Evaluation of a Water Jet Barrier in Ice Conditions

Principal Investigator: Francine Laperriere
Environmental Emergencies Technology
Environment Canada
Ottawa, Ontario

Limitations of conventional barriers for containment and deflection of oil spills in currents above 1 knot have promoted the study of alternative systems which generate locally a horizontal surface current to oppose the movement of floating oil. Air jets were tested at EPA's OHMSETT facility (Cohen, Lindenmuth, 1979) but it was shown that a large pressure drop in the duct would preclude the development of an operational barrier. Plunging water jets were also tested at the same facility (Nash, Farlow, 1984). Used with low pressure (150 kPa (22 psi)) and high water volume (300 lpm (80 U.S. gpm)), they showed good efficiency in a deflection configuration. Unfortunately, the logistics increases rapidly with the deflection distance and the current strength. Flat fan high-pressure water jets, horizontally oriented above the surface of the water, which showed potential in tank testing at OHMSETT, were used in an array configuration in rivers and canals (Meikle, Whittaker, Laperriere, 1985). Deflection in currents of about 2 kts was possible even though the system used was not fully optimized but sufficiently operational to test the concept. Alternative uses of this technique were identified and considered for further testing to contain oil in the presence of floating ice, to sweep and protect tidal mud floats, and to burn floating oil in-situ more efficiently.

The evaluation discussed in this report is the containment of oil in the presence of ice.

The objectives of this evaluation of a water jet barrier in ice conditions were (1) the assessment of the impact strength of flat fan high pressure water jets on ice floes in motion towards the deflectors, and (2) the assessment of the distance of influence in front of flat fan high pressure water jets used in ice floes as an oil deflector.

Knowing the limitations of Environment Canada's high pressure water jet prototype barrier in clear water, very specific ice and current conditions were sought: 1.5-10 m^2 ice floes, low density ice cover, less than one knot current.

Simulation in a tank was not possible because of the large test area required. Desired ice and current conditions can generally be found in some locations on the St. Lawrence River during springtime. Two sections of the river were considered for conducting the testing in the vicinity of Trois-Rivieres and Quebec harbors.

Testing was to be accomplished with the help of Canadian Coast Guard ice breakers. Logistic problems related to the assembly/disassembly of the prototype barrier were to be minimized using a vessel to move the barrier to the best test area(s), with the power generation system also on board.

In March 1987, the ice cover on the St. Lawrence River broke-up earlier than usual due to very high temperature and left rapidly towards the Gulf. It affected this evaluation in terms of ice floe availability. The national harbors considered did not experience drifting ice floes by their docks within the time frame planned for the testing. Other test areas were looked at on March 24, 1987 (private harbors and sheltered basins) but sudden shifting winds cleared the areas from ice floes before the testing could start.

An attempt to evaluate the barrier was finally made on March 26, 1987 at the St. Charles River estuary, in calm water, near a pier. The ice coverage was about six to seven eights.

The barrier, its possible configurations and the power system, are described in Meikle, Whittaker, Laperriere (1985). A barrier length of 10 m was assembled on the pier and loaded onto the deck of the ice breaker "Bernier" together with the high pressure pump. A short barrier length (half of the usual size) was used because of control and maneuverability difficulties in such ice coverage conditions. The use of a small boat for nozzle adjustments and tightening connections throughout the testing was impossible, the water was too cold. Both ends of the barrier were attached to a rope and the barrier was lifted on board using a crane when adjustments were required.

The barrier could not be tested while the vessel's propellors were operating. The turbulence generated cleared the water surface of ice for a 12-15 m radius around the vessel.

Because of the high density ice coverage, the water surface was first cleared around the vessel, the barrier was then deployed along the vessel, using a crane. The jets were operated at 6895 kPa (1000 psi) and the ice floes were pushed back towards the barrier using a motorized barge, Figure 1.

Figure 1 — Operation of the Waterjet Barrier.

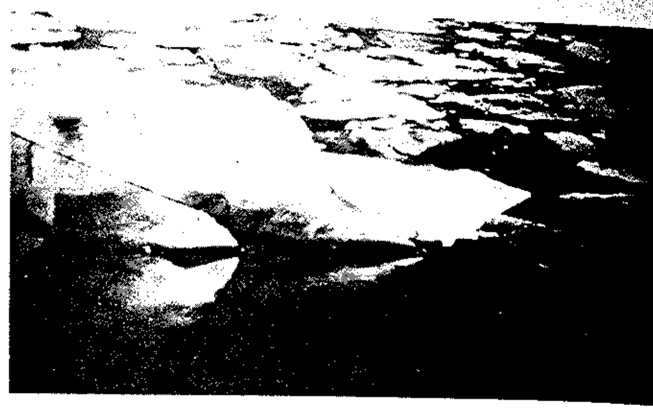

Figure 2 — Slow Deflection of the Ice Flow.

At a pressure of 6895 kPa using 57 lpm/jet (15 US gpm/jet), the jets could not push away the floes already touching the floats. When the flows were pushed in front of the first barrier's jet, very slowly the ice floes were deflected, Figure 2.

The distance of influence on the ice floes in front of the barrier was difficult to estimate because floes could never be brought towards the barrier the same way. However, during the deflection of an ice floe of about 3 m^2, 1 m thick, 0.15 m above the water surface, a deflection distance of 1.8-2.4 m in front of the nozzles was kept clear using a pressure of 6895 kPm, Figure 3.

The influence of the jets on spilled peat moss between and behind isolated ice floes could not be

Figure 3 — Keeping the Ice Flow Clear.

Figure 4 — Absence of Ripples Near Ice Flow at Greater Distance from Waterjet.

verified. Difficulties controlling the number of ice floes in front of the barrier and the clearance between them prevented specific measurements. The jets were deflecting the mass of ice rather than just the peat moss.

On the subject of turbulence on the water surface generated by the jets, when in front of a broken ice mass, in openings of about 0.8 m wide, parallel to the jet, there was some turbulence up to 4.5-6.0 m away from the jets. In openings of 0.3 m wide parallel to the jet, at 4.5 m away from the barrier there were no more ripples on the water surface. No turbulence was noticed behind ice floes with edges perpendicular to the jet, at a distance of about 3 m from the jets, Figure 4.

From previous tank testing with water jets of the same type, aperture, angle and height, we know that air flows generated have a noticeable velocity up to 6 m away. This is not in contradiction with the observations made in the present evaluation. In wide openings among ice floes with edges parallel to the jet, the same turbulence range on the surface of the water was noticed as in the tank testing. In smaller ice openings parallel to the jet, the influence of the edges of the ice seem to be more important since surface turbulence is less noticeable. For openings perpendicular to the jet, the ice edges seem to strongly reduce the water turbulence.

These few observations were done without using peat moss. Observations with peat moss at least, but preferably with oil, in a controlled ice environment are required to assess the limitations of high pressure water jets in an ice environment.

Conclusions

This short test showed that although the waterjet barrier had some potential in ice, its current configuration was not suitable. A more rigid system would be required. It is recommended that a system of waterjets, mounted in rigid pipe, which can be affixed to the bow of vessels of opportunity should be investigated. If such a system appears feasible, it should be built and tested in ice.

References

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