for the ARCOP selected scenario**

ARCOP's selected scenario for the loading terminal corresponds to the eastern area of the Pechora Sea.

The assumed functional requirements of the pipeline correspond to a sub sea length of approximately 48 km and to supply a loading system suitable for loading of 120,000 t dwt tankers, in a water depth of about 22 m. A flow rate of 8,000 m3/h is considered as a reference.

The properties of the oil to be transported in the pipeline system are based on the standard characteristics of the Russian Arctic oil blend, with pour point between –15 °C to –10°C, density of about 870 kg/m3.

**Standardisation references**

For many years, the oil and gas industry has referred to the rules issued by Det Norske Veritas (DNV) in 1981 (Rules for Submarine Pipeline Systems), as a recognised standard for offshore pipelines. These rules have been updated and revised several times after 1996. Presently the latest revision, DNV OS-F101 Submarine Pipeline Systems (2000), is a worldwide used reference for the industry. It is accompanied by a number of Recommended Practices and Guidelines dealing with various aspects of the design and operation.

In 1997 the Norwegian offshore sector industry initiative (NORSOK) issued the standard Y-001, rev.1 Sub sea Pipelines. This was to replace the individual oil company specifications for use in existing and future petroleum industry developments. It was intended that subject to implementation into international standards, this standard, administered by the Norwegian Technology Standards Institution (NTS) be withdrawn.

ISO issued its standard ISO 13623:2000 P&Ngi – Pipeline transportation systems, to specify requirements and provide recommendations for the design, materials, construction, testing, operation, maintenance and abandonment of land and offshore pipelines for petroleum and natural gas industries. The European version of this standard is EN 14161:2003. It has been translated in Russian and approved by GOST RK for Agip

KCO. Other ISO standards related to this subject are also under development in ISO/TC67.

The Canadian Standards Association (CSA) provides their standard CSA Z662-99, Oil and Gas Pipeline Systems.

The American Petroleum Institute (API) has issued their Recommended Practice RP 1111 on Design, Construction, Operation and Maintenance of Offshore Hydrocarbon Pipelines (Limit State Design). For Arctic applications, the RP 2N Recommended Practice supplements this for Planning, Designing and Constructing Structures and Pipelines for Arctic Conditions (1995).

Additional reference codes for pipelines, although they are not specific of Arctic applications, are the ASME/ANSI Pipeline Safety Standards, such as the B31.4 – Liquid Petroleum Systems and the B31.8 – Gas Transmission and Distribution Piping Systems.

Most of the above standards are supplemented by standards and guidelines relevant to specific designs and operation aspects and components of the pipeline system.

In addition to the industry standards, as a part of the production and export facilities, the pipeline systems must comply with the governmental regulatory codes of the State under whose jurisdiction the Arctic Shelf lays.

Although considerable progress has been made on the design and installation of the Arctic offshore pipelines, supported by the successful completion of projects both for the Russian and Alaskan shelf and Canadian waters, a number of technical issues need further progress and investigation. They are much dependent on the particular characteristics of each site, so their importance has to be considered case by case:

- investigation of sea ice gouging, for optimization of the burial depth of the pipeline, pipeline protection and to avoid excessive costs of installation,
- determining the location and characteristics of the sub sea permafrost and of the sediment type,
- evolution of the shore line processes to understand how they influence the pipeline shore approach,
- investigation of the corrosion processes in the Arctic's cold and salty waters,
- effects of earthquakes on the pipeline performance, methods to effectively monitor the conditions and control leaking.

**Discussion**

The scope of the presentation was the pipeline part of the loading system. This was because of the considerable distance from shore to the terminal, which means that the costs from the pipeline would be considerable, even bigger than the terminals costs.

The presentation was followed by suggestions to obtain data and experiences from the Murmansk Shipping Company's new loading facility and include them in the study. The MSCO terminal pipeline solution is a rigid pipe buried in the sea floor. The main obstacle in using these data is in this case getting the data from the site since the material is mainly kept confidential. There has been one presentation of this terminal at the first ARCOP workshop and hopefully additional information is released later during the project.

Risk calculations for loading facilities were brought up and it was enquired whether these would be included in the study. Mr Busetto explained that risk calculations are not in the scope of ARCOP. In the ARCOP project only the conceptual design is conducted, and not detailed design, that would allow complete risk calculations. All the relevant material is, however, available and it is possible to conduct the risk analysis later on.

## 5. TRAFFIC MANAGEMENT SYSTEMS – BASIC REQUIREMENTS

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### Abstract

The purpose of VTS (Vessel Traffic Service) is to improve the maritime safety and efficiency of navigation, safety of life at sea and the protection of the marine environment and/or the adjacent shore area, worksites and offshore installations from possible adverse effects of marine traffic in a given area. This definition according to IALA (International Association of Marine Aids to Navigation and Lighthouse Authorities) has been implemented worldwide to several areas e.g. ports, waterways, coastal zones etc.

Besides IALA “VTS guidelines” it is necessary, that further rules and laws have to be considered:

- National and local laws, by-laws, rules and recommendations,
- International Ship and Port Security Code (ISPS),
- the SOLAS Convention (International Convention for Safety of Life at Sea),
- the IMO Res. A.857 (20) [International Maritime Organisation: guidelines on VTS]

and any other applicable international rules, regulations and recommendations.

The conditions for the transport of oil and gas through the NSR differ a lot from those under “normal” conditions. It is necessary to define a specific organisation responsible for sailing means and regulating the traffic in the ARCOP context. Most significant are the extreme environmental conditions and the huge area, the long sailing routes accompanied by low traffic density. These might lead to divergences from the definitions and guidelines applied on other specified VTS.

The first step is to focus on the definition of VTMIS (Vessel Traffic Management and Information Service). It can be seen as a supplementation of VTS with its basic functions of evaluating and distributing traffic information, giving navigational assistance and doing the traffic organisation. Additionally waterborne transport related information is included, to allow for co-operative resource management. The terms VTS and VTMIS are used in parallel, since it might be necessary for ARCOP, to widen the existing definitions and regulations anyway.

The two primary partners are the VTMIS as the land based authority and the vessel’s command with its responsibility to navigate safely. VTS/VTMIS instructions to a vessel should be “result orientated” only, leaving the details of execution to the master, officer of the watch or pilot onboard the vessel.

To point out the main requirements of a VTMIS at ARCOP, the Service and Operation Options defined by IALA have been investigated. These basic services have to be widened and adjusted in the ARCOP context.

1. The Information Service has the primary function to provide essential information to the general traffic such as the traffic image, the VTS area and the variables influencing the navigation of the vessel. At ARCOP it is most important to consider specific information reflecting the environmental arctic conditions such as hydrographical and hydrometeorological support and the results of ice services and ice reconnaissance. Additionally legal information (e.g. about military areas) must be considered.

2. The Service of Navigational Assistance is very important in the ARCOP context since differences to sailing in open waters are significant. The primary service is to monitor and to assist the vessel's command decisions relying on data like course and position. Supplementary shore based pilotage and ice pilotage should give advice on basis of recent information and experience of the area and its conditions. Furthermore icebreaker support has to be coordinated and instructed when requested and/or when the need is deemed to exist.

3. Even if traffic density is low, the Traffic Organisation is important since tankers or nuclear powered icebreakers could cause serious environmental incidents. The task of ensuring efficient traffic movement must include the organisation of convoy and escorting.

4. Operating Rules and Regulations comprise the organisational matters of a VTS/VTMIS. This includes the definition of the coverage area, sub-areas, regulations as communication frequencies, reporting points, compulsory pilotage and pilot boarding areas, etc. Especially the delineation of the ARCOP VTS/VTMIS areas is very important due to the big distances between ports and the specific geographic conditions. It is proposed to widen the VTMIS areas to allow seamless handing over along the whole NSR passage, taking into account national and local regulations.

5. The Cooperation with Allied Services is solely supplementing the traffic regulation. The VTS/VTMIS fulfils the task of establishing action agreements between services and vessels to ensure efficient cooperation of the involved parties. In case of incidents, emergency services have to be organised and orchestrated (e.g. Search and Rescue (SAR)). Furthermore the collaboration between adjacent VTS/VTMIS must be ensured to exchange information about traffic, cargo flows, etc. In the ARCOP context the most obvious services in this regard are ice clearance, harbour breakout, port related services and support actions.

To fulfil these tasks it has to be considered that the vessels, as well as the vessel's command, have the ability to navigate safely in ice and the willingness to cooperate and comply with advice from ashore.

When regarding "physical" support the availability of service might depend on the location of the vessel requiring assistance, conditions of ice and weather but also the capability of a resource, e.g. in case of icebreaker support.

It is not possible to only adapt the general VTS/VTMIS concept to comply with the surveyed ARCOP requirements. Services have to be supplemented and organisational, as well as administrational changes, have to be applied.

For ARCOP it is proposed to define a VTS/VTMIS covering the total voyage on the NSR through arctic waters by combining

- a wide area VTS based on vessel tracking and

- additional local or thematic services according to the vessels’ actual needs.

All regular VTS services should be offered tailor-made for the trade’s special requirements based on a network of local/regional VTS/VTMIS and related services. The VTS/VTMIS feature means to enhance a classical VTS by transport-related information services.

To achieve this it is not considered reasonable to just extend existing services. It is proposed to establish an overall concept to build an appropriate VTMIS for arctic conditions taking into account the requirements listed above.

**Commentary presentation**

**Mandatory ship reporting systems in the Gulf of Finland – Safety for the Gulf of Finland**

Jorma Rytkönen &  Sanna Sonninen, VTT Industrial Systems, Finland

The number of vessels transiting the Gulf of Finland has increased significantly during the last years and will further increase in the future. With the heavy passenger traffic between Helsinki and Tallinn, and the rapid development of Russian oil harbours, the traffic image has also diversified. The volume of oil transported in the gulf was 50 million tonnes in 2001, 77 million tonnes in 2003, and is expected to increase to 150 million tonnes by 2010. The increase in maritime traffic along the Gulf of Finland has necessitated the introduction of risk control measures for the gulf area. As one of the main measures, the mandatory Ship Reporting System for the Gulf of Finland (GOFREP) will be implemented on the 1st of July 2004.

The main safety concern related to the increasing ship traffic in the Gulf of Finland is the increase of the risk of collisions between different types of vessels, and environmental damage due to subsequent oil spills. In particular, the passenger vessel and recreational boat traffic, intersecting the tanker routes in the area between Helsinki and Tallinn, is seen to cause a potential threat to the safety of navigation and to the marine environment.

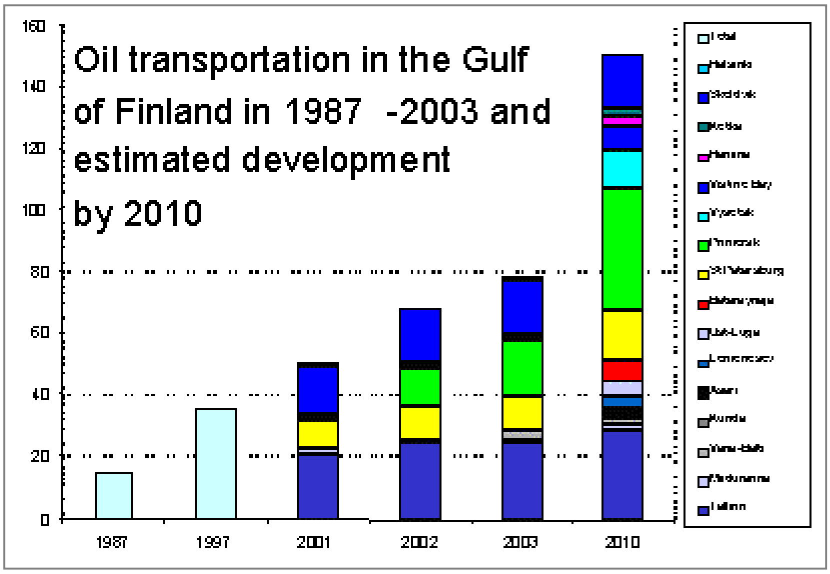



***Figure 1. Estimation of the marine oil transportation development in the Gulf of Finland.***

In the summer of 2000 Finnish Maritime Administration, VTT Technical Research Centre of Finland and Saint Petersburg Business Contact Centre started a joint preliminary survey on the advantages of implementing a joint VTMIS (Vessel Traffic Management and Information System) for the Gulf of Finland. Encouraged by the results of the survey, the Ministries of Estonia, Finland and Russia signed a Memorandum of Understanding on Strengthening the Cooperation to Further Enhance the Maritime Safety in the Gulf of Finland in 2001. The main points of the MoU were the need to adjust the traffic separation schemes of the gulf and to launch the development of a joint VTMIS. The work was started immediately. As a result the first steps of the VTMIS, the amended traffic separation schemes and the mandatory ship reporting system were submitted for approval to the IMO (International Maritime Organisation) Sub-Committee on Safety of Navigation (NAV) to its 48th session.

A Formal Safety Assessment (FSA) study on the implementation of the traffic separation schemes and the GOFREP was made by VTT and Helsinki University of Technology in 2001-2002. The FSA was conducted to support the proposal submitted to IMO for the implementation of these risk control measures. As background information of the study a wide statistical traffic analyses was made to get a realistic view over the current traffic and the prognoses up to year 2010. The results of the study indicated that the implementation of the systems would significantly decrease the risk of ship-to-ship collisions and the related economic loss due to oil spill. The cost-benefit performance of the systems was assessed in terms of the expected total return of investing in a particular option. The results indicate that the investment in GOFREP can be recommended. The Reporting system was adopted by the IMO in its Maritime Safety Committee on 5th of December 2002 (Resolution MSC.139(76)).

The ensuring of safe and effective operation of the GOFREP has required development of both technical solutions and common operational procedures for the three cooperating countries. A common database is developed for the national Traffic Centres for storing the information on vessels transiting the gulf. In addition to the database, other relevant systems are utilised. One of these is the future AIS Helcom, a technical system for mutual exchange and deliveries of AIS (Automatic Identification System) information, which should be fully operational by the 1st of July 2005 in all Baltic Sea countries. However, Estonia, Finland and Russia shall exchange AIS information already by the implementation of the GOFREP.

In accordance with IMO recommendations, joint operational procedures for the three countries have been developed since 2002 and the work has been encouraging. Finnish Maritime Administration and VTT have arranged several workshops for expert working groups consisting of representatives from all three countries. Workshops have been carried out at the Meriturva Maritime Safety Training Centre's Simulator Unit in Otaniemi, Finland. During these sessions the experts have developed joint procedures and evaluated the correctness and functionality of these by using simulations.

Simulation was used as a user-centred design (UCD) method for the procedure development. The aim of UCD is to produce a system that supports users in their joint core-task, and allows them to carry out their work with effectiveness, efficiency and satisfaction. Simulation is an UCD-method that can be used for requirements gathering, requirements validation, and also system validation especially in safety critical environments. In the development of GOFREP, the simulations provided a medium to acquire experience of the intended procedures in different kinds of operating situations. Also, the simulations enabled the participants to make comparisons and judgement between two or more prospective alternatives. During the development work the level of simulation was varied.

As a result of the procedure development, a document of joint procedures for the Finnish, Estonian and Russian GOFREP operators has been written. This document provides guidance and instructions to their daily work. The development work of GOFREP still continues before the actual start-up of the joint work, i.e. July 1, 2004. Before the system starts operating, both the technical and operational preparedness will be tested to validate that the goals of operation can be achieved. In the first testing phase all three national GOFREP Traffic Centres have verified the functionality of their operation. During the second phase the whole system i.e. equipment, interconnections, data transmissions and operational procedures will be tested.

Ship reporting systems are introduced to enhance maritime safety and to protect the environment. In order to accomplish this, the GOFREP operation will after its implementation be continuously reassessed both from the operational and technical point of view. The development of vessel traffic in the Gulf of Finland will make further demands to GOFREP, to which it has to adjust as an effective risk control measure. In addition to the needs for technical innovations, one of the future challenges in the development of ship reporting systems and vessel traffic services is the implementation of human-technology interaction (HTI) approach in the system design.

***Figure 2. View over the Finnish GOFREP-Traffic Centre.***

**Discussion**

It was commented, that the use of an onshore pilot is justified only by in case of unavailability of on-board pilots.

The discussion went on to handle the data exchange needed for updating the ice routing reports. It's possible to use satellite links to transfer VTS data. There are some satellite connections available, but at the moment there is no real need for them. If needs would emerge, the connections would be available on a commercial basis.

# 6. TRAINING FOR ARCTIC NAVIGATION

Anniek Platzer

Wagenborg Shipping

**Abstract**

Purpose of this Presentation

In phase one of this study we determined how shipping companies currently train their crews for navigation in ice.

And in the second phase of this assignment we have investigated the existing training courses and facilities.

The ultimate objective of this study is to create recommendations for the training system needed to run a large-scale Arctic transportation system.

**Availability of Training**

To collect information on current available training, we have set-up a questionnaire that was sent to some 100 training institutes and other parties all over the world.

Unfortunately we did not receive as many responses as we hoped, but with the help of Meriturva and CNIIMF we were able to get information from 13 institutes of which 2 training institutes indicated that they discontinued their training because of lack of interest.

It is no surprise that the information we received are from institutes from countries like Finland, Russia, Germany, Sweden, Canada, Philippines, Netherlands

The courses that are organised by these training centres is usually in the language of the country, is mostly held at the training centre’s location, and in some cases at the customer’s location.

The institutes do not advertise the training very much, which made them very hard to find.

**Types of Training**

The responses we received show that the courses are mostly theoretical.

There are some simulator courses and very little training of real life situations on board of vessels.

The duration of the courses vary from 1 to 10 days for theoretical training, 1 to 7 days for simulator training and 3 to 30 days for training onboard vessels.

Most courses are not specially organised for any specific kind of vessel, but if particular vessels are mentioned, Icebreakers are mentioned more often than other vessels.

As for the trading area, most courses concentrate on the Baltic. Some courses are not directed at any specific area and currently there are no courses that specialise in the Northern Sea Route.

There are courses available for navigators, engineers, pilots and ratings.

There is however a difference in level of training for different activities and positions.

Officers of icebreakers and pilots are trained more extensively than officers of vessels that use the services of icebreakers.

**Basis and Goals of Training**

There are no unambiguous international rules that regulate training for operating in ice.

In 2002 IMO did publish guidelines for training but they are not mandatory.

At the moment general safety is considered the major reason to train people for operations in ice.

Training of specific skills is mostly arranged for officers of icebreakers and to a lesser degree for pilots and officers of vessels that use the services of an icebreaker

The fact that most courses are based on specific requests from the customer and that there is a need for practical experience indicates that the training centres are flexible, willing, and able to develop tailor-made courses.

Turns out that knowledge on ice formation is considered a very important ingredient in training and is indispensable for safe operations in ice.

**Commentary presentation**

*Leif Baarman, Maritime Safety Training Centre Meriturva*

The presentation was composed of three main subjects as follows:

1. As an introduction, the main training activities of Meriturva were shortly described;
2. Keeping in mind the training facilities presented, their prospective application to ARCOP-related training subjects was surveyed;
3. Finally, some aspects related to the scope and objectives of the required training were discussed.

**Meriturva's training activities**

Meriturva is a state funded organization operating under The Finnish Board of Education and consisting of three functional units for survival training, fire training and simulator training.

The survival-training unit has an indoor facility with a 45m x 27m basin, which allows the training with e.g. life rafts and slides to be conducted in well-controlled and safe circumstances. The 5 meter deep basin is equipped with a wave generator and effective blower units, by which the conditions of the training situations can be varied according to the needs of each exercise. An outdoor facility that is in the planning phase will consist of a set of rigs for manning, launching and operation of conventional lifeboats, free fall boats and MOBs.

The main facility at the fire-training unit is a 5-deck mock-up of a cargo vessel superstructure that is equipped with the same kind of safety and emergency outfit, which is installed onboard existing ships. This mock-up can be used in the training of actual fire fighting and smoke diving as well as in the operation of various safety appliances.

The ship simulator unit consists of four full-scale bridge simulators for navigation training. In addition to the bridges there is also an engine control room simulator, which is still under construction as an in-house development project. The bridge simulator has mainly been used in training of pilots and navy officers. Connected with simulators, the subject of Bridge Resource Management has also been one training topic.

***Figure: Meriturva's ship simulator unit***

### Training related to ARCOP

Considering the material resources currently available at Meriturva's training units, some realistic examples of ARCOP-related subjects could be mentioned as follows:

- training of fire fighting, rescue and survival operations during winter time at the outdoor facilities;
- the software packages, on which the engine control room simulator is based, offer wide possibilities to train different kinds of liquid cargo handling procedures and power plant operation including the generation of electrical and steam power for pumping and heating purposes;
- the navigation simulators are equipped with applications for training of navigation in level ice or ship handling in a lead.

The actual item that readily could be applied to the framework of ARCOP is the 'Ice Operations Training'. As a result of an EU funded MARITRAIN project executed during 1996-99 the package consists of a curriculum for a course of 5 to 7 days and an outline course material. Ice Operations Training is dealing with the special matters of winter navigation in the Baltic area. Based on this model course, a couple of full-length training sessions - including lectures and observations onboard - have been arranged during the years 1999-2002.

In co-operation between Meriturva, VTT Technical Research Centre and Helsinki University of Technology a survey on requirements of ice navigation simulators was performed in 1997. This preliminary study resulted in an outline specification of a full-scale simulator to be built in connection to Meriturva's simulator facilities. The specification comprised the instrumentation and functionality required on the bridge as well as the properties of the mathematical models. As a modelling item, the description of the ice field and its transformations was considered to be an arduous task both in the terms of model management and processing power of the computers available at the time.

**Scope and objectives in ARCOP WP3.7**

The main objectives set for WP3.7 are dealing with training in order to facilitate the running of a transportation system. However, the more detailed definitions given by tasks 1, 2 and 3 seem to concentrate on the matters of navigation and piloting.

One of the main factors, which contribute to the ship's capability of performing its transportation task, is the personnel's ability to deal with hindrances and stress factors induced by the ambient conditions. The actual navigation and manoeuvring in ice infested sea form one important portion of the required abilities. Anyway, a significant part of the phenomena causing problems to the ship and its operation is aroused by the cold environment itself having effect e.g. on deck machinery and cargo systems and also on many items inside cargo spaces, the engine room and the superstructure.

Thus, the focus of future training plans should clearly be extended to consider also the aspects of running and operating of ship systems as well as cargo handling procedures. Also, some training for the persons working with fleet management and new building projects might be worth consideration.

It is expected that in the near future there will be an increase in the demand for training of specific ice-conditions and specific vessels. This is based on the increase of offshore oil-recovery projects in the Sakhalin area and the expected activities in the Barents Sea.

The Guidelines for ships operating in ice-covered waters published by IMO in 2002 are not yet mandatory and not many training centres have indicated that they are concentrating on these guidelines, but when these rules become mandatory it is expected that there will be a great demand for training in ice, theoretical training in particular.

In order to determine whether the training facilities, that are currently available, meet the future needs for training for operations in the Arctic Region, all aspects that influence navigation in the Arctic Region need to be considered: ice formation, vessel design, the transport system to be used and how intensive the traffic will be.

These issues will form the basis of the third phase of this study in which recommendations for training in ice will be formulated.

Preceding the third phase, Wagenborg has contacted the Maritime Academy Willem Barents in The Netherlands. They indicated to be able and willing to organise tailor-made theoretical and simulator training, but in order to do so they need very specific information on the ice conditions and vessel designs.

And judging from the responses that Wagenborg received from training institutes it is believed that there are more institutes that are able and willing to organise tailor-made training for ice navigation, but they too need more information.

**Discussion**

The presentation and the following discussion on maritime training revealed the incoherence of the training procedures, especially regarding transportation in the Arctic.

In the USA there are training programs and courses regarding ice, but training related to ship handling and escorting is done mainly on board. In the US it is mandatory to have people trained for ice navigation onboard when sailing to Antarctica. The US coast guard, for instance, has it's own inherent training program for it's officers but there is no commercial training available.

The onboard training is facing difficulties because there is lack of experienced staff onboard – the mariners take jobs onshore and experience is lost. Especially training related to ice and offshore operations are in difficulty for there aren't instructors that know the both worlds. Statistics have shown, that during heavy winters accident frequency has risen due to collisions and damage caused by ice. It seems that this information has not reached the persons that make the decisions regarding relevant crew training.

Simulator training is not possible, since the computers are not able to provide ice training simulations, as the models used to describe ice-related problems are so complex. In Finland, Meriturva has offered ice training regularly twice a year but lately the interest towards this kind of training has decreased.

# 7. CHANGING MARINE ACCESS IN THE ARCTIC OCEAN

*Lawson W. Brigham*

*U.S. Arctic Research Commission*

**Abstract**

Marine access in the Arctic Ocean has been changing in unprecedented ways during the past five decades. Studies have shown that Arctic sea ice extent has decreased by ~3% per decade and that the multiyear ice of the Central Arctic Ocean has decreased in area by ~7% per decade. There has been a general increase in the length of the ice melt season and reductions in ice thicknesses reported as high as 40% (over four decades). Observational data for the Northern Hemisphere sea ice extent during the 20th century shows the largest decrease is in summer, although there is a decrease in extent for all seasons.

In addition, during 1977-2003, 44 transits have been made to the Geographic North Pole by polar icebreakers of Russia, Sweden, Germany, USA and Canada; five trans-Arctic icebreaker voyages have also been accomplished in 1991,1994 and 1996. Year-round navigation has been maintained along the western reaches of the Northern Sea Route to the port of Dudinka on the Yenisey River since the late 1970's, and pioneering icebreaker and icebreaking cargo ship voyages have been conducted along the Northwest Passage. Icebreaker access to nearly all regions of the Arctic Ocean was assured by the end of the 20th century.

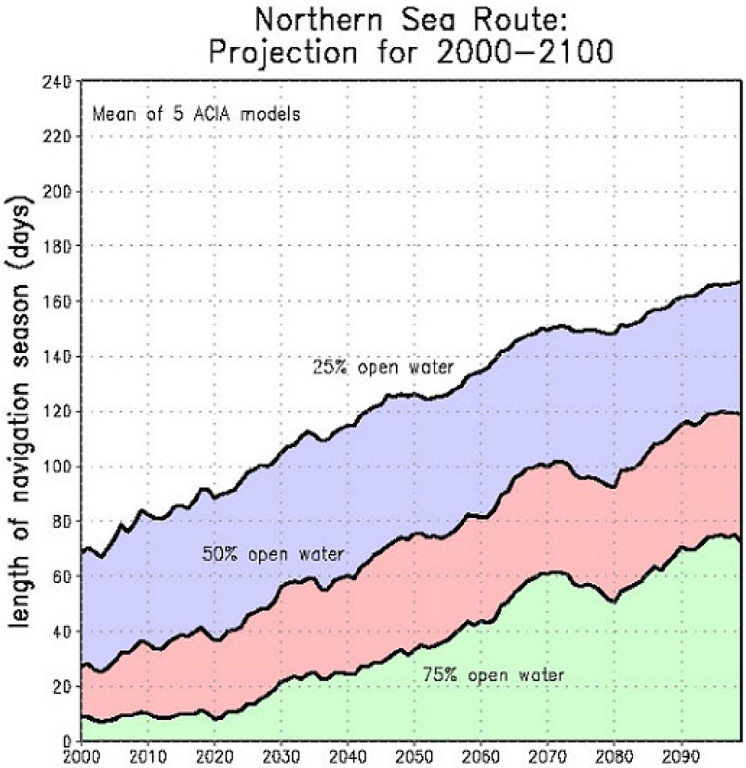
The Arctic Climate Impact Assessment (ACIA), a project of the Arctic Council and the International Arctic Science Committee, has evaluated ongoing and projected changes in the Arctic climate system.

One significant conclusion is that the Arctic is a preview of Earth's future climate: 10 years of change in the Arctic is approximately equivalent to 25 years of change in the rest of the planet. Key changes, among others, identified by the ACIA evaluation include: increasing winter temperatures; thawing of previously frozen ground; variations in the ranges in animals and ecosystems; increases in storm surges and coastal erosion; increased river flows in Siberia; warming of the Arctic oceanic waters; record low levels of stratospheric ozone; increased ground levels of ultraviolet radiation; and, reduced sea ice thickness and extent.

Changes in sea ice are of major importance within ACIA, not only because of the key roles of sea ice in the climate system, but also because of potentially significant impacts of sea ice changes for marine navigation, offshore development, marine ecosystems, and coastal erosion. Within ACIA, projected changes in Arctic sea ice have been evaluated in the context of possible improvements in marine access throughout the Arctic Ocean. The evaluation is based on monthly fields of sea ice from simulations by five different global climate models (GCMs), each forced by the conservative IPCC B2 scenario of increasing greenhouse gas concentrations.

While greenhouse warming reduces sea ice coverage in the five model simulations, especially during summer and in the coastal Arctic seas, there is a considerable range among the retreats projected. One model projects an ice-free Arctic Ocean during summer by 2050-2060. Overall, the seasonality of the retreat produced by the models

(largest in summer) is consistent with trends in observed sea ice coverage during the second half of the 20th century. The suite of plausible, alternative futures of Arctic sea ice during the ACIA time periods (2010-2030, 2040-2060, and 2070-2090) represent a first-order, strategic guide to future marine access in the Arctic Ocean.




The work of ACIA also included initial attempts at regional assessments for the Northwest Passage (NWP) and the Northern Sea Route (NSR). Two serious constraints limited an assessment of the NWP: the GCMs could not resolve the complex geography of the Canadian Archipelago; and, the observed sea ice trends (analyzed by the Canadian Ice Service), although negative for extent since the late 1960's, indicated a very large interannual variability of sea ice coverage. Sea ice simulations conducted for the NSR (by analyzing the region from Kara Gate to Bering Strait) indicated decreasing sea ice coverage and plausible increases in the length of the navigation season for the NSR throughout the 21st century. Many of the simulations showed the retreating ice continues to interact with the northern tip of Severnaya Zemlya, which implies a potential reliance on a transit route through Vilkitskii Strait between the Kara and Laptev seas.

The observed retreat of Arctic sea ice is a very real phenomenon and ACIA projections for the 21st century show extensive and increasing open areas in summer around the entire Arctic Basin. While it may be plausible that regular marine surface navigation in the Central Arctic Ocean may be possible by summer 2050, increasing navigation seasons along the NSR may prove more feasible. The ACIA assessments tested the limitations of the GCMs and pointed to a general recognition for the need of greatly improved Arctic regional models. ACIA will become a key guide to future Arctic climate trends and consequences, and will continue to provide critical planning information for future marine access in the Arctic Ocean.

**Discussion**

It was explained, that the modelling results presenting estimates of the effects of climate change were based on $CO_2$ for it is the most important one of the compounds causing climate change in the arctic. It was also estimated, that real-time imaginery will be available in a few years, enabling regional ice forecasts. Already today the ships receive the satellite information directly from the satellites.

The Arctic sea ice coverage is decreasing. The studies have shown the development both in the areas with multiyear ice and regular sea ice. The largest decrease is in summer, although the ice extent has decreased in all seasons.

The arctic climate is changing faster than the rest of the planet as the studies show that change occurring in the Arctic during 10 years is approximately equivalent to 25 years of change in the rest of the planet. The key changes listed in the studies include reduced sea ice thickness and extent, warming of Arctic oceanic waters and warming of winter temperatures. These changes might have significant impacts on Arctic navigation, as the sea ice extent reduces. The ARCOP project will continue to follow the developments in the field of climatic change research.

# 8. CONCLUSIONS AND RECOMMENDATIONS FOR WORKPACKAGE 3

### WP 3.1 Selection of transportation scenario

Selected scenario, of transportation from Varandey to Rotterdam, is quite topical since the small scale oil transportation has already started and there is on-going discussion on the ways and routes to transport the large volumes of oil.

The large volume transportation is expected to start in a few years. If the chosen cargo volume 320000 barrels (15 mln ton annually) is not economically feasible, the scenario will be updated by finding additional cargo.

The target value for transportation costs in ARCOP is 15 USD/ton. It is a challenge to be met but there are many ways to achieve it. The transportation costs are affected by the size of the tankers, efficiency of terminals and loading systems, insurance costs etc. It is believed, that the target value is reasonable. Most of the work regarding the economic evaluation of the transportations system parameters will be done in 2005.

### WP 3.2 Parameters for transportation vessels

The factors affecting the decisions when designing cargo vessels are numerous. The uncertainties related to the harsh and changing environmental conditions are a particular challenge the designer has to meet. Available data is scarce and limited only to few vessels in operation, which blurs assessing the design principles.

Comparing the traditional and Double Acting tanker provoked a lot of discussion, which indicates that there are some open questions regarding the Double Acting tankers, especially their performance in different environmental conditions.

Cost-estimates based on reliable data would give valuable support to decision makers. Due to the long distances in the arctic, vessel design should aim at low fuel consumption and thus lower transportation costs. The long distances and scarcity of icebreaker assistance in the NSR inevitably raise the need for capability of independent navigation.

### WP 3.3 Parameters for assisting fleet

The target of the study is to find new solutions for safe transport and operations in the northern seas. The possible solutions are new icebreaker types and new guiding and assisting tactics presented here.

The wide, power-saving bow type icebreaker has not been tested in an ice tank, and it was designed in a series of computer simulations. Ice tank experiments would bring answers to the questions that were brought up.

Oblique icebreaker has been tested also in an ice model basin, but so far no full-scale experience exists.

The presentation discusses the findings related to the problematic of a cargo vessel being considerably wider than the assisting icebreaker and the possible technical solutions. The presentation portrays the results on a general level.

It is recommended that workpackages 3.2 and 3.3 co-operate closely to produce a uniform view of the technical characteristics of the transportation fleet.

It was noted that no secondary use for the icebreakers has been considered. This topic should be discussed when evaluating the fleet economics.

### WP 3.4 Loading facilities

The loading facilities are an important link in the transportation chain of hydrocarbons. The economical efficiency of the whole transportation system is depending on the loading facilities and their ability to serve the calling tankers. The design of the loading facilities is thus an essential phase.

In this report, the author is focusing on the characteristics of the pipeline from shore to the platform. The author discusses the environmental phenomena, the types of pipeline configurations and the installation techniques as well as the affect of the climatic conditions during installation. The aim is to find the most suitable and environmentally safe technique for the pipeline construction.

The presentation focused on the pipelines, whereas the aim of the study, when completed, is to produce a representative scenario and a concept of a loading system. The study should aim at producing a uniform scenario, including all parts of the loading facility.

It was recommended, that if possible, the practical experience of Murmansk Shipping Company MSCo and other companies that have recently initiated projects to build new loading facilities in the Arctic, would be included in the study.

### WP 3.5 Economics of the transportation system

The role of economic evaluation is to consolidate all the work within ARCOP. Workpackage 3.5 should provide the other workpackages a list of economic parameters that are needed for the evaluation.

### WP 3.6 The vessel traffic management and information system (VTMIS)

The purpose of using VTS is to improve the safety and efficiency of marine transport. The long sailing routes, low traffic density and the extreme conditions in the area make the NSR differ from many other sailing routes in the world. This is why there are certain requirements the VTS must meet as well.

It is essential to define a specific authority to regulate the traffic and to take responsibilities for the route. The service should be tailor made to meet the needs of the operations. The author recommends establishing a new VTS/VTMIS service instead of extending the existing services. The service should be divided into a wide area VTS with basic services and a local service, adjusted to meet the particular needs of a port or an area.

In the Baltic Sea the traffic volumes have grown very fast during the past years. The oil transports from Primorsk oil terminal and the passenger traffic between Tallinn and Helsinki have grown, and it is expected, that the growth will continue.

The authorities have joined their forces to develop a Ship Reporting System for the Gulf of Finland (GOFREP). The system was implemented on the 1st of July 2004. Collisions leading to oil spill and environmental damage are feared. The safety of recreational boats is a concern as well.

The task of the workpackage 3.6 is to develop the requirements for an arctic VTMIS system. The current VTMIS infrastructure in the area is not sufficient for the increasing traffic volumes. The author suggests abandoning the idea of renewing the current services and supplementing them with modern elements. The existing services should, however, be considered as the basis to develop the more advanced system.

It is recommended, that the Russian experience is utilized more widely in this workpackage. It must also be reminded, that workpackage 3.6 should communicate closely with workpackage 1 (ice information system).

**WP 3.7 Training for Arctic navigation**

The fact that two training centres discontinued their courses might give the impression that there is not much demand for training in ice navigation. This is, however, not the case.

The statistical evidence and data about ice damages is available but still all ship-owners are not aware of the risks. It seems that the flow of information from research organisations to ship-owners and training centres is inadequate.

The traffic in the Baltic Sea is growing, and as it is known, the ice conditions in the Gulf of Finland are harsh. The growing traffic is increasing the risks of collision and environmental damage. The oil transportation activities from the ports of Dikson, Varandey and Indiga are about to grow tremendously and the industry is investing in ice-going ships. It is imperative to develop training related to ice to produce personnel able to work on these routes.  Recommendations for the content of such training are required urgently.

The investments in training are considered justified from both safety and economical point of view.  Workpackage 3.7 should provide WP 3.5 with adequate data to evaluate this issue.

# 9. GOALS AND PROGRESS OF WORKPACKAGE 4 “ENVIRONMENTAL PROTECTION AND MANAGEMENT SYSTEM FOR THE ARCTIC”

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**Abstract**

Waterborne transport of oil and gas products from the Pechora and Kara Sea region as well as oil/gas exploration in arctic waters will increase the risk of oil spills in this highly vulnerable environment. One basic issue is to identify and quantify relevant impact factors to the Environmental Impact Assessment (EIA) and Environmental Risk Analysis (ERA) in terms of e.g. shipping routes, ship types, and regular discharges to the sea. Based on the generic function of environmental risk, the probability of an event is combined with the likely impact of the given event. The probability includes both regular shipping activity and accidental events, while the likely impact is estimated by the inherent characteristics of the natural resources at risk and their vulnerability to waterborne transport.

Consequently, a systemized base on best available data on the temporal and the spatial distribution of the natural resources will be compiled. Possible environmental damage and the impact significance will be assessed qualitatively and quantitatively, and ranked with regard to geographical areas and periods of time. Tailored GIS applications form the centerpiece of the assessment, both regarding baseline data storage and damage and risk estimations.

The establishment of sea transportation routes and the associated infrastructure (e.g. oil/gas pipelines, offshore loading terminal, camps/settlements, etc.) in remote areas have an influence on the local communities and indigenous people, of which social, cultural and economic welfare strongly depends on their livelihood. The industrial implementation may lead to changes in indigenous and local communities with respect to the sociological and economical aspects.

Thus the objective is to make a census with respect to the assessment of the potential sociocultural impacts of arctic marine transportation on indigenous and local communities. The assessment is also a basis to specify the needs and priorities to be considered before the realization of industrial implementation in order to secure or preserve indigenous and local social environment and welfare in the Russian Arctic.

Even when an accident occurs in ice-infested waters, active oil spill response has the highest priority in this vulnerable area. The knowledge of the weathering properties of the specific oil types transported in ice-infested waters is important in order to form a reliable ERA and Oil Spill Response Analysis. Numerical model tools are used to perform quantitative scenario-based Oil Spill Response Analysis for the use in the ERA including oil spill position, oil type, amounts of oil released, duration of the release, etc.

After the development of risk-based scenarios and input from present knowledge of oil weathering, stochastical drift and spread modelling of oil on the sea surface will be performed to give a statistical documentation of the potential influence area from the various spill scenarios. The application of the OSCAR 2000 Model System enables to generate quantitative information (mass-balances, exposure areas, etc.) of alternative spill response strategies for the relevant spill scenarios.

The results of these investigations can be used as a basis for preparing guidelines, definition of requirements for preparing an oil spill response / contingency plan for this specific area. In addition information is provided with respect for the potential of improvements and for recommendations for decision-making processes.

# 10. ECOLOGICAL SAFETY OF OIL TRANSPORT AND TERMINAL IN THE BALTIC SEA – ENVIRONMENTAL CONTROL AND PROTECTION MEASURES

*Natalia Kutaeva*

*RF Ministry of Transportation*

**Abstract**

In 2003 the volumes of bulk cargoes transfer operations in seaports of the Baltic basin add up to about 227,9 million tons, from which the share of the Russian ports constitute about 35,7 million tons i.e. about 16 %.

Presently in the Russian part of Baltic Sea there are three ports, which carry out transfer operations of oil. Those are Primorsk, Saint Petersburg and Kaliningrad.

The port of Primorsk in Leningrad area is situated at natural depths. This is the only Russian deep-water port on the Baltic. During 2003 the port shipped 17.7 million tons of crude oil.

The second biggest port by volume of oil transfer operations is the Port of St. Petersburg. In 2003, 11 million tons of crude oil was shipped.

On the same year, the port of Kaliningrad shipped 7 million tons of oil. Thus the total amount shipped via Russian ports on the Baltic, was 35.7 million tons. Out of that figure, 28.7 million tons was shipped via ports of the Eastern part of the Finnish Gulf. For reference – in 2002 the shipments via the Russian part of the Baltic Sea were 27.8 million tons. The main increase was due to the increase of oil transfer capacity of the port of Primorsk.

***Table: 61,2 million tons of oil cargo of Russian origin was shipped via the ports on the Baltic***

| Port | Shipment, million tons. |
|---|---:|
| Riga | 5.0 |
| Ventspils | 17.5 |
| Liepaya | 0.9 |
| Tallinn | 23.8 |
| Klaypeda* | 3.2 |
| Butinge | 10.8 |

Via port of Klaypeda in 2003 it was transferred 6,6 million tons of cargoes, inclusive 3,4 million tons of Belorussian cargoes.

The total volume of oil and oil product transfer operations via the ports on the Baltic Sea in 2002 constituted of 199,4 million tons, including the 27,8 million tons transferred via Russia ports.

Forecasted estimation of oil cargoes transfer operations via Russian ports of the Baltic Sea can be seen on slide 4.

***Table: Forecasted estimation of oil cargoes transfer operations via Russian ports of the Baltic:***

| Port | Volume of shipment, million ts | Type of cargo | Planned year of future cargo shipments | Builder (operator) of terminal |
|---|---|---|---|---|
| Primorsk | 60 | Crude oil | 2006 | Transneft |
| | 20 | Oil products | 2008 | Transnefteproduct |
| St. Petersburg | 15 | Oil products | 2008 | St. Petersburg, oil terminal.<br>Roads transfer operations. |
| Kaliningrad | 8 | Crude oil<br>Oil Products | 2006 | LUKOIL |
| Vysotsk | 12 | Oil products<br>Liquid Chemicals | 2008 | LUKOIL |
| Total | 115 | | | |

It should be pointed out that in accordance with national legislation the ecological safety of oil terminals is planned before their construction by the state ecological expertise of the projects of oil platforms, oil terminals, oil pipe lines etc. As a must the plans include the issues of preparedness and response to oil spills. Herewith the oil terminals are subjected to strict requirements in accordance with section 2 of "IMO Manual on Contingency Planning", legislation of RF, and in particular on basis of federal laws on issues of environmental protection:

- "On Protection of Natural Environment", FL-7 dated 10.01.02
- "On Mineral Wealth", FL-27 ВФЕУВ 03.03.95
- "On Ecological Expertise", FL-174 dated 23.11.95
- "Waters Code of Russian Federation", FL-167 dated 16.11.95
- "RF Merchant Marine Code ", FL-81 dated 30.04.99
- "On RF Continental Shelf", FL-187 dated 30.11.95
- "On RF Interim Sea Waters, Territorial Sea and Adjacent Zone", FL-155 dated 31.07.98 and some other.

Inter allia, we have to comply with rules and regulations introduced by various agencies and in particular:

- GOST 17.13.02-77 “Regulations on Waters Protection from Pollution during Oil and Gas Exploration and Oil Production at Offshore Wells”,
- SP П-102 -97 “Engineer-Ecological Explorations for Construction Works”,
- “Procedures on Search and Rescue ” by the RF Ministry of Transport.

Regarding prevention of oil pollution at sea and response to oil spills at sea we have appropriate regulations, based on the following international conventions for which the Russia is a part of:

- International Convention for the Prevention of Pollution from Ships 1973, as amended by the Protocol of 1978 relating thereto (MARPOL 73/78);
- International Convention on Oil Pollution Preparedness, Response and Co-operation, 1990 (OPRC 1990);
- Convention on the Protection of the Marine Environment of the Baltic Sea 1992 (Helsinki Convention);
- UN Convention on the Law of the Sea etc.

The provisions of the conventions are implemented in national legislation, including the legal acts mentioned before.

The oil terminals have developed a system of port reception facilities that allows to accept and process clean and contaminated ballast waters, sewage waters, any garbage and meal wastes from ships.

There is also a control system on the operation of port reception facilities (basic receipts that cover the transfer of the ships’ wastes and are handed over on departure from the port).

In order to maintain ecological safety of oil and oil products transfer operations during bunkering operations, in accordance with “International Manual on Safety for Oil Tankers and Terminals” (ISGOTT)”, “International Manual on Oil Transfer from Ship to Ship” and Rules of Oil and Oil Products Carriage at Sea “Regulations 7-M”, the following arrangements are overseen:

- development of booms during ship to ship oil transfer operation;
- the standby of special vessels at places of loading and unloading operations of oil products and during bunkering operations;
- introduction of check lists basis international proformas for tankers and oil terminals, during ship-to-ship transfer operation and during bunkering operations (in accordance with Recommendation of Europe Harbor Masters Association).

The control of dangerous cargo transfers is carried out within the framework of Maritime Port Administration Order to have concurrency of transfer operations, technological charts, schemes of loading operations, concurrence of safety rules etc.

The territorial bodies for environmental protection of the Ministry of Natural Recourses of RF also effectuate control over compliance to national environmental protection legislation.

To minimize the risks of incidents of oil pollution at sea some constructive and organizational arrangements are taken to oil tankers.

It should be noted, that if previously more than one third of oil and oil products was carried in single hull oil tankers, their number will sharply decreased in 2005 due to the enforcement of Regulation 13G of MARPOL 73/78 on acceleration of putting single hull oil tankers out of operation. Slide 6.

***Table: Tankers Calling to Ports of the Baltic Sea (J. Rytkönen and others, 2002.)***

| Terminal | May-June 2001 | | | Average age |
|---|---|---|---|---|
| | DH | DB | SH | |
| Muuga (Estonia) | 48% | 17% | 35% | >15 |
| St. Petersburg | 48% | 14% | 38% | 11 |
| Scolvig (Finland) | 42% | 27% | - | 13 |
| Klaipeda | 20% | 13% | 67% | >19 |
| Ventspils | 37% | 23% | 40% | 13,2 |

*(DH - double hull, DB - double bottom, SH - single hull tankers)*

For 20th April 2004 there was only one single hull tanker of category 1 (tankers of deadweight over 20 thousand tons) flying under the Russian flag, that is planned for demolition by 05 April 2005, i.e. the date when the new MARPOL 73/78 Regulation comes into force. The timetable for taking tankers of category 3 (tankers of deadweight from 5 till 20 thousand tons) out of operation is strictly within the requirements of MARPOL 73/78. None of category 2 tankers are flying under the flag of Russia. To fulfil the requirements of MARPOL 73/78 from the year 2005 onward, it would be prohibited for single hull oil tankers to dock at oil terminals. This measure has already been introduced at the oil terminals of Primorsk and Vysotsk. In conclusion it is advisable to once again recall the position of Russia: any measures aimed at restriction of international navigation shall be approved by IMO, Russia is strictly against any regional, local approach in the solution of such issues.

However, in spite of all taken measures it is impossible to fully prevent ship accidents and oil spills.

As shown by IMO research, the main reasons of ships' incidents and consequently of oil spills are the human factor and conditions of navigation.

In accordance with international statistics about 84-88% tanker incidents have happened due to human error. The reason of ship collisions and groundings in the majority of cases (89-96%) are due to human error. 75% of fires and tanker explosions are due to the same reason. Therefore the international shipping practice, particularly in Russia, has taken considerable effort to decrease the influence of the human factor. All major ports of Russia introduced a system of ship traffic regulation that allows controlling the position of vessels with an accuracy of 10 meters. In ports with intensive ship traffic, a system of vessel traffic separation scheme is being introduced.

World practice has shown that expenses of combating oil spills and oil recovery is less than ten times the expenses of cleaning up the shoreline from oil contamination.

It is necessary to permanently develop the system of readiness to respond to oil spills.

In Russia the system of oil spill response at sea was established in the mid 80s. At all basins was established a Basin Search and Rescue Division (BASU/ASPTR), whose work is being managed and co-coordinated by State Marine Pollution Control Salvage and Rescue Administration of the RF Ministry of Transport (MPCSA), which also incorporates marine rescue-coordination centres and sub centres (MRCC/MSSC). In the Baltic Sea region, the Baltic Tugs BASU is being operated. It is located at St Petersburg with an affiliated subdivision at Kaliningrad, which is equipped with specialized vessels and oil recovery equipment.

MRCC (MSSC) is responsible for receipt and transfer of all distress signals inclusive oil spill reports. MPCSA at the regional and federal level is responsible for oil spill response at sea from ships and facilities regardless of their agency and national status.

Some recourses of environmental control equipment and of a specialized fleet are also available from Maritime Administrations of Ports (MAP). The resources are used for ecological operations at water areas of seaports of Russia.

Besides the resources for oil spill combating, all organizations and enterprises regardless of their agency status are included in regional oil spill contingency plans, which are being developed and approved by MPCSA, and in port plans that are concurred by MPCSA. These plans require continuous updating.

In accordance with international requirements, there is a three-tier oil spill response system in Russia.

According to the system, oil spills of the first tier will be responded with the means and resources of the facility owner. The 2nd and 3rd tiers will be responded with the means and resources of the facility owner, as well as those that are located in the region or Federation accordingly.

The Government of the Russian Federation Decree dated 21 August 2000 №613, as well as the Federal Law on Safety of Dangerous Industrial Facilities, it is foreseen that enterprises and organizations conducting operations with oil, shall have at their facility their own resources for oil spill response at relevant tiers. But in the case of major oil spills, they will have access to regional and national resources, and have their own emergency divisions and conclude agreements with professional emergency maritime services.

Thus the oil spill contingency plan developed for Primorsk oil terminal envisages the 1st tier oil spill has a volume of 500 tons of oil. For responding to the oil spill, the terminal must have a sufficient quantity of booms and skimmers. It has been assigned by OSR Contingency plan, that for Primorsk oil terminal, there should be stored 7000 meter of booms, skimmers of total recovery capacity about 1000 m3 of oil per hour, capacities for temporary storage of oil for about 2000 m3, as well as means and resources for cleaning up the shoreline.

In addition to these means to prevent oil spills at oil terminals, Primorsk terminal has taken some additional measures:

- Shipments of oil made by double hulled oil tankers only. In winter time it is planned to only use oil tankers with an ice class;
- Oil tankers during loading operations shall be contained by oil containment booms;
- At the oil terminal there has been arranged a permanent watch by vessels with oil spill combating equipment on board.

The stage of OSR Contingency Plan materialization and consequently the level preparedness of the region depend on the level of co-ordination of all co-operating agencies and companies. IMO recommendations provide close co-operation with the oil and gas industries. Here MPCSA is trying to consolidate all resources of the region's oil industry available. This requires establishing more flexible structures capable of quickly reacting to requirements and services in order to maintain ecological safety. Such companies of "Ecoshelf" system were established at marine basins and included the Baltic Sea region – at St. Petersburg. The task of these companies – to secure ecological safety by means of consolidating resources and by means of materialization of no standard financial arrangements.

In conclusion it is deemed necessary to note an efficient international co-operation in issues of pollution prevention at sea and in oil spill combating at sea. They are both established within the frameworks of the Helsinki Convention and within bilateral agreements, particularly Russia – Finland intergovernmental Agreement on cooperation and combating oil spills and leaks of harmful substances in the Baltic Sea in emergency situations in 1989. Within the framework of Russia Finland Agreement the meetings of joint planning group as well as joint oil spill response exercises take place at regular intervals.

In 2003 under auspices of HELCOM there was a successful realization of a project involving Russia, Denmark and Finland. The project was on delivery and sharing the holding basis of equipment for oil spill response in order to secure an adequate state of readiness in the Russian zone of responsibility at the Baltic Sea. It was aimed to enforce the strike teams of MPCSA in the region by additional contemporary means and resources for OSR.

Taking into account increasing volumes of oil and oil product shipments in the Finnish Gulf, by initiative of the Finnish Party in 2004, the financial means were allocated for its realization. The Russian – Finnish Project was established, which is similar to the one realized in 2003 involving Russia, Denmark and Finland.

In January 2004, talks were conducted with the Finnish Party and the plans for the Russian – Finnish project were approved.

The Russia - Estonia and Russia - Lithuania bilateral agreement in the field of oil spill preparedness and response are currently under development.

**Discussion**

Environmental concerns regarding private oil terminals were brought into discussion. Mrs Kutaeva explained, that the companies that are operating oil terminals are subjected to federal laws. Authorities control these operations. According to the regulations, each enterprise has own ecological control divisions, which develop their own plan on ecological control. These plans will have to be approved by the federal environmental authorities.

The oil transportations from Russia have been rising during the past few years. Oil companies are looking for new export routes, since the current pipeline infrastructure is insufficient. Without new pipeline investments the expansion of the industry will be limited.

The ecological safety of the Baltic ports is secured by strict regulations. New plans are subjected to environmental protection official's inspection. Most of the single hull tankers, that have been heavily criticized since the Prestige disaster, will be put out of operation during 2005, and from that year onward they will be prohibited to dock at Russian oil terminals.

Oil spill response procedures have developed during the recent years to meet the international standards. Russia has taken part in several international projects to develop the co-operation of states in emergency situations.

# 11. CHARACTERISTICS OF SHIPPING AND NAVIGATION IN ARCTIC AREAS

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## Abstract

For the assessment of risk of probable environmental pollution in the Arctic, within the framework of WP 4.1.2 the present and prospective characteristics of shipping and navigation on waterways of the Northern Sea Route were considered. Special attention is paid to the study of the intensity of the tanker traffic for the export of oil from the Arctic and the delivery of petroleum products to arctic ports. Principal technical and operational characteristics of transport schemes of the work of arctic tankers taking out oil from the White, Barents and Kara seas were evaluated. On the basis of the analysis of navigational, hydrometeorological and ice conditions restricting shipping in the Arctic the scenarios of seasonal and year round navigation on principal transport schemes were developed, prospective types of tankers selected and their main characteristics determined. As applied to the schemes in question calculation was made of the time budget and of the number of voyages during winter and summer navigation for the predicted traffic volumes.

## Shipping

Development of Arctic shipping in Russia essentially depends and will depend in the foreseeable future on the rates of the development and export of hydrocarbon resources situated in the Far North to Europe and USA. In the long term outlook (up to 2010) the program provides for the development of a group of fields in the Pechora Sea (Varandeyskoye, Prirazlomnoye), in the Ob Bay (Lenzitskoye, Sandibenskoye, Salekaptskoye, Novoportovskoye), in the basin of the Ob River (Kislorskoye, Serginskoye, Rozhnikovskoye) and in the basin of the Yenisei River (Bolshehetskiy gas and oil producing region).

A transport seaway of the Arctic Region – the Northern Sea Route (NSR) – linking the Ob and Yenisei Rivers into an integrated water transport system helps to boost rapid development of new deposits.

Navigation along the southern coast of the Arctic Ocean takes place in extreme conditions characterized by complex weather conditions, low temperatures, and existence of ice cover and dark period of time in winter.

Regular marine transportation of oil and gas from the Russian Arctic regions is possible only by using specially designed vessels for year-round navigation in the Arctic conditions. Additional icebreaking support is required to escort transport vessels along the ice routes and for their support at a loading terminals on the areas of deposits.

Now the transportation of crude oil in the Western region of the Arctic is carried out from a number of points in following sea basins:

**White Sea**

Oil loading berth Talagi in Arkhangelsk

To the berth oil are delivered by rail primarily from the Volga region.

In 2002 about 2 million tons of crude oil and oil products was exported from there; an increment in export of oil by 2.5 million tons per year is expected by 2006. The oil-loading berth is accessible for vessels with 8.5 m draught.

*Port-point of Vitino*

The port is situated in the Northwest part of the Kandalaksha Bay. The port is accessible for sea and river vessels. It is linked to the central part of Russia, to the Black and Caspian Seas by the navigable canals. The port has 4 berths; one of them – a floating berth with a depth of 13.7 m – is capable of accommodating tankers of up to 50000 dwt.

The oil loading complex of the port is capable of handling up to 6 millions tons of oil products annually; 5.7 million tons of oil cargoes were loaded in 2003.

*Offshore oil loading terminal Onega*

The terminal has carried out roadstead cargo transhipment from river vessels and barges into large tankers since 2002. In the long term outlook the cargo volume to be handled by the terminal is expected to come up to 700 thousand tons per navigational season.

*Offshore oil-loading terminal Severodvinsk (for the future)*

The terminal is expected to be in operation in 2005-2006. The first stage of the construction provides for handling up to 2 million tons of oil products per year and up to 5 million tons in the future.

On the whole, the volume of oil and oil products to be loaded through the oil loading complexes looks promising for the development from 5 million tons at the present time up to 15 million tons in the future. Oil is delivered to the ports of Europe. Partly with the transhipment to large non-ice tankers in the Kola Gulf in the Murmansk area.

**Barents Sea (Timan-Pechora region)**

*Offshore oil-loading terminal by Kolguyev Island*

The terminal loads up to 400 000 tons of oil in summer period into tankers of up to 100 000 dwt and more.

*Offshore oil-loading terminal Varandey*

The terminal is capable of handling tankers with up to 10 m draught. In 2003 there were shipped about 500 000 tons of oil. The throughput capacity of the terminal can reach in the long run about 3 million tons per year. When the construction of the second stage of the oil-loading terminal is over, the terminal will accommodate vessels of up to 100 000 dwt and will increase the volume of oil loading up to 15-20 million tons.

*Offshore oil-loading terminal Prirazlomnoye (for the future)*

The terminal is designed for loading up to 6-7 million tons of crude oil annually. It will be able to accommodate vessels of 70 000-90 000 dwt.

*The harbour-reloading complex of the Northern pipeline system Indiga (prospective)*

..is being designed by the Oil Company "Transneft" for the loading of up to 50 million t of crude oil a year including: 25 million ton for the ports of Europe and 25 million ton for the ports of the USA. It will be capable of accepting ships with a deadweight of up to 150 000-300 000 t. This project is being studied as an alternative of the loading of oil through ports of the Kola Peninsula.

The total volume of oil cargoes shipped through the Arctic oil-loading terminals of the Barents Sea will increase from 800 000 tons now up to 70 million tons and more in the future.

**Kara Sea**

Experimental shipping of oil from the fields in the basin of the Ob River with transhipment in the Gulf of Ob from river tankers into sea tankers is now conducted. The construction project of an oil-loading terminal in the region of the Dikson Island (Yefremov Bay) with designed oil loading up to 16-17 million tons of crude oil annually is very promising. Oil will be delivered by the oil pipeline from the Vankorskoye field. This oil-loading terminal will be capable of accommodating vessels of 90 000 to 100 000 dwt.

The transportation schemes under consideration are shown in fig. 1. The technical and operational characteristics of the designed transport schemes differentiated by periods of navigation are shown in table 1.


***Figure 1. Transportation schemes of export of oil from terminals on White, Barents and Kara seas***

***Table 1. Technological and operational transport schemes***

| Transportation Scheme | Distance of carriage, sea miles | | Navigation period, days | Design cargo volume, ths. t | | Project vessel types |
|---|---|---|---|---|---|---|
| | total | In ice | | per year | per month | |
| A. Summer period of navigation | | | | | | |
| White Sea–Murmansk | | | | | | |
| Arkhangelsk–Murmansk | 400 | – | 180 | | | |
| - existing | | | | 2000 | 170 | HO-20 |
| - designed | | | | 10000 | 830 | HO-60 |
| Vitino–Murmansk | 520 | – | 160 | | | |
| - existing | | | | 2800 | 230 | HO-40 |
| - designed | | | | 6000 | 500 | HO-60 |
| Timan-Pechora–Murmansk | | | | | | |
| Varandey/Prirazlomnoye–Murmansk | 540 | – | 150 | | | |
| - existing | | | | 3000 | 250 | HO-20, HO-40 |
| - designed | | | | 24000 | 2000 | HO-70 |
| Kolguyev Island–Murmansk | 400 | – | 120 | 400 | 134 | HO-70 |
| Kara Sea–Murmansk | | | | | | |
| Dikson–Murmansk | 1000 | – | 125 | 15000 | 1250 | HO-70, HO-125 |
| B. Winter period of navigation | | | | | | |
| White Sea–Murmansk | | | | | | |
| Arkhangelsk–Murmansk | 400 | 220 | 185 | | | |
| - existing | | | | 2000 | 170 | HO-20A |
| - designed | | | | 10000 | 830 | HO-40A |
| Vitino–Murmansk | 520 | 350 | 205 | | | |
| - existing | | | | 2800 | 230 | HO-20A |
| - designed | | | | 6000 | 500 | HO-40A |
| Timan-Pechora–Murmansk | | | | | | |
| Varandey/Prirazlomnoye–Murmansk | 540 | 200 | 215 | | | |
| - existing | | | | 3000 | 250 | HO-20A |
| - designed | | | | 24000 | 2000 | HO-70A |
| Kara Sea–Murmansk | | | | | | |
| Dikson–Murmansk | 1000 | 670 | 240 | 15000 | 1250 | HO-70A, HO-125A |

**Oil transportation on Murmansk–Dikson route**

The scenario is based on a long-term experience of organization of year-round Arctic navigations on Dudinka direction, analysis of account and statistical information on shipping in the Western Region of Arctic.

*Summer navigation period (July–September)*

During summer navigation the character of ice conditions along the routes are determined by cyclonic activity in the preceding winter period. In July–September vessels follow the route Novaya Zemlya Straits–Dikson as a rule autonomously. Icebreaker assistance is needed only for some separate segments, when sailing through ice dams of heavy residual ice. The running speeds are close to operational speed.

The reduction coefficient of operational speed (Kl) by types of navigation according to ice conditions is as follows:

| | | |
|---|---|---|
| a) | Mild | $K_l$ = 0.90–0.85, |
| b) | Moderate | $K_l$ = 0.85–0.80, |
| c) | Severe | $K_l$ = 0.80–0.75 |

*Extended navigation period (October–November)*

This period is characterized by beginning of intensive ice formation on the routes of navigation. The thickness of young ice is 20–25 cm, and the formation of fast ice is in progress.

Sailing in ice-free waters takes place on the segment the Murmansk–Karskiye Vorota Strait. On the other route segments the ships follow under escort of icebreakers located along the route in places of concentration of residual fragments of the ice massive.

The reduction coefficient of operational speed by types of navigation are characterized by the following values:

| | | |
|---|---|---|
| a) | Mild | $K_l$ = 0.83–0.78, |
| b) | Moderate | $K_l$ = 0.78–0.68, |
| c) | Severe | $K_l$ = 0.67–0.63. |

*Winter-spring navigation period (December–May)*

By the beginning of the period, fast ice starts forming and intensive ice accretion is observed both in the Yenisei Gulf and in the Novaya Zemlya ice massive.

In the Kara and Barents Seas the thickness of fast ice reaches 110-140 cm. In the Yenisei Gulf and in drifting massive the mean ice thickness is by 30-50 cm less.

Navigation without icebreaker support is possible only up to the Kolguyev Island, and up to the meridian of the Svyatoy Nos or the Kanin Nos Peninsulas in severe shipping seasons. The speeds of caravans under icebreaker assistance are determined by transport ability to proceed along channel in the wake of the leading icebreaker.

The reduction coefficients of operational speed in caravan mode of sailing by types of navigations are characterized as follows:

a) Mild $K_I$ = 0.58–0.54,

b) Moderate $K_I$ = 0.53–0.46,

c) Severe $K_I$ = 0.46–0.40.

The principal characteristics of ice-going tankers designed for export of crude oil from the region of Obskaya Guba and Yenisei River basin, and for delivery of oil products to certain points of the Arctic Region are listed in table 2. Prospective designed types of large-capacity tankers intended for Arctic navigation are given in table 3.

Calculation of trip number and time budget for different transportation schemes and summer or winter shipping seasons

The results obtained from calculations of both number of trips and transportation time budget (in terms of vessel-days) made for vessels of prospective construction by periods of navigation, are given in table 4.

***Table 2. Principal characteristics of ice-going tankers designed for export of crude oil from Obskaya Guba and Yenisei River basin, and for delivery of oil products to certain points of Arctic Region***

| **Characteristic** | **HO-6A** | **HO-20A** | **HO-30A** | **HO-40A** |
|---|---|---|---|---|
| Deadweight, t | 5 490 | 20000/18200 | 31 000 | 40 050 |
| Cargo capacity, $m^3$ | 6 200 | 22 000 | 35 100 | 45 900 |
| Net tonnage, t | 4 900 | 17300/15500 | 27 700 | 36 300 |
| Length overall, m | 113 | 175 | 218 | 255 |
| Beam, m | 18.3 | 24.4 | 31.0 | 33.6 |
| Draft loaded, m | 6.7 | 9.6/9.0 | 9.0 | 9.0 |
| Main engine type | Slow speed diesel | Medium speed diesel | Medium speed diesel | Medium speed diesel |
| Operational power, kW | 4 050 | 7 500 | 9 000 | 10 260 |
| Service speed, knots | 15.2 | 14.4 | 14.3 | 14.2 |
| Ice class of RMRS | LU5 | LU7 | LU7 | LU7 |

***Table 3 Principal characteristics of large arctic tankers designed for export of crude oil from Barents and Kara seas***

| Characteristic | HO-60A | HO-70A | HO-90A | HO-125A |
|---|---|---|---|---|
| Deadweight, t | 60000 | 70000 | 90000 | 125000 |
| Length overall, m | 226 | 255 | 262 | 300 |
| Beam, m | 32.2 | 32.2 | 40.0 | 45.0 |
| Draft loaded, m | 13.6 | 13.6 | 15.0 | 16.0 |
| Main engine type | Medium speed diesel | Medium speed diesel | Medium speed diesel | Slow speed diesel |
| Number and operational power, kW | 2×10000 | 2×11000 | 1×27000 | 2×18200 |
| Service speed, knots | 14.0 | 14.0 | 14.5 | 14.5 |
| Ice class of RMRS | LU6 | LU6, LU7 | LU7 | LU7 |

***Table 4. Number of trips and the budget of time for a year on transportations on the periods of summer and winter navigation***

| Transportation scheme and point of loading | Cargo volume, ths. t | Type of tanker | Number of trips | | | Vessel-days on transportations | | |
|---|---|---|---|---|---|---|---|---|
| | | | summer | winter | total | summer | winter | total |
| White Sea – Murmansk | | | | | | | | |
| *Arkhangelsk* | | | | | | | | |
| - existing | 2000 | HO-20A | 54 | 54 | 108 | 152 | 163 | 315 |
| - designed | 10000 | HO-40A | 138 | 138 | 276 | 392 | 422 | 814 |
| *Vitino* | | | | | | | | |
| - existing | 2800 | HO-20A | 60 | 84 | 144 | 219 | 335 | 554 |
| - designed | 6000 | HO-40A | 70 | 98 | 168 | 259 | 396 | 655 |
| Timan-Pechora – Murmansk | | | | | | | | |
| *Varandey/Prirazlomnoye* | | | | | | | | |
| - existing | 3000 | HO-20A | 65 | 91 | 156 | 247 | 364 | 611 |
| - designed | 24000 | HO-40A, | 275 | 385 | 660 | 1056 | 1554 | 2610 |
| | | HO-70A | 155 | 217 | 372 | 546 | 803 | 1349 |
| *Kolguyev Island* | | | | | | | | |
| - existing | 400 | HO-70 | 6 | - | 6 | 16 | - | 16 |
| *Kara Sea – Murmansk* | | | | | | | | |
| *Dikson* | | | | | | | | |
| - designed | 15000 | HO-70A, | 80 | 160 | 240 | 522 | 1238 | 1760 |
| | | HO-125A | 40 | 80 | 120 | 280 | 633 | 913 |

In accordance with data of the OAO Petroleum Company (PC) “Rosneft” the oil of the Prirazlomnoye field situated in the south-eastern part of the Pechora Sea will be produced from the off-shore platform filling up tanker-shuttles and subsequently delivering oil to the floating depot which may be installed in the area of Pechenga of the Murmansk region. The planned oil distribution by years is shown in fig. 2. For taking out oil from the off-shore platform it is intended to use LU6 ice class tankers with a deadweight of about 70 000 t. For the period of 2006-2008 it is planned to use one tanker subsequently putting into operation the second tanker for 2009-2019. Beginning from 2020 and up to the end of production one tanker will be required.

The transportation of oil of the Vankorskoye group of deposits situated in the Taimyr district will start in 2009 and will be carried out by the pipeline system to the port of Dikson, further on filling up tanker-shuttles and subsequently delivering oil to the floating depot in the area of Pechenga as for the oil of the Prirazlomnoye field. Expected distribution of the shipment of the Vankorskoye oil by years is graphically presented in fig. 2.

For the transportation of oil out of the area of the Dikson Island the Oil Company “Rosneft” is planning to use LU7 ice class tankers with a deadweight of 70 000-80 000 t, up to 254 m long, up to 38 m wide with a draft of up to 14.5 m, though depths permit using tankers of a larger deadweight (up to 125 000 t). In 2009 it is planned to use two tankers, subsequently, in 2010, putting into operation the third tanker, further on in 2011 the total number of tankers will be increased to five units and finally beginning from 2012 the total number of used tankers will be brought to six ones and this number will be retained up to 2020.

In accordance with the assessment of the Oil Company “Rosneft”, for the reliable regular transportation of oil from the Prirazlomnoye and Vankorskoye fields the icebreaker assistance will be required:

- on line Prirazlomnoye – Murmansk in April-May;
- on line Dikson – Murmansk in January-May.

Total number of voyages on routes Prirazlomnoye – Murmansk and Dikson – Murmansk is presented in table 5.

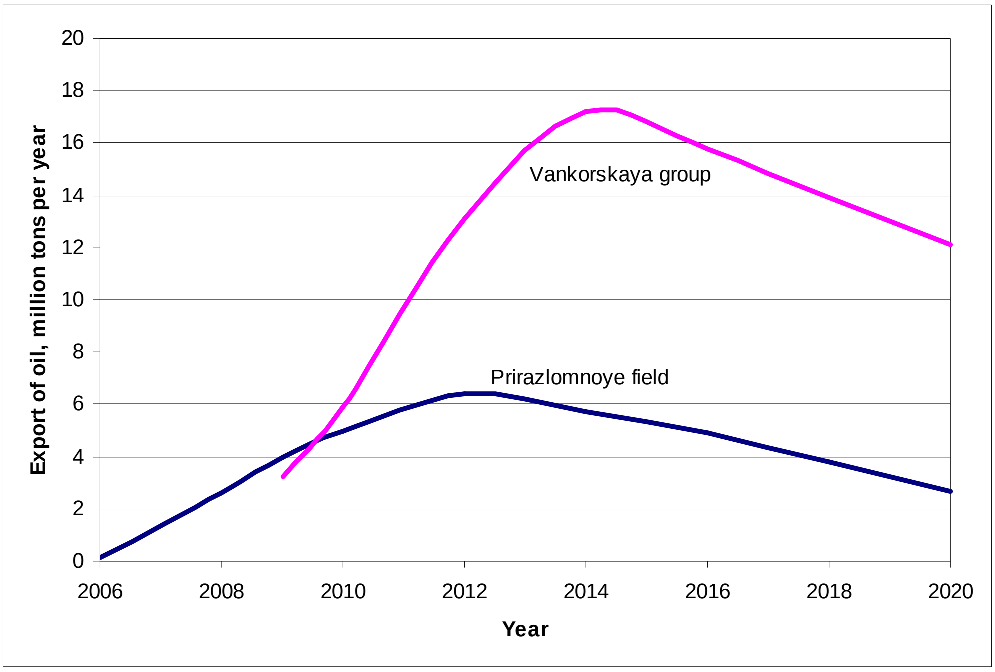


***Figure 2. Distribution of export of oil from Prirazlomnoye oil field and Vankorskoye group of fields***

***Table 5. Total number of voyages with icebreaker escorting on routes Prirazlomnoye–Murmansk and Dikson–Murmansk***

| | January | February | March | April | May |
|---|---|---|---|---|---|
| **2009** | 4.0 | 4.0 | 4.0 | 9.0 | 9.0 |
| **2010** | 7.0 | 7.0 | 7.0 | 13.0 | 13.0 |
| **2011** | 12.0 | 12.0 | 12.0 | 19.5 | 19.5 |
| **2012** | 16.0 | 16.0 | 16.0 | 24.0 | 24.0 |
| **2013** | 20.0 | 20.0 | 20.0 | 23.0 | 23.0 |
| **2014** | 20.5 | 20.5 | 20.5 | 23.0 | 23.0 |
| **2015** | 20.0 | 20.0 | 20.0 | 22.5 | 22.5 |
| **2016** | 19.0 | 19.0 | 19.0 | 22.0 | 22.0 |
| **2017** | 18.0 | 18.0 | 18.0 | 21.5 | 21.5 |
| **2018** | 17.0 | 17.0 | 17.0 | 21.0 | 21.0 |
| **2019** | 16.0 | 16.0 | 16.0 | 20.0 | 20.0 |
| **2020** | 15.0 | 15.0 | 15.0 | 18.5 | 18.5 |

**Navigational and hydrographic support of shipping on the waterways of the Northern Sea Route**

The navigational and hydrographic support (NHS) of shipping on the waterways of the Northern Sea Route (NSR) is entrusted in Russia to the federal body of executive power in the field of transport – Ministry of Transport. The Federal State "Hydrographic Enterprise" (HE) under the Ministry of Transport of the Russian Federation directly affects the NHS. Zones of responsibility of the arctic branches of the HE are shown in fig. 3.


***Figure 3. Zones of responsibility of the arctic branches of the HE***

The Federal State HE possesses the world largest fleet of hydrographic ships of the strengthened ice class including 13 ones built in Finland of series "Dmitry Ovtsyn", "Fyodor Matissen" and "Alexei Maryshev" intended for the survey and relief mapping, installation and maintenance of navigational aids of sea routes and equipped with special outfit for the operation under severe arctic conditions (see fig. 4).

***Figure 4. Hydrographic vessel***

The comprehensive system of the NHS of navigation on waterways of the NSR involves:

*1. Investigation of the underwater relief of arctic seas and inland waterways suitable for sea navigation in view of publishing navigational charts and manuals*

By the present moment, main sections of arctic seas encompassing 90% of traditional shipping routes are covered with the detailed survey of the bottom relief and soil survey. Since their establishment in 1933, divisions of the Hydrographic Enterprise have carried out more than 5.3 million kilometers of sounding (table 6).

A set of sea navigational charts for the NSR produced on the basis of the performed surveys amount to about 700 admiralty numbers out of which more than 650 were opened for public navigation including 194 English-Russian versions. Plans of the approaches to main points of the roadstead unloading and detailed charts for the sailing of sea-going ships along the Yenisei, Khatanga, Anabar and Kolyma rivers have been drawn up. Twenty various navigation manuals satisfying the needs of any ship when sailing in arctic seas have been published.

***Table 6. Numerical indices of the sounding works performed by hydrographic expeditions in arctic seas in 1933-2003***

| Type of sounding by periods | 1933-1952 linear km | 1953-1964 linear km | 1965-1983 linear km | 1984-2003 linear km | Total in linear km |
|---|---|---|---|---|---|
| From ship | 291 000 | 901 000 | 2 112 000 | 905 000 | 4 209 000 |
| From launch | 47 000 | 49 000 | 86 000 | 63 000 | 245 000 |
| From ice | 70 000 | 203 000 | 452 000 | 141 000 | 866 000 |
| Total | 408 000 | 1 153 000 | 2 650 000 | 1 109 000 | 5 320 000 |

On the basis of the analysis of the extent of hydrographic exploration the areas of arctic seas were determined, where it is necessary to continue large-scale hydrographic studies to bring the knowledge of the investigated underwater relief of arctic seas to the level of modern requirements (see fig. 5).

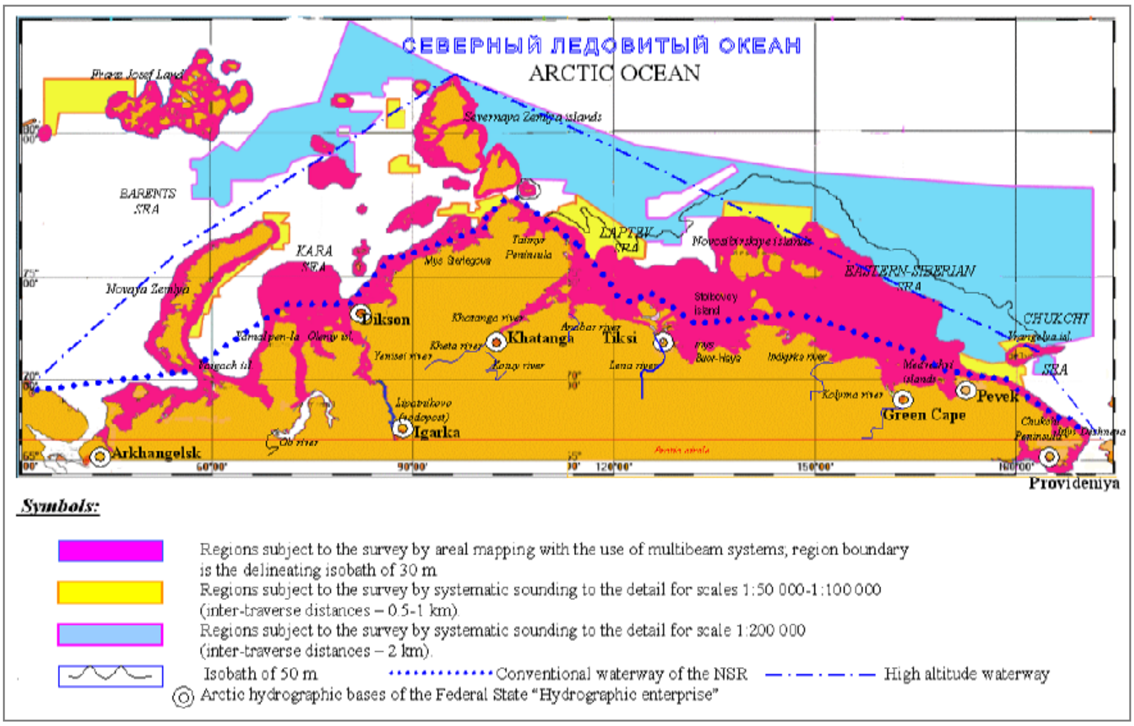


***Figure 5. Regions of the planned hydrographic investigations over the water area of the Arctic Ocean***

*2. Assurance of the operability of navigational aids*

At present, along waterways of the Northern Sea Route about 2200 different types of navigational aids (NA) are installed and maintained. Necessary navigational and hydrographic infrastructure was set up ensuring all the year round navigation in the Western Arctic area on line Murmansk – Dudinka.

*3. Pilotage and composition of the Arctic pilot service*

The "Hydrographic Enterprise" provides the pilotage of ships in the lower reach of the Yenisei, Khatanga, Anabar rivers and along the Kolyma river. Total length of the pilotage sections is 686 miles. Statistical data about the work of the Arctic pilot service are presented in table 7.

***Table 7. Number of pilot operations performed by pilots of the Arctic pilot service***

| River | 1994 | 2000 | 2003 |
|---|---|---|---|
| Yenisei | 276 | 78 | 66 |
| Khatanga | 8 | 20 | 3 |
| Anabar | 8 | 0 | 0 |
| Kolyma | 123 | 133 | 104 |
| Total: | 364 | 231 | 173 |

*4. Distribution of information about the change in the navigational conditions*

One of the most important components of the NHS is to provide mariners with information and in the first place to transmit the information about changes in the navigational conditions and mode of navigation. Transmission of messages is carried out through the SafetyNET via two satellites of the INMARSAT system (areas of the Indian and the Pacific oceans) and NAVTEX points for the transmission to the NSR sections not covered by the SafetyNET. NAVTEX station operates in the port of Tiksi. In June 2000 the transmission of navigational information to waterways of the NSR through the SafetyNET started and the transmission of both navigational and hydrometeorological information started in October 2001.

*5. Measures on the prevention of pollution from ships of Arctic seas*

Control of the observance of rules for the prevention of pollution of arctic seas is an important component of the NHS system. The control is affected by specialists of the Hydrographic Enterprise holding the rank of Inspectors of the NSR Administration following two principal directions:

- planned checks of port petroleum storage depots and of other shore-based facilities, of cargo handling operations with tankers, availability and state of the water protection equipment and means for the localization and elimination of consequences of the emergency spills of oil in port water areas;
- direct control over ships in the Arctic.

To ensure the full-scale control in the Arctic including control over ships sailing along waterways of the NSR the use is made of aviation as well as of hydrographic and auxiliary ships.

**Lines of the improvement of the Northern Sea Route NHS**

Analysis of international and national requirements in the field of the navigational and hydrographic support of shipping allows formulating principal tasks and lines of the improvement of the Northern Sea Route NHS. It involves:

1. Development, trial and putting into operation of the network out of 11 coastal differential stations of global navigational satellite systems, GLONASS/GPS.
2. Creation of the data bank of electronic navigational charts (ENC) for waterways of the NSR meeting requirements of the Standard of the International Hydrographic Organization S-57, of the correction system and electronic mapping service.
3. Development of sea electronic cartographic navigational information systems (ECS) complying with the requirements of the International Maritime Organization for icebreakers, tankers, cargo, hydrographic, geological survey and other specialized ships and special "portable" ECS for the Arctic pilotage.

Within the framework of the above activity the following is already deployed:

- Coastal differential station (CDS) of the global navigational satellite systems GLONASS/GPS on Oleniy Island, CDS GPS on Lipatnikovsky Sandbank (Yenisei River), on Cape Sterligova (the Kara Sea, Taimyr Peninsula) and in the port of Zelyoniy Mys (East Siberian Sea, Kolyma).

The ENC collection for waterways of the NSR as of the beginning of 2004 consists of 996 units produced on the basis of 221 sea navigational charts. All main waterways of the NSR and mouths of large rivers (Ob, Yenisei, Khatanga and Kolyma) suitable for the sea navigation are covered by electronic navigational charts.

Hydrographic ships and the Arctic pilotage service are provided with arctic electronic mapping systems "TRIS-100" operating with the ENC data base made by the

Hydrographic Enterprise according to the IHO standard S-57. All pilotage operations on the Yenisei, Khatanga and Kolyma rivers are carried out with the use of mobile software-hardware systems “Lotsman TRIS-100” with a bank of ENC.

Principal tasks on the modernization of the navigational aids system in the coming years are to be the following:

- Introduction of alternative sources of energy including wind generators, solar panels and replacement of radionuclide power plants.
- Development and implementation of the systems of monitoring and automatic remote control of elements of the navigational aids system.

**Discussion**

The new regulations for NSR are being prepared, and it’s possible that the regulations will be extended westwards to the Barents Sea. Today the regulations apply to the area beginning from the Kara Gate (Novaya Zemlya). The old regulations were approved by the Ministry of Transportation. The Western European practice is that such regulations are approved on a Governmental level. It is expected, that the RF Government will approve of the new NSR regulations during 2004-2005.

It was questioned, if there are any physical restrictions in Dikson, which limit the vessel size to 125 000 tdw instead of bigger vessels like Suez max. The comment was that the presented scenario follows the plans of Rosneft and the terminals are designed based on that. The bigger tankers up to 300 000 tdw will be used from the open water port of Murmansk.

Experts expect that the traffic along the NSR and in the Barents to increase exponentially in the near future. Several companies have plans to develop their transportation fleet and facilities in the area. Increase in transports in the area calls for development especially in the available ice breaking services but also in the hydrographical and navigational support.

The Northern Sea Route NHS is improved in several sectors including global navigational satellite systems (GLONASS/GPS), electronic database of navigational charts (ENC) and electronic cartographic navigational information systems (ECS). The work has already been started.

The navigational and hydrographical support includes also the investigation to find new routes and waterways and implement them, assuring the availability of navigational aids and pilotage, and distribution of information on changes in the navigational routes. The measures also include the prevention of pollution from ships.

The maintenance of the NSR infrastructure is the key factor in the development safety and efficiency of marine transport. If the traffic and transported cargo volumes will grow as it is expected, the risks of accidents will increase if the infrastructure is not developed to meet the new needs

# 12. SHIPPING CHARACTERISTICS AND NAVIGATION: ENVIRONMENTAL RISK ANALYSIS PERSPECTIVES

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*Alpha Environmental Consultants*

## Abstract

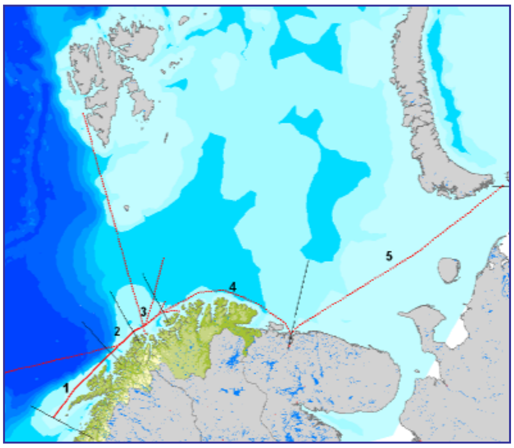
As an important input to the Environmental Impact Assessment (EIA) and Environmental Risk Analysis (ERA), shipping characteristics and accidental frequency calculations have been prepared for selected ship-routes within the ARCOP scenario.

Key impact factors from ship traffic includes:

- exhaust gases and combustion waste
- evaporation of loading and cargo etc.

Discharges to sea

- sewage and garbage
- anti-fouling paints
- ballast water (alien species)
- fuel residues etc.




Land based activities

- fuel residues etc.
- Safety

Accidental events

- loss/ release of cargo / oil

All of these impact factors will be addressed in the EIA, while the ERA will focus on accidental events and the release of oil to the environment. Accidental frequencies has been calculated for:

- Collisions
- Groundings
- Structural failures
- Fire/Explosions

Among these, the frequencies for drifting grounding are the highest, and are somewhat higher than the added frequency of structural failures and fire/explosion. After the introduction of a Traffic Separation Scheme in January 2004 (assumed to be extended), meeting collisions have almost been eliminated, and play an insignificant role in the risk. Incidents leading to total loss of oil in the tankers have a total frequency of 1/6 to 1/10 of the total accidents. The majority of these accidents are due to drifting grounding or fire/explosion.

The environmental resources at risk, contributes to the other major input to the ERA. For these resources information is obtained of their

- Temporal & Spatial Distribution (Baseline)
- Abundance
- Life-history
- Status & Trends
- Sensitivity & Vulnerability to the given Impact Factor

By conducting an aggregation of these resources in coastal segments, one will obtain a kind of environmental index value, indicating the environmental sensitivity of various parts of the coast in different seasons. Further, by introducing the risk of an accident along the coast, one will obtain an environmental risk value, suitable for comparison and identification of high-risk areas. The work with the ERA will be finally reported in 2005 and hopefully bring valuable input to the oil spill response planning and to identify mitigating measures for the decision makers.

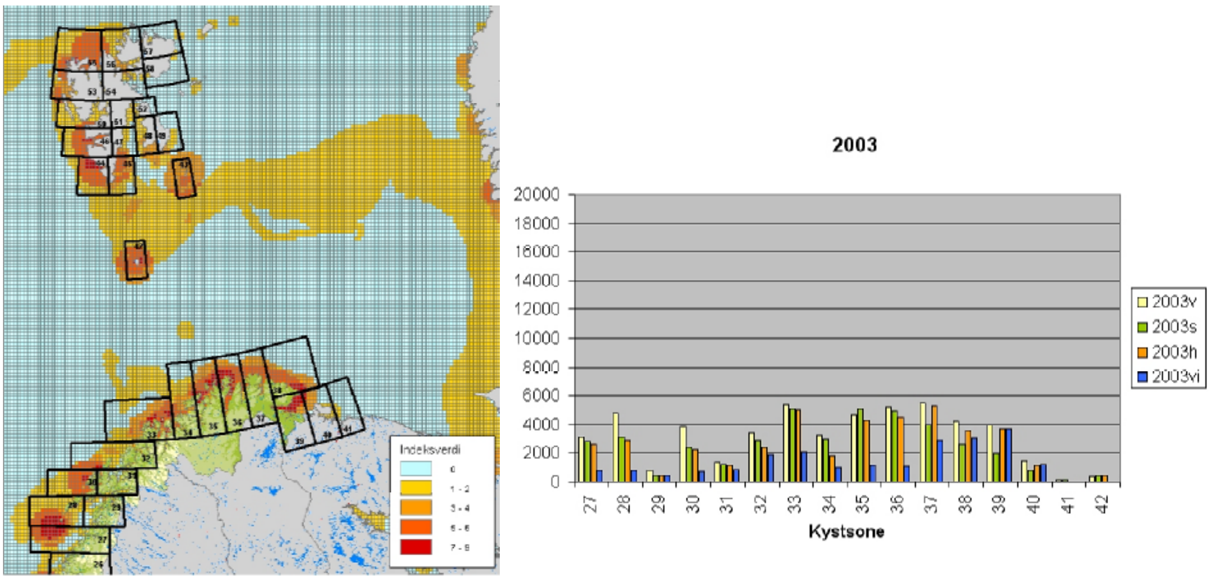



***Figure: Aggregated environmental index values along different coastal segments.***

## Discussion

The calculations that were used to obtain the probabilities of possible accidents and their return period were based on last year's (2003) scenarios and included the estimated increase in traffic. Although the results showed accidents to be quite rare (estimated frequency being hundreds of years), the actual environmental effects will be much more significant than what a sheer number implies.

Another restriction of the results is that they only apply when dealing with accidents in Western waters. Ice conditions, which are found east from Murmansk, were not taken into account in this report and should be dealt with in the future. The open water assumptions and simplifications should also be made more accurate.

Although human error is the most usual cause for accidents, it's effect was left out of the calculations simply because it is too hard to quantify. The main causes for accidents were grounding and drifting. The risk of a major accident while drifting is quite low, because it usually happens away from the shore and is usually quickly dealt with emergency anchoring and then by calling for assistance.

The calculations did include the Norwegian part of LNG transportation and terminal operation, but lacked the Russian part of LNG transportation, which was deemed very important and will be included in future reports. Another aspect that the report lacked was the environmental impact on smaller organisms such as plankton. This was mainly because of the difficulty of quantifying all possible effects of a large-scale accident.

## 13. OIL SPILL WEATHERING AND RESPONSE

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*Sintef Applied Chemistry*

### Abstract

In case of a mishap or accident associated with the ARCOP transportation of oil by tankers from an offshore terminal at Varandey to a reloading terminal in the Murmansk area, an oil spill in most months of the year could happen either in ice or in open waters.

This presentation gives an overview of the report from sub Task 4.2.1.1, which is addressed to oil spill weathering and response. General fate and weathering of oil in arctic waters are described, and examples are given on weathering predictions by use of the SINTEF Oil Weathering Model for 5 different oils existing today in the Oil Weathering Model oil database. A comparison of results is also presented from in-the-field weathering of one specific oil type in cold conditions with ice and temperate conditions in open water. The examples do not include crude oils from Varandey since information about these oils is not sufficient to run the Oil Weathering Model. Extensive research has earlier been performed to understand the fate, behaviour and weathering processes that take place when oil is spilled in arctic sea conditions. This research has included field tests, observations as well as laboratory and numerical studies. Most of the work is now 10 years or older, and there is a need to continue this research.

The sub-task also gives a fairly extensive status on existing oil spill response alternatives for use in arctic and ice-infested waters, including mechanical recovery techniques, oil spill dispersants, in-situ burning and bio-remediation. Except for the bioremediation presented separately by AWI, the presentation gives an overview of these response alternatives. Of the various response alternatives, in situ burning has the highest potential to remove large quantities of oil, especially in ice. At the same time, mechanical response capabilities have to be in place during all seasons to combat spills in open water. Continuing developments of mechanical methods also improve the possibilities to fight a spill in cold and ice, partly as a consequence of improved techniques for response to spills from highly viscous oils. Dispersant effectiveness for oil in ice has been expected to be very limited, but use of dispersants in cold conditions and ice have gained considerable interest lately, especially from oil companies that are currently developing oil fields requiring transportation of oil through ice, like the Sakhalin area.

## 14. BIOLOGICAL DEGRADATION OF CRUDE OIL IN ARCTIC SEA ICE

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### Abstract

Cold-adapted bacteria play a significant role in in-situ biodegradation of hydrocarbons in cold environments, such as the Arctic sea ice, and are of interest for biotechnological applications.

The influence of oil contamination on changes of bacterial communities of Arctic sea ice and the effectiveness of crude oil bioremediation in Arctic sea ice is being investigated with laboratory experiments at -2°C as well as field experiments in Van Mijenfjorden on Svalbard.

Changes in bacterial diversity were analyzed by using culture-independent molecular methods DGGE (Denaturing Gradient Gel Electrophoresis) and FISH (Fluorescent In Situ Hybridization). Cultural methods like MPN (Most Probable Number) approaches are applied to differentiate between the capabilities to degrade aliphatic and/or aromatic oil compounds. Bacterial activity is used as an indicator for the potential of oil degradation. By measuring the evaporation of CO2 with infrared sensors in closed mesocosm experiments, the bacterial activity can be monitored. Samples of the crude oil will be analyzed by GC-FID (Gas Chromatography with Flame Ionisation Detector) to observe the degraded compounds.

Oil degradation is mainly limited by the availability of nutrients, like nitrogen and phosphorus, as well as by electron acceptors including oxygen. Therefore, different nutrients (fertilizers) are supplied to overcome these limitations. Temperature is another limiting parameter for microbial activity. However, about 90% of the sea ice bacteria are cold adapted and their enzymes are found to have high catalytic efficiencies at low, often sub-zero temperatures.

In this study hydrocarbon degradation could be determined at temperatures of -2°C within two months. Molecular analysis showed a significant reduction of bacterial diversity with the predominant bacteria belonging to the g-proteobacteria group. These are closely related to well-known hydrocarbon degraders but are cold adapted.

The final aim of this study is to develop an inoculum containing a consortium of cold adapted indigenous sea ice bacteria capable of degrading oil compounds, nutrients and eventually biosurfactants to enhance biodegradation.

### Discussion

The decision upon best available treatment of oil spills is answered by looking at the conditions and also information on the spills age. As the spill ages the potential for biodegradation processes decreases. At the moment there are no experimental results available on combined treatments, in which the first method chosen would deal with the initial and immediate problem and the second method would deal with the long-term effects. These are not studied in this project and should be looked into in the future.

The bacteria used in biodegradation processes are the same that is found in the water in natural conditions. Most of the species are cold-adapted bacteria and active in ice compared to water for there are nutrients available. The bacteria of different water systems (for example fresh water systems) differ from seawater bacteria so that bacteria mixture for oil spill treatments in different water systems differ correspondingly.

# 15. ARCTIC SEA ICE BIOTA

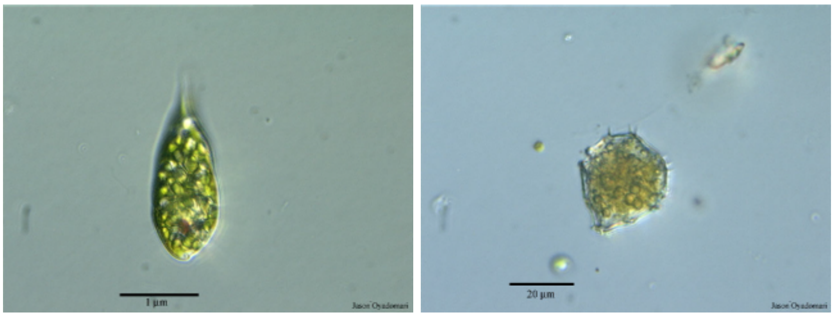
*Johanna Ikävalko*

*Finnish Institute of Marine Research*

**Abstract**

This work is a literature survey of unicellular and invertebrate organisms that have been encountered in Arctic sea ice since the turn of the last century (Gran, 1904) until today. A total of 91 sources of data - earlier published literature, submitted manuscripts and the author's own unpublished data - is used for the purpose. The author's own unpublished data originates from an expedition to the North Pole on the Swedish icebreaker Oden in summer 2001. Only literature that was relevant to the preparation of the checklist, i.e. articles and reports with taxonomic names of adequate resolution (genera, species, subspecies, forma) were included. Thus, this checklist is a list of unicellular and invertebrate organisms associated with Arctic sea ice, not a thorough literature survey of all data published on this topic.

A highly diverse community of unicellular and invertebrate organisms inhabits the Arctic sea ice. Their size varies from a few nanometres to macroscopic. As an effort to overview the diversity, i.e. the number and kind of these organisms, the author made a survey of taxonomic work done on the arctic sea ice biota. Earlier published literature, submitted manuscripts and the author's own recent unpublished data was used. The oldest article is by Gran (1904), while earlier reports were excluded due to questionable reliability of the species determination.



***Flagellates (taxa group 314)***

The author's own data on microscopic organisms within sea ice in the high Arctic were collected during an expedition to the North Pole in summer 2001 onboard the Swedish icebreaker Oden. Most data originates from the ice drift when the icebreaker was moored to a large ice floe (1x2 km in size, thickness 2-3 m) for three weeks in August 2001 (Knulst et al. 2003). Ice cores were drilled and processed according to the methods described in detail in Ikävalko & Thomsen 1997. The species determination and cell counts were made by inverted light microscope (Leitz DMIL, 500xfinal magnification). For scale-bearing organisms, e.g. coccolithophorids, a JEOL-JEM 100CX transmission electron microscope at the Division of Electron Microscopy, University of Helsinki, Finland was used.

Organisms from the following systematic ranks have been recorded living associated with arctic sea ice: Cyanophyta, Cryptophyceae, Dinoflagellata, Chrysophyceae and Dictyochophyceae, Bacillariophyceae, Pedinellales, Xanthophyceae, Haptophyceae, Chlorophyceae, Euglenida, Pedinophyceae, Prasinophyceae, Raphidophyceae, Straminopiles, Heliozoa, Amoebae, Choanoflagellida, Foraminifra, Radiolaria, Ciliata, Hydrozoa, Ctenophora, Turbellaria, Rotatoria, Nematoda, Gastropoda, Bivalvia, Polychaeta, Ostracoda, Copepoda, Cirripedia, Mysidacea, Amphipoda, Isopoda, Euphausiacea, Decapoda, Chaetognatha, Echinodermata, Tunicata, Chordata, Mollusca, Pelecypoda, Incertae sedis. Thus, the food webs within arctic sea ice consist of photosynthesising microscopic algae, heterotrophic flagellates and larger metazoans. Both juvenile and adult stages of metazoans were found.

## Commentary presentation

### Arctic sea ice biota

*David N. Thomas, School of Ocean Sciences, University of Wales-Bangor*

Sea ice is a unique marine habitat for a complex food web comprised of both microscopic and macroscopic organisms. These ice bound organisms are in turn a vital food source for grazers at the peripheries of ice floes, in the water column and on the seafloor below. The ice biology is recruited from open waters when ice forms, but changes in composition as ice thickens and gets older. With respect to future ARCOP activities, or even projects following ARCOP there are several issues that seem pertinent to consider further:

- Exchange properties between the water column and the ice.
- Ice of different ages and physical characteristics.
- Ice with varying snow loading.

Recovery of ice biota to oil spills on time scales of months, and even years. These questions will only be answered by long-term experiments that can look at seasonal differences in ice thickness and porosity. Central to such experiments will be the use of ice tank facilities that enable cost-effective work to take place.

In conclusion we need integrated models that allow us to determine ecosystem effects including on top, inside and below the ice. This will only be possible by increased cooperation and integration of physicists, chemists and biologists, and of course better integration of field investigation/ ice tank experimentation that extends over several seasons.

## Discussion

In addition to oil spill effects on biota, also another way of contaminating the waters was brought up. In recent years there have been several cases of unwanted organisms being imported with ships ballast waters and spreading in the new habitat.

In arctic waters the water temperature usually takes care of foreign species if they're released from ballast water. Organisms need favourable conditions in order to be able to colonize. Bacteria are different and they can survive even in the harsh conditions if a cargo ship imports them.

Sea ice contains big communities of biota. Populations of microbes within the ice change as the ice thickens and ages or changes with season.

Regarding life in sea ice, questions pertinent to ARCOP are: how fast does the oil affect the system as it passes through ice upwards or downwards and how are these processes affected by changing conditions. Also: the sea ice contains a variety of heterogeneous environments – how does the oil affect those and how to the degradation processes work?

Important restrictor of light is snow and how thick the layer of snow is. Snow changes the interactions, but it is yet to be studied how the snow actually affects the processes.

Recommendations for further studies include long-term experiments to find out more about seasonal differences and ice of different porosity and thickness. Winter is the most interesting season and drift stations or winter cruises would be a key to understanding these questions.

It’s also possible to conduct ice tank experiments in controlled conditions: tanks can be used for meaningful studies, create ice and copy to conditions – the question is: are they real means of doing long-term studies under controlled conditions.

Ice is just a cover and there is life under the ice. It should be noted that there are effects from the material falling from the ice to the benthos and water column as well.

Biodegradation is a method that might be efficient weeks or months after the spill. To develop the methods, the efficiency of different bacteria species should be studied. Seasonal studies are also important, because due to sunlight the bacteria will be much more active during summer and not so active during winter.

## 16. SOCIAL IMPACT OF ARCTIC TRANSPORTATION

*Nina Messhtyb*

*University of Lapland/ Arctic Centre (AC)*

**Abstract**

The social impact assessment (SIA) study was done on the basis of the analyses of the contents of the work packages of the ARCOP project, literature on SIA, regional mass-media press concerning oil transportation and multiple field data. This report presents a picture of current situation in the area of the proposed activity of the oil marine transportation with special emphasis on the security of the social environment of the indigenous peoples of the area.

The background material was collected during several trips to Nenets autonomous region. During those field trips the author interviewed the locals and officials and collected statistical and periodical data. Data was also collected by questionnaires in Indiga and in Varandey tundra.

The oil extracting and it further transportation is important for the future development of the Nenets autonomous region (AR). In the meantime the oil industry is a relatively new branch of economy for the region where reindeer herding, fishing, hunting, gathering and municipal services still have a considerable significance for the employment of the local population. Reindeer herding is a base for daily subsistence and for cultural identity of the Nenets peoples that are indigenous for this territory (Nenets people consisted 18,7% of the population of the Nenets AR).

One of the main consultation topics during fieldwork has been the question of how the oil marine transportation system, including future infrastructure, might affect the local population and its wellbeing. What are the most affected groups and what are their concerns?

The peculiarity of the Nenets autonomous region is that 63% of the population of the Nenets AR live in regional centre Naryan-Mar and its satellite settlement Iskateley, the other 37 % of the population are scattered all over the region in 42 multi national villages of various sizes (from 10 to 1700 peoples). Along with settled population in Nenets AR existed nomadic and semi-nomadic population (Nenets and Komi reindeer herders).

The coastal territory that might be under the direct impact of the integrated oil marine transportation system within the Varandey terminal has no officially permanent inhabitants. However the affected territory as well as territory needed for the terminal activity are in permanent lease of the cooperative of the private Nenets reindeer herders "Erv". Currently the land rented by "Erv" from the state (about 700 thousand hectares) are recognised as *"territories of traditional land use».*

"Territories of traditional land use" was distinguished as a special category of land and were formed according to the Federal law «About preservation of the environment» (№ 7 from 10.01.2002); the Federal law «About territories of traditional wildlife management of indigenous peoples of the North, Siberia and the Far East of the Russian Federation» (from 07.05.2001) and in the performance of the decision of administration of Nenets autonomous region «About territories of traditional land use of the indigenous peoples of the North in Nenets autonomous region» (from 29.12.2001 № 1025). The Recognition of the "Erv" pastures as *"*territory of traditional land use*"* establishes its status as specially protected territory with limited economic activities. The regional law prioritises traditional forms of land management on this territory. All industrial activity should be carried out with the consent of communities of indigenous peoples of the North or their representatives.

The indigenous peoples in Varandey tundra are concerned about the possible impact of the active marine transportation on fishing, but the main trouble is connected with reindeer pastures – it quality and availability that could be damaged by the terminal infrastructure in future.

One of the important findings of the SIA study was that misunderstanding between land users is starting when one party avoids early consultation with the primary land tenants. One example comes from 2002, when a new pipeline connected the Varandey terminal with oil pumping stations and oil deposits cut the access for two brigades to 20 thousand hectares of valuable pastures (Nenets peoples consider the coastal pastures highly valuable for the reindeer especially during the late autumn season when animals should accumulate weight for the coming winter). Officially, the oil company took only land for the storage terminal building and pipelines, and other land was not officially allotted and was not reimbursed by financial compensation. In turn reindeer herders had delayed permission for an additional lands for further construction and, in response, the oil company appropriated the land and began construction without official permission (which as well entailed a number of consequences, like the loss of taxes for the regional budget, low responsibility of the company for the condition of unofficial allotted land etc). The conflict between sides could ratchet up even further, but then everybody would lose. Involved intensive and extensive land users nowadays come to understanding of the necessity to rich a balance of mutual interest, but are impeded and limited by the lack of information about essential needs and prospect plans of each others.

Among other objectives of the social assessment study is to highlight for the planners the values and the needs of the local stakeholders and on that basis suggest possible mitigation measures. Herders and local settlers consider that following measures might allow the avoidance of mistakes and many additional losses for all interested parties:

- Direct early and continuous consultation with communities during all stages of the industrial activity and its planning

- Strict adherence to the existing regional laws and regulations
- Fulfillment by the companies of their obligations toward local communities.

On the base of the field data and literature sources on the Russian Arctic report presents examples of occurred and possible direct and indirect impacts and consequences connected with oil crude marine transportation on the well being of local inhabitants.

Practical recognition of the rights of the indigenous peoples to continue their way of life from the direction of the businessmen, policy makers and civil society is important and could make positive impact of the oil marine transportation tangible in long term perspective. Involvement of the Russian oil companies in the integral oil marine transportation system might contribute to the regional sustainability on the condition of assumption and fulfillment of the international ecological standards. The ARCOP workshops represent an important mediator task in bringing together the international community of scientists, politicians and industrial experts where the values and needs of different stakeholders could be recognised and considered as a critical component of the Northern Dimension policy of the EU.

**Commentary Presentation**

*Yana Kislyakova, Nenets Autonomous Area (NAO), RF*

**The Russian Arctic** is one of the most unattached regions in the world. Here one can find both a well-preserved pristine Arctic biodiversity and huge natural reserves. On the other hand, the Russian Arctic is a region where an intensive industrial development is expected.

Within the European part of Russia, the Nenets Autonomous Area (NAO) is the only region of the Northern-Western Federal District with a significant oil and gas production growth potential.

The distinguished feature of the NAO compared with the regions of Eastern Siberia is its availability of well-prospected and proved hydrocarbon reserves and their convenient location and proximity to the European markets. Thus natural resources, and in the first turn those of hydrocarbon, are considered to be the only real base for the socio-economic development of the NAO.

Presently, oil and gas production makes up to 95 % of the Okrug's economy, and its volume increases every year: annual oil production is estimated to be over 17 million tons by 2006.

**Experts' estimations** forecast generally positive impacts of the oil and gas production growth on the territory, mainly in transport and general infrastructure development, payments to the regional budget, jobs for the local population and the development of local expertise.

Today the transport infrastructure is with no exaggeration extremely poor in the NAO causing huge complications in passenger and cargo transportations as well as rendering public services in remote villages useless. The main transport mean is by helicopter, whereas it is expected that the construction of pipelines for oil and gas production needs will be accompanied by deployment of general-purpose roads. This, above the development of passenger transportation, would help to solve the problem of the so-called northern supply of goods that presently "eats" a large part of the Okrug's budget.

Another positive consequence of oil and gas production growth in the area is an increased amount of obligatory and other payments to the regional budget thus helping the region's socio-economic development.

Development of the oil and gas resources in the NAO under a target federal program will mean also more tenders for oil and gas blocks in the region, which will provide for more payments - obligatory payments and bonuses - to the regional budget.

The intensification of petroleum industry activities in the NAO brings more jobs for local people (what is stipulated in every license agreement), training opportunities as well as construction of social objects.

**However, along with** the positive tendencies, growth of oil and gas production and following the broadening of the infrastructure works and transportation is definitely bringing some serious challenges for the local community.

According to the experts' estimates, there are going to be several *oil and gas production centers* in the Timano-Pechora province. Located in the NAO territory are the Kolguev area, Varandey, Prirazlomnoye (partly) and that of Kharyaga-Usinsk. Crude oil from the former three will be transported by sea and from the latter one - by main pipeline.

Exploitation of these routes will have and already do have direct and indirect impacts on the local population, and especially on the indigenous people.

As it is correctly mentioned in the presentation of SIA of Arctic transportation in the NAO, these are:

- infringement of reindeer herd's grazing areas and migration routes;
- damage to and exception of important fishing and hunting areas;
- social differentiation, mal-adaptation of nomads to the settled way of living;
- unemployment;
- crisis in reindeer herding because of workers' move to more profitable branches of industry (petroleum);
- dramatic change of the economy's structure and pricing etc:

In the vicinity of Varandey there are reindeer grazing territories belonging to the reindeer farm of "Erv", which will thus be directly affected by the petroleum industry in this area.

Also on Kolguev island the situation is challenging. This island is unique because there is registered the highest density of waterfowls in the whole Western Arctic, and Kolguev has traditionally been a precious hunting area. On the other hand, the Kolguev reindeer herd is famous for the animals' big size and high quality of meat.

Presently the island faces problems related to the pastures that are converted for oil production purposes and affected by the polluting of the environment by helicopters, heavy vehicles etc.

Prirazlomnoye oil field is located in the water area near the natural reserve "Nenetsky", Vaigach Island. Besides the biodiversity value, it has some Nenets sanctuary sites as well. Any accident that happens here will have a dramatic impact on the whole area.

Near the Kharyaga oil fields are grazing areas of several reindeer farms, both from the NAO and the Komi republic.

The largest payment in the taxation scheme paid to the regional budget came from the oil and gas companies in the region, who paid for the shared subsoil usage tax. According to the federal legislation, this tax has been recently reduced from 20% to 13,4%. According to the new Russian Taxation Code to come into force in 2005, only 5 % of this important tax will be retained in the region. That is a challenging trend because in such a situation the region would be deprived of a major part of its income.

**There are different ways** to solve the acute social and environmental problems caused by the development of the petroleum infrastructure. These are:

- open up a dialog with all parties interested (state, local authorities and surveillance bodies, companies, NGOs, indigenous population and their representatives);
- common monitoring of the impacts from industrial activities;
- social programs;
- support of SME businesses related to traditional activities.

To give some examples of such work, it is worth mentioning the following activities that are presently being done:

- in accordance with federal policy, the NAO authorities adopted a regional law "On Reindeer Breeding", a Regional Environmental Strategy until the year 2010 and a decree on "Concerning territories of traditional occupation of the indigenous people of the North in the NAO", which are aimed at defending the interests of the indigenous population and protection of the environment in the risk zones;
- allocation of subsidies for production and transportation of reindeer meat as well as funding the projects aimed at developing reindeer breeding;
- the NAO administration has strongly supported some international initiatives in this field, such as the ECORA project supported by GEF, which is about the complex management of the Kolguev island; studies of the impacts on reindeer grazing areas by intensified oil and gas production;
- the work is conducted by creating various databases on the state of the environment in the territories affected by the petroleum industry;
- The local authorities, as well as representatives of oil companies operating locally, should actively take part in the public meetings arranged by the "Yasavey" Association, which is the main institution working on representing the Nenets people and defending their interests.

Now we are witnessing the fact that the oil infrastructure development influences the traditionally living local population and vice versa. Recently an oil outflow happened from a pipeline in the NAO, and it was a reindeer herder who first reported it.

As it was mentioned about the transport infrastructure, it has not yet been developed in the NAO, but it can be seen as a positive precondition. This is because it leaves room for the development of well-balanced programs of oil and gas production and transportation in the region taking into account all environmental and ethnological risks and also the interests of all the parties concerned.

## 17. CONCLUSIONS AND RECOMMENDATIONS: WORKPACKAGE 4

### WP 4.1.1 Coordination of WP 4

It was noted, that the work of several sub-workpackages of WP 4 is delayed. It is recommended that WP 4 coordinator update the workpackage progress and, if required, the schedules. WP 4 should take into account the recommendations for each sub-workpackage given below.

### WP 4.1.2 Characteristics of shipping

The presentation gives an overview of the current oil and gas transportation activities in the Russian Arctic. The data will be transferred to GIS format, containing details of the routes, ports, and cargo. The GIS-part of the work has not been completed. It is recommended that ALPHA and CNIIMF work closely to produce the data in GIS format.

The workpackage leader has not utilized the resources of the partners. It is recommended that workpackage leader ALPHA contact the partners to discuss the progress of the workpackage.

### WP 4.1.3 Environmental Impact Assessment (EIA) and Environmental Risk Analysis (ERA)

Discussion contained suggestions and needs regarding the EIA study. The most important finding is, that the ice conditions are not taken into account in the study, when they, in fact are very important characteristic of the area in question.

It is recommended that Russian partners would be consulted to acquire data from the area of ARCOP scenario. At the moment, the study is including only the Norwegian part of the Barents Sea, but it should focus more on the Russian side of Barents Sea. The characteristics of the Russian side of the Barents Sea, the ice conditions in particular, are very different from the Norwegian side.

It is recommended that ALPHA integrate the Russian partners in the work as soon as possible.

### WP 4.1.4 Social Impact Assessment (SIA)

The work of the Arctic Centre concentrates to portray the possible affects the developing oil industry has on the indigenous peoples. According to the presentation given by a representative of the Nenets Autonomous Area (NAO), the oil industry affects the whole local community, not only the indigenous peoples, in negative and positive ways.

Referring to the presentation of Yana Kislyakova we should expect in general positive impacts of the oil and gas production growth on the territory, mainly in transport and general infrastructure development, payments to the regional budget, jobs for the local population and the development of local expertise: training opportunities as well as construction of social institutions.

The two presentations give two very different impressions of the situation. Along with the positive aspects of oil and gas production and associated improvement of infrastructure there might be some serious challenges for the indigenous communities as described above.

Given that the Nenets AO has decided to support the growing oil and gas industries, ARCOP's social impact study should take this development into account and focus on producing a general view of the social impacts, including all social groups: indigenous and other local communities.

The workpackage should focus on the analysing the acquired data carefully and thoroughly, as the qualitative nature of the questionnaire does not allow statistical analysis of the data.

**WP 4.2.1 Oil weathering and oil spill countermeasures**

The presentation refers some recommendations for the different response techniques from the state-of-the-art study. For open water conditions it is commonly accepted that oil on water exercises, where equipment and procedures could be tested and personnel could get training under realistic conditions, have contributed significantly to improve oil spill response technology. For all response alternatives such training and testing are mandatory to improve the oil spill response capabilities for ARCOP conditions.

The presentation gave an overview on the present status of the oil spill countermeasures and their applicability in arctic conditions and evaluated the effectiveness of these techniques.

The efficiency of different oil spill countermeasures depend on a number of variables related to the ice/sea water characteristics, oil type and the general conditions such as air temperature. Many of these variables also change with time. The possibility of using biodegradation processes as an independent or complementary oil spill countermeasure would bring new encouraging views to fighting spills. It would also open the question on treating old spill remnants and treatment leftovers in particular.

It is recommended that the workpackage 4.2.1 leader work closely with the Russian partners in the final subtasks.

**WP 4.2.3 Biology and potential effect of oil spill**

The effects of oil spill on sea ice biota are studied from immediate effects point of view and also from biodiversity and ecosystems point of view. There is historical data regarding the sea ice biota but all the available data is not reliable due to problems in taxa descriptions.

Integrated models are needed to determine the impacts an oil contamination has on marine ecosystem. Such a model should include ecosystem on top, inside and below the ice. This will only be possible by increased cooperation and integration of physicists, chemists and biologists, and of course better integration of field investigation and ice tank experiments. The studies should be extended over several seasons to achieve overall view on the processes. Workpackage 4.2.3 should give recommendations for such long-term studies.