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Equipment and Operational Issues for Terminal and Escort Work in Ice Conditions

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SYNOPSIS

As the remaining hydrocarbon and mineral resources on our planet are located in increasingly challenging and remote places, more and more tugboat operations will take place in locations where, for at least part of the year, sub-zero temperatures and varying ice conditions prevail. Climate change can also open new routes, such as the North-East and North-West passages, for global trade, thereby generating possible potential for different assistance operations in arctic conditions.

This paper lists and briefly describes important issues for setting up escort and terminal towage operations in such conditions, including key points for design subjects and operator skills.

BACKGROUND

Tugboat assistance in winter conditions with significant ice has previously been exercised in the Northern Baltic Sea, and in US, Canadian and Russian Arctic waters. These operations have normally been simple harbour ice-breaking and assisting small- to medium-sized general cargo vessels and product carriers using mainly conventional tugs.

The locations of existing hydrocarbon resources and new shipping routes have recently raised interest in fresh oil terminal and offshore operations at high latitudes, with the resulting need for high capacity towage services. Until the opening of the Russian Primorsk terminal near St Petersburg, Neste Oil Porvoo refinery terminal was the only refinery terminal in the world with severe ice conditions prevailing during a typical winter.

OPERATIONS AND PREVAILING CONDITIONS

Knowing the environmental conditions and scope of intended operations is paramount for any new towage services, but even more so for operations in severe ice conditions. This includes normal cartography, meteorological and hydrographical conditions, tides and currents. Any available data of assisted vessels' own ice performance, if available, is also most important.

As with any remote location, when setting up this type of operation, normal maintenance and service, as well as manning and supply logistics, should also be carefully assessed and planned. The most important issue for Arctic operations is, naturally, the prevailing ice conditions. Ice and ice conditions are extremely variable, and even neighbouring locations can have a totally different severity of ice environment-related operational issues. Collecting and analysing all possible data of local conditions is essential in judging correct dimensioning of vessels and scope of operations in general.

At the very least, the following ice conditions locally should be considered:

- Type of ice, salinity, snow coverage;
- Normal and maximum level of ice thickness;
- Ice coverage;
- Amount and severity of ridging, consolidation of ridges;
- Ice drift speeds and ice pressure;
- Land-fast and grounded ice.

Up-to-date weather and ice data from other vessels, ice charts, reconnaissance flight data, terra and radar satellite images are vital in the planning stages, but also during actual operations. Availability of this data should be considered and arranged during the set-up phase of operations in any ice conditions and it should be continuously available for the operators during the operational phase.

WHICH TYPE OF TUG?

Selecting the best, or at least an acceptable, tug for intended operations is a challenge, especially when considering operations in ice. First of all, it is essential to understand that the Finnish-Swedish ice rules, the most popular rules for ice-operating commercial vessels, and related class rules, apply to merchant vessels that follow an ice-breaker in a broken channel. F-S rules are not designed to cover the structural or equipment strength of vessels operating independently in ice, which is what tugs in ice conditions actually do most of the time. When scaling the ice thickness to tug size and weight, relative ice conditions are often extremely severe. In any escort operation it must be taken into account that the combined mass of the tug and tanker can be more than 100 times the tug's own mass and could "tow" the tug through ice that would normally immediately stop any independently manoeuvring tug.

Another important issue to remember is that even the majority of the full size ice-breakers have much lower power/weight ratios than modern tugs. This means that a tug's independent ability to accelerate, decelerate and turn is even better than the full-size ice-breakers' ability, but it can also ram and hit harder than most of the ice-breakers are able.

Last but not least, modern azimuth-thrust tugs can perform manoeuvres that result in excessive ice-breaking loads on the hull and underwater appendages and equipment. Some of these issues are not yet fully covered, even in real ice-breaker class rules.

This all means that the designer, propulsion-line manufacturer and the yard must be highly experienced in order to overcome the lack of adequate design and construction guidance within regular class rules. Experienced operators' input in the early design phase is also vital for any successful and cost-efficient new building project. Some classification societies have recently introduced so-called 'winterisation' rules which can be used at least for guidance to design and construct functional solutions for lesser systems on-board, although some of these rules are more directed towards larger commercial vessels and any application to tug-sized vessels is unpractical.

Major construction and arrangement issues when considering the potential operations and conditions in tug selection, or during design and construction phases, include:

- Required ice-breaking capacity versus other required capacities: high ice class normally means less BP per installed propulsion kW. Increasing ice- breaking capacity means reducing open water indirect steering forces;
- Tug type: tractor, ASD or conventional, the last two being most suitable for severe ice conditions;
- Main engine and propulsion system, direct mechanical FP/CP or various diesel-electric arrangements: in this selection the most important issues are system torque/rpm curves, and the machinery's ability to be used for prolonged periods at high or full power, including tolerance for extremely rapid load variations;
- Nozzle/open propeller: nozzle blocking versus loss of maximum BP (generally, VS propulsion is not applicable in severe ice conditions);
- Torsion loads and vibrations in propulsion line owing to propeller ice contact, ice between hull and propeller blade and blockage of nozzles owing to ice;
- Cooling arrangements that will maintain adequate cooling capacity in the case of ice-blocking sea chests, strainers pumps or piping; adequate strength grids for possible box coolers; sufficient box cooler surface temperatures to avoid barnacles and other organism build-up; systems must provide undisturbed cooling under full-power operations and dimensioning must also allow full power during sometime relatively warm summer periods;
- General equipment, piping and cable tray fastening strength must be dimensioned to very high level to withstand ice-breaking generated vibrations and impact load accelerations;
- AC, heating and insulation for accommodation and machinery temperature and dew-point issues, as well as overall noise control on-board; in general, over-dimensioning insulation helps to control noise and also provide required summer cooling capacity;
- Design and systems solutions to minimise external ice build-up; means to remove ice from deck and deck structures without damaging the underlying equipment.
- Towing gear operability to maintain workability of lines, winches and fenders; protection against freezing spray and snowfall;
- Extremely good searchlights, working lights and general visibility issues, including window heating and demisting arrangements, wiper heaters and washing-line purging systems;
- LSA and Internal FiFi systems that also work in sub-zero temperatures.

To ensure a safe and efficient working environment, all personnel in exposed conditions must wear not only the required PPE and footwear that minimises risk of slipping, but also warm clothing that breathes and allows efficient movement. Vessels must also have adequate means on board to dry any wet clothes.

OPERATOR SKILLS

There are two main operational skills for severe ice conditions escorts or assistance towages, which they have to be at a very high level to ensure safe and efficient operations.

The first is the operator's ability to precisely and rapidly manoeuvre the tug with maximum power levels. The required accuracy and speed of response is undoubtedly higher than that which is considered adequate in open water operations. However, this should not be interpreted that, in ice, the boat should always be used at maximum power; but the operator must be used and competent to doing so, as the conditions often require it. Much of this skill can be trained without any ice, and expert simulator training with an experienced trainer can speed up the learning process remarkably.

Secondly, and the most crucial skill, is the operator's ability to read and predict ice and ice conditions, based on both visual and radar information and all available preliminary information. This skill is based on being able to find the easy spots and cracks in the ice, to assess the risk of nozzle-blocking, predict the potential of passing through a ridge without ramming, and the amount and development of ice pressure etc. Although the principles and basic knowledge can be initially taught in a classroom, it also requires extensive practice, preferably passed on by an experienced operator. Currently, some simulators also have limited ice modelling, but they are still only good for training the simpler side of ice operations.

Although navigation is not the primary subject of this paper, it is still worth mentioning that often the weather conditions and nature of independently navigating in severe ice sets additional requirements for the navigation equipment and the navigator using them. An experienced navigator can drastically speed up the process of learning these skills, too.

Because some of these operations include the highest of economical and environmental values, the skills of both operator and pilot operations in general should be assessed in order to achieve the best possible operational performance and general safety. At the very least, this type of assessment should take place when starting new operations or employing new key personnel, but preferably assessments should be performed at regular intervals.

Currently, the problem with these assessments is a lack of standards against which the assessment should be judged. Some classification societies are presently developing these standards, but due to their general nature an experienced operator should be included to evaluate operator skills, applied methods and operations in general.

OPERATIONS

Operations in ice are so dependent upon local and prevailing conditions that only general guidelines and advice on the most critical issues are given below. Actual techniques, safe speeds and distances should be assessed locally and be based on the personal experience and skills of the operators of all vessels participating in operations and the actual performance of the tugs being used.

Tugs for ice-scouting in open seas, and fairway assistance

These operations, also known in some places as ice-breaker escorts, must be performed with the utmost care, especially in limited visibility. A tug's relatively low mass compared to the assisted vessel's mass means that if a tug encounters any difficult ice conditions that reduce it's speed rapidly, there is an imminent risk of the assisted vessel running over the tug. It also means that normal towing with a short line is risky in these conditions.

In order to prepare a sufficiently wide channel for the assisted vessel, it might be necessary to use more than one tug to create parallel channels, a technique that also effectively reduces the above-mentioned risk of collision. In general, such operations require great "ice-reading" skills from the tug operators, especially as the tugs normally give a relatively reduced field of vision and so limited potential for judging the ice conditions ahead.

Efficiency of escort and applicable techniques

In extreme ice conditions, when a tanker can barely move under its own power, active tanker escorting (as normally understood in the towage business) is not applicable. In these conditions, if there are any technical problems on board the tanker, it will stop immediately of its own accord. However, in lighter or varying ice conditions, following in a tanker's wake when fastened isn't a problem, and generating high steering and braking line loads can be done by combining ice-breaking resistance with indirect or direct towing methods. Recognising and reacting to nozzle blocking during these operations calls for a well trained and practised tug operator. Due to extremely rapid changes in the ice-breaking loads, towing line forces must be controlled by a winch. The tug operator should also be well aware of the possible high hull loads and, in general, this requires an even higher level of ice-reading skills than the above-mentioned "ice-scouting" or "ice-breaker escorts".

Terminal pre-arrival/pre-departure ice-breaking and ice-management in both short and long term

Local conditions, varieties of jetties etc are the most important factors for this work. Normally anything more than few centimetres of unbroken ice can prevent tankers from coming alongside or leaving, so effective pre-breaking is frequently essential. In most cases, the area that has been broken up has to be large enough for the broken ice displaced by the moving tanker and tugs to disperse. For maximum efficiency, high-speed and the largest possible tug-generated wave should be used. This also means that aiming to minimise wave build-up and resistance for the tug hull is not always the best solution.

Cleverly using azimuth-thrust tug propulsion washes is also an efficient method of removing accumulated ice from the underside of jetties, from closed basins or dead ends. It is also an effective method of preparing an open water channel and jetty front for an arriving vessel. On a larger scale, and to prevent accumulated ice build-up, favourable wind and current conditions can be used to move accumulated ice from the critical areas in a terminal.

During cold periods, ice-breaking actually increases the total amount of ice, so excessive ice-breaking should always be avoided, while sometimes for certain operations, and in agreement with the pilots, breaking a narrow channel works best for arriving and departing vessels.

Terminal assistance, tug-pilot co-operation

In general a genuine tugmaster/pilot co-operation is far more crucial in ice conditions that it is in open water operations. But when the co-operation is there and tug operators have skills to fully utilise the methods available with modern azimuth thruster tugs, berthing and un-berthing operations normally take less time than in open water, and risk levels are even lower than in open water.

"The good news is that ships don't drift in stationary terminal ice; the bad news is that they don't want to move anywhere at all."