Review of Oil Spill Herders

Merv Fingas
Spill Science, Edmonton, Alberta, fingasmerv@shaw.ca

Abstract

Herding agents are surfactant mixtures or singular surfactants, used to drive thin slicks of oil to a desired location or to push slicks together so that they can be collected or burned. Herding agents contain a surfactant which has a spreading pressure greater than that of oil. Historically these agents were not used to any extent. Recently they have been tested as agents which may assist the burning of oil in ice situations. The idea is that the herding agents may push the oil together to yield burnable thicknesses in those cases where it is too thin to burn.

Herding agents have limitations such as they are not useful in any but calm conditions and the limitation is that only about a 3 mm slick can be herded together. Further, the herding effect diminishes with time as the surfactants dissolve slowly or adhere to solid objects in their path. Action is probably limited to about one hour. Herding agents would be used by spraying them around the slick to compress the slick inward. At this time, herding agents are not approved for use in the USA nor are they common commercial products.

The Agents

Most oil-soluble surfactants will herd oil. The essential characteristics are that the surfactants should be less water-soluble and only slowly oil-soluble, and float on water.

In the early years, dispersants and a variety of cleaning agents were found to herd oil. Companies like Shell and Exxon produced versions of oil spill herders. In recent years a number of products were tested (Buist and Meyer, 2012).

These include:

Corexit 9580 is a surface washing agent. Testing has not continued on this product, as it was not as effective as specifically-designed products.

The original U.S. Navy cold water blend (65% sorbitan monolaurate [Span-20] and 35% 2-ethyl butanol). This product is typically referred to in studies as the USN product or as a hydrocarbon herder.

A warm-water herder blend suggested in the original US Navy study (75% sorbitan monooleate [Span-80] and 25% 2-ethyl butanol). It should be noted both Span-20 and Span-80 are sometimes used as part of the surfactants in oil spill dispersants.

OC-5, was a proprietary Exxon Oil Collector. The product was active 30 years ago.

Silsurf A108 is a proprietary silicone surfactant mixture. This product has been found in recent testing to be the most effective of all the herders.

Silsurf A004D is another propriety silicone surfactant mixture.

Literature Summary

Buist and Morrison (2005) report on a small scale preliminary assessment of a shoreline-cleaning agent with oil herding properties to assess its ability to herd oil on cold water and among ice. Using the shoreline cleaner on cold water reduced the area of sheens of fluid oils, but the thickness of the herded oil was only in the 1-mm range. On thicker slicks, the shoreline cleaner effect was much more promising and could herd slicks to thicknesses of 2-4 mm. Although the presence of ice forms in the pans slightly retarded the effectiveness of the herding agent, the agent still thickened oil among ice. The composition of the oil played a strong role in determining potential efficacy. The application of a herder to thin oil slicks in pack ice was considered to hold potential for thickening oils for in situ burning. The presence of waves did not diminish the short-term effectiveness of the herder on a slick.

Buist et al. (2006) report on the results of testing at larger scales at CRREL and at Ohmsett. The first two of three planned mid-scale tests were carried out to explore the effectiveness of oil-herding agents in pack ice conditions. They assess that there is potential for the application of chemical herders to contract oil slicks in pack ice to thicknesses for in-situ burning, particularly in light wind conditions.

Buist et al. (2008) summarize the use of oil herding surfactant chemicals to contract oil slicks spilled on water within drift ice in a 4-yr program. Results prompted middle-scale testing at the US Army Cold Regions Research and Engineering Laboratory, the Ohmsett facility, and the Fire Training Grounds in Prudhoe Bay, AK. The non-proprietary cold-water herder formulation used was shown to be effective in contracting oil slicks in brash and slush ice concentrations of up to 70% ice coverage. Slicks in excess of 3 mm thick were routinely achieved. Herded slicks were ignited, and burned equally well in both brash and slush ice conditions at air temperatures as low as -7°C.

Buist et al. (2010a) summarize a 2-day field research program conducted off Svalbard in late May 2008 to test the efficacy of a chemical herding agent in thickening oil slicks on water among open drift ice for subsequent in situ burning. The goal of the work was to conduct two meso-scale field burn experiments with crude oil slicks of approximately 0.1 and 0.7 m^3 in open drift ice. Prior to the field experiments, two series of small laboratory tests were carried out with candidate crudes (Heidrun and Statfjord) for the field experiments to determine the ability of the USN herder to contract slicks of the oils. The first field experiment used 102 L of fresh Heidrun crude released into a monolayer of USN herding agent that had just been placed on the water. This slick was carried by currents to a nearby ice edge where the oil was ignited and burned. Approximately 80% of the oil was consumed in the ensuing burns. The second experiment involved the release of 630 L of fresh Heidrun crude onto water in a large lead. The free-drifting oil was allowed to spread for 15 minutes until it was too thin to ignite (~0.4 mm), and then USN herder was applied around the slick periphery. The slick contracted and thickened for approximately 10 minutes at which time the upwind end was ignited using a gelled gas igniter. A 9-minute long burn consumed an estimated 90% of the oil.

Buist et al. (2010b) reported on experiments to study the use of herders to improve skimmer operations in drift ice in a lab and at Ohmsett using both weir and oleophilic skimmers. The addition of herder improved the performance of the weir skimmer by factors of 3 to 10. No significant improvement was found in the performance of the disc skimmer. A series of small-scale experiments was also undertaken in the lab to determine the feasibility of using herders to clear oil slicks from salt marshes. The experiments utilized similar local fresh water marsh plants as surrogates for salt marsh species. In none of the static tests did the herder clear the oil completely from the marsh plants. In some tests the herder caused the oil slicks to contract in size sufficiently to significantly reduce the oiled area of the marsh; however, even in these cases, there remained a ring of oil at the waterline around the originally oiled stalks of the marsh plants. Tests were conducted at Ohmsett to compare dispersant application on herded slicks. The use of herders on an oil slick were not found to reduce the effectiveness of chemical dispersant application.

Buist et al. (2011) summarized 7 years of studies on herding agents. Small-scale laboratory experiments were completed in 2003 and 2005 to examine the use of herding agents to thicken oil slicks in loose pack ice for the purpose of in situ burning. Further mid-scale testing was carried out in 2006 and 2007 at the US Army Cold Regions Research and Engineering Laboratory (CRREL) in Hanover, NH; at Ohmsett, in Leonardo, NJ; and, at the Fire Training Grounds in Prudhoe Bay, AK. The hydrocarbon-based herder formulation used in these experiments proved effective in considerably contracting oil slicks in brash and slush ice concentrations of up to 70% coverage. Slicks in excess of 3 mm thick were routinely achieved. Herded slicks were ignited, and burned equally well in both brash and slush ice conditions at air temperatures as low as -17 °C. The burn efficiencies measured for the herded slicks were only slightly less than those for equivalently-sized, physically contained slicks on open water. Meso-scale field trials of the technique were carried out in the Barents Sea off Svalbard in the spring of 2008. The larger field experiment involved the release of 630 L of fresh Heidrun crude onto water in a large lead. The free-drifting oil was allowed to spread for 15 min until it was too thin to ignite (~0.4 mm), and then the hydrocarbon-based herder was applied around the slick periphery. The slick contracted and thickened for approximately 10 min at which time the upwind end was ignited. A 9-minute long burn ensued that consumed an estimated 90% of the oil. From 2007 to 2009 experiments were carried out in the laboratory and at CRREL comparing the efficacy of silicone-based herding agents, silicone-based herding agents, and the hydrocarbon-based herder. The results showed that the fluorosurfactant-based herders did not function better than the hydrocarbon-based herder; however, the new silicone surfactant formulations considerably outperformed the hydrocarbon-based herder. Experiments were conducted in 2010 to determine if herding agents could: 1) improve skimming of spilled oil in drift ice; 2) clear oil from salt marshes; and, 3) improve the efficiency of dispersant application operations.

Buist and Meyer (2012) summarize tests of two types: 1. A series of comparative experiments was undertaken in the lab with hydrocarbon-based and silicone-based herding agents in 1-m^2 pans, a 10-m^2 pan, small pans mounted on a rocking shaker and the SL Ross wind/wave tank to determine the best of several candidate herders for use on warmer water. Overhead digital photographs and video were taken and analyzed by computer to determine the herder effectiveness in the pan tests. 2. Surfactant film persistence was investigated in an 8-day test program at Ohmsett in 2011. Overhead digital video and photographs were taken to qualitatively compare and determine the persistence of three herding agents in calm conditions, a swell and breaking waves. A total of 11 experiments were completed with three herding agents (USN, Silsurf A108 and Silsurf A004-D). The following conclusions were drawn: a) The monolayer of each of the herders will survive for more than 45 minutes in a calm sea. b) The presence of breaking or cresting waves rapidly disrupts the herder monolayer and the oil slick resulting in many small slicklets. c) The monolayer survives for considerable periods of time in a swell condition, but the constant agitation of the herded slick results in elongating the oil slick and slowly breaking the slick into smaller segments. d) The Silsurf A108 herder performed better than the other two herders in all test conditions.

References

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