Paper #8-6

MECHANICAL RECOVERY - CURRENT PRACTICE/OPERATIONAL AND TECHNOLOGY CONSTRAINTS, AND OPPORTUNITIES

Prepared for the

Technology & Operations Subgroup

On March 27, 2015, the National Petroleum Council (NPC) in approving its report, *Arctic Potential: Realizing the Promise of U.S. Arctic Oil and Gas Resources*, also approved the making available of certain materials used in the study process, including detailed, specific subject matter papers prepared or used by the study's Technology & Operations Subgroup. These Topic Papers were working documents that were part of the analyses that led to development of the summary results presented in the report's Executive Summary and Chapters.

These Topic Papers represent the views and conclusions of the authors. The National Petroleum Council has not endorsed or approved the statements and conclusions contained in these documents, but approved the publication of these materials as part of the study process.

The NPC believes that these papers will be of interest to the readers of the report and will help them better understand the results. These materials are being made available in the interest of transparency.

The attached paper is one of 46 such working documents used in the study analyses. Appendix D of the final NPC report provides a complete list of the 46 Topic Papers. The full papers can be viewed and downloaded from the report section of the NPC website (www.npc.org).

This page is intentionally left blank.

Topic Paper

(Prepared for the National Petroleum Council Study on Research to Facilitate Prudent Arctic Development)

8-6	**Mechanical Recovery - Current Practice/Operational and Technology Constraints, and Opportunities**
Author(s)	**Victoria Broje (Shell)**
Reviewers	
Date: October 1, 2014	**Revision:** Final

SUMMARY

The goal of mechanical recovery is to remove oil from the surface of water using specially designed skimming devices or sorbent material, and to store the recovered fluids on board a skimming vessel, a backup storage barge, or shoreside storage facility. This topic paper provides a background summary of mechanical oil recovery and its applicability to future accidental spills in Arctic waters.

The goal of mechanical recovery is to remove oil from the surface of water using a specially designed skimming device or sorbent material, and to store the recovered fluids on board a skimming vessel, a backup storage barge, or shoreside storage facility. Recovery may also involve the onboard treatment of recovered fluids and the decanting of water to maximize storage capacity. A full cycle of recovery operation will also include the disposing or recycling of the recovered liquids and oil-contaminated materials. These are well practiced response techniques used under a variety of conditions around the world and are often favored by the general public based on the notion that when mechanical recovery is successful, oil is "removed" from the environment. This consideration, however, does not account for the fact that mechanical recovery may be insufficient in recovering large volumes of oil or ineffective due to wind and sea conditions. Often overlooked as well are the impacts associated with the ultimate treatment and disposal of any recovered fluids and debris.

The containment and recovery of oil is often effective when responding to small operational spills and for large spills in relatively calm waters without heavy concentrations of ice or debris. The success of such recovery depends upon the availability and rapid deployment of appropriate equipment and personnel, both challenging in remote arctic areas. The reliance upon the mechanical recovery alone for cleaning up large widespread slicks in remote offshore regions may significantly reduce the efficiency of a response and the resulting protection of the environment. In such cases the entire "response toolbox" (surveillance and monitoring, mechanical recovery, dispersants use, and *in-situ* burning) should be available in order to adapt to changing environmental conditions, handle large, widespread releases of oil, and ensure that environmental impacts are minimized. This is especially true for the offshore arctic environment where a spill may involve a broad range of wind, wave and ice conditions, darkness or limited visibility, and remote locations with limited shore-based and aerial support.

The safety of responders and personnel is always the highest priority in any operation. Depending upon the spill scenario and environmental conditions, it may be impractical or unsafe to conduct immediate containment and recovery operations. As described in Chapter XX , some arctic conditions may offer responders a longer window of opportunity to implement response strategies and tactics during extended periods of light. The presence of ice can reduce the spreading of oil and dampen waves thereby enhancing efficiency of certain recovery operations. Cold water and ice can also provide favorable conditions for the use of controlled *in-situ* burning without the need for containment boom. Response decisions are guided by qualified safety professionals, subject-matter experts, and experienced response managers making frequent assessments of changing conditions. When it is safe to do so, mechanical recovery will always be considered and used if practical, given the nature and volume of a release, the oil properties and weathering state, and the environmental conditions during the response.

Many decades of experience with mechanical recovery under cold-climate conditions around the world have advanced the understanding of the recovery process and led to the development of well-practiced response tactics and specialized equipment. Ice-strengthened vessels are used in arctic waters where ice may be present. Several configurations of arctic-capable response vessels, both with built-in and over-the-side recovery equipment, have been designed and are currently in operation (Wilkman et al. 2014). Azimuthal Stern Drive (ASD) vessels are invaluable for arctic oil spill and emergency response due to their high maneuverability in ice and ability to effectively support both mechanical recovery and vessel-based dispersants operations. High capacity arctic skimmers have been developed and tested for the recovery of oil in ice while operating at low temperatures (Sørstrøm, 2010; SL Ross, 2010; Meyer 2014). Just as with car designs, some mechanical response systems resemble their earlier versions while incorporating significant engineering and design improvements that draw upon real-life experience during laboratory, meso-scale and actual field trials under extreme conditions. Advances with skimmers include improved oil and ice processing, the ability to handle larger volumes of cold viscous oils and oil/ice mixtures with low water uptake, and the heating of critical components to prevent freezing. Various viscous oil pumping systems and techniques have also been developed to facilitate efficient transfer of cold and viscous mixtures of oil water and small ice pieces (Potter 2007, Hvidbak 2001, Fleming and Hyde Marine 2003).

Since an uncontained oil slicks can spread on open water to very thin layers (thinner than a piece of paper), containment is almost always required to concentrate oil into a thicker layer thereby increasing the efficiency of skimming systems. Selection of a suitable containment and recovery system for arctic waters is determined by the type and concentration of ice cover.

- At 0-10% drift ice coverage, conventional open water containment and recovery techniques can be used. As ice concentration increases, the opening of a containment boom can be adjusted to maneuver around individual ice floes.

- At 10-70% drift ice coverage, vessel-towed booms can be replaced with short sections of a boom connected to an ice-strengthened skimming vessel with "outrigger arms." These narrower systems are easier to maneuver around ice floes and can be lifted, as needed, to avoid excessive ice concentrations and possible damage to equipment. Some skimming systems are specially built to process small ice pieces, as well as slush and grease ice between larger ice floes. To facilitate movement and access to oil in such conditions, these skimmers often have their own propulsion systems, or they may be lifted and positioned by a crane aboard a vessel.
- At drift ice coverage greater than 70%, specialized skimmers are operated by ice-strengthened response vessels. At high ice concentrations, booms cannot be used; however, the ice itself often provides containment, preventing oil from spreading on the surface of the water. In this case oil may be recovered from concentrated "pockets" of oil between ice pieces using skimmers deployed from the side of a vessel.

Oil encounter rate (the amount of oil accessed by a skimming system per unit of time) often determines the feasibility and effectiveness for mechanical recovery. As oil spreads, reduces in slick thickness, and breaks into patches or windrows, the swath and speed at which boom systems can advance through the slick become limiting factors for efficient response. Conventional containment booms cannot be towed at speeds greater than about 1 knot. In recent years there has been a number of innovative designs capable of containing oil at greater speeds, such as the Vikoma Fasflo™, the NOFI Current and Ocean Busters™, HISORS™ , MOS Sweeper™ and the Oil Shaver™ (Potter 2012; Jensen 2012). These systems modify the flow of oil and water in the containment area to create a more quiescent zone for skimming, thereby allowing them to collect oil at speeds around 3 knots in calm water and 2 knots with light to moderate waves (USCG 2001). Such systems can be successfully combined with high capacity skimmers to significantly improve encounter and recovery rates; for example a combination of NOFI Ocean Buster™ and Crucial™ disk skimmer has demonstrated its effectiveness on Alaska (Miller, S. 2014). Recent Wendy Schmidt Oil Cleanup X CHALLENGE resulted in a development of several novel skimming approaches including an Elastec™ recovery system, which combines oil collection boom with a high capacity disk skimmer (Meyer, 2012). Boom Vanes™ is another innovative technique, which allows the positioning of containment booms while using fewer boats (Hansen 2000). When deployed, a Boom Vane acts as a horizontal kite to develop a hydrodynamic force that pulls the end of the boom into the current and positions it at a fixed position relative to the towing vessel. Finish researchers have developed and tested several skimming as well as ice processing devices that are suitable for the ice conditions of the Baltic Sea (Wilkman, 2014).

Sea state is another important consideration for mechanical recovery as oil is often entrained beneath or splashed over booms in short-period wind-waves exceeding 3-4 feet. Mechanical recovery equipment can operate in more developed "swell" waves not exceeding 5-6 ft. Increasing wave heights make equipment deployment/retrieval difficult, reduce the effectiveness of skimmers, and may result in unsafe working conditions. Under such conditions, dispersant use will often become a valuable response tool as dispersants are most effective with increased mixing energy due to wind and waves. Dispersants can be deployed from vessels and from aircraft safely and with minimal exposure of personnel to harsh environmental conditions. Concerns over possible environmental impacts of dispersant use are also reduced, realizing that a significant portion of a slick will disperse naturally under high sea conditions and be distributed within the water column.

Critical factors for an effective containment and recovery operation in a remote arctic location include the availability of resources to store recovered oil/water/ice mixtures on the skimming or specialized vessels; the ability to transfer recovered fluids to backup storage; and the availability of suitable facilities for oil disposal – all of these activities without halting or delaying recovery operations. The decanting of free water accumulated during recovery operations can be used to optimize storage and to facilitate the transfer of the recovered fluids, thereby reducing downtime for such operations. A full recovery system analysis is necessary to assess the advantages and disadvantages of mechanical recovery and the results of its use compared to the controlled burning of oil and the application of chemical dispersants. An important consideration in this comparison is a number of resources (personnel and equipment) that each of these strategies requires as well as duration of response activities. Experience shows that mechanical recovery operations require significantly more personnel, equipment and corresponding logistics support over a longer period of time than any other response technique. This consideration may become a critical factor when responding to spills in remote arctic locations, which may not be suited to host necessary number of equipment and personnel for the extended period of time without excessive negative impact on local communities and environment.

Similarly to oil spill response in open water, effective oil slick identification and location, spotting for vessels, and the monitoring of response performance, is critical to the success of the overall response operation. During much of the open water period in the arctic when containment and recovery methods are most feasible, extended daylight facilitates these activities and allows the use of conventional remote sensing and observation techniques. During periods of darkness and for detection of oil under ice, specialized techniques must be used as discussed in Chapter XX of this report.

A Net Environmental Benefit Analysis for the use of mechanical recovery in arctic waters would need to adopt a "cradle to grave" approach, considering environmental impacts associated with all phases of the response operations, including the use of in-situ burning and dispersants. This would include impacts of the oil that may remain unrecovered, burned and/or dispersed; the presence of a potentially large number of vessels and aircraft and associated air and noise impacts; impacts associated with the transfer of oil to a disposal facility that may be located a significant distance from the response site; impacts from the recovered product disposal, possibly including incineration, recycling or a landfill; and all impacts associated with ISB products of combustion, chemically treated oil, and the full range of support requirements needed to implement these response options.

Synopsys

- Mechanical recovery is a proven and valuable response tool for small to moderate spills in open water or very open drift ice and potentially small localized spills contained in closer pack ice. Various response strategies and equipment types are available for this purpose.
- The reliance on mechanical recovery as the main strategy of responding to a large spill especially in the Arctic may result in ineffective response and will unnecessarily increase the risk of environmental impacts.
- Any future improvements to mechanical recovery in ice are expected to be evolutionary rather than revolutionary due to the physics of recovery process.
- Increasing a size or a number of mechanical recovery assets in the field will not necessarily improve their ability to encounter a significant percentage of the spilled oil and such operations will be further complicated by the logistics challenges in the Arctic.
- Azimuthal Stern Drive (ASD) vessels are invaluable for arctic spill and emergency response due to their high maneuverability in ice and ability to effectively support both mechanical recovery and vessel-based dispersants operations.
- Planning for mechanical recovery in arctic waters should consider logistical and environmental impacts associated with all phases of the response operations including the presence of a potentially large number of vessels and aircraft, and associated air and noise impacts; presence of a large number of shore-based personnel in environmentally and culturally sensitive areas; impacts associated with the transfer of oil to a disposal facility that may be located a significant distance from the response site; impacts from the recovered product disposal, possibly including incineration, recycling or a landfill; etc.
- Mechanical recovery should be viewed as one of several response techniques available for arctic spill response (a "toolbox" concept) and used appropriately.

References:

Fleming Environmental and Hyde Marine, 2003.Final Report - The Joint Viscous Oil Pumping System (JVOPS) Workshop. A united effort by the U.S. Coast Guard, Canadian Coast Guard, U.S. Navy, and Response Community to promote and improve heavy viscous oil marine lightering response. Conducted at CENAC TOWING, INC. Houma, Louisiana, USA December 1 to 15, 2003. Prepared for: United States Coast Guard Ocean Engineering Division G-SEC-2 Office of Civil Engineering Contract No: HSCGG8-04-C-ECB004 20 June 20 2003

Hansen, K. 2000. Boom vane field tests. Report prepared for United States Coast Guard, Marine Safety and Environmental Protection Systems. Washington, DC, USA.

Hvidbak, F . 2001. The Development and Test of Techniques for Emergency Transfer of Extreme Viscosity Oil (Refloated Bitumen). Proceedings of AMOP Conference.

Jensen, HV, Andersen JHS, Gyltnes SL. 2012. Norwegian Oil Spill Response Technology Development. Proceedings of INTERSPIL conference.

Meyer, P., Schmidt B., DeVitis D., and Delgado J.-E., 2012.High Capacity Advancing Oil Recovery System Performance Testing at Ohmsett for the Wendy Schmidt Oil Cleanup X CHALLENGE. Proceedings of Interspill Conference.

Meyer P., 2014. Testing of Oil Recovery Skimmers in Ice at Ohmsett, the National Oil Spill Response Research & Renewable Energy Test Facility. Proceedings of the International Oil Spill Conference.

Miller, S. 2014. Alaska's Approach to Determining Oil Recovery Rates and Efficiencies. Proceedings of the International Oil Spill Conference.

Potter S, Bronson M, Thompson E, Majors L. 2007. Testing of Various Options for Improving the Pumping of Viscous Oils and Emulsions. Proceedings of the AMOP Conference.

Potter, S., I. Buist, K. Trudel, D. Dickins and E. Owens. 2012. Spill Response in the Arctic Offshore. Prepared for the American Petroleum Institute and the Joint Industry Programme on Oil Spill Recovery in Ice, D. Scholz (ed.). American Petroleum Institute, Washington.

Sørstrøm, S.E., P.-J. Brandvik, P.J., Buist, I., Daling, P., Dickins, D., Faksness, L.-G., Potter, S., Rasmussen, J.F., Singsaas, I.. 2010. Joint Industry Program on Oil Spill Contingency for Arctic and Ice-covered Waters: Summary Report. Oil in Ice JIP Report No. 32, SINTEF, Trondheim, Norway.

SL Ross. 2010. Evaluation of the Crucial Coated-Disk Skimmer in Arctic Conditions. Report to Alaska Clean Seas.

Wilkman G. W., Uuskallio A., Ritari E. , Niini M. K. Technological Development in Oil Recovery in Ice Conditions. Arctic Technology Conference Proceedings. Houston, 2014.