United States
Environmental Protection
Agency

Municipal Environmental
Research Laboratory
Cincinnati OH 45268

Research and Development

EPA-600/S2-84-074 May 1984

EPA

Project Summary

OHMSETT Test Series 77: Global Oil Recovery Skimmer, Veegarm Skimming Arm, Kebab 600, Wylie Skimmer, and the Skim-Pak Cluster

Michael Borst

A series of tests was performed at the Oil and Hazardous Materials Simulated Environmental Test Tank (OHMSETT) to provide information about the current state-of-the-art in oil spill response equipment. Funds were provided by the OHMSETT Interagency Technical Committee (OITC) to test three advancing skimmers (the GLOBAL oil recovery skimmer (GORS),* the Veegarm sweeping arm, and the Wylie skimmer) and two stationary skimmers (the Kebab 700 and the Skim-Pak cluster).

The Hydrovac Veegarm and Kebab 600 are effective in the situations for which they were designed. The Skim-Pak cluster is somewhat of an improvement over the basic device. The GORS shows attractive potential for at-sea separation of collected oil and water, although the proposed improvements tested here were unsuccessful. The Wylie skimmer failed to collect oil in all but the mildest test environments.

This Project Summary was developed by EPA's Municipal Environmental Research Laboratory, Cincinnati, OH, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

The OHMSET Test Series 77 was funded by the OITC. Members of this group include the U.S. Coast Guard, the U.S. Minerals Management Service, Environmental Canada, the U.S. Environmental Protection Agency, and the U.S. Navy. Each of these agencies has an interest in the oil spill equipment and annually sponsors testing at OHMSETT. All are committed to maintaining an active knowledge of the current state-of-the-art in oil spill response equipment. To make effective use of funds, to ensure the widest possible distribution of information obtained, and to avoid costly repetition of testing, these member agencies pooled their resources and experience for testing three advancing and two stationary skimmers during the 1980 OHMSETT test season. The three advancing skimmers chosen for testing were the GORS, the Veegarm sweeping arm, and the Wylie skimmer. The stationary skimmers were the Kebab 600 (a rotating disc device) and the Skim-Pak cluster (a floating-weir skimmer).

The GORS is a modification of the DiPerna skimmer, which had been tested at OHMSETT previously. The external head had been removed, and a floating weir was substituted. Three rows of angle iron had been welded across the bow of the skimmer to dissipate waves before they contacted the weir.

The Veegarm is a rigid boom skimmer in commercial use around the world. The skimming arm is the only part of the skimming system tested.

The Wylie skimmer is a prototype skimmer designed for use with a boom rigged in a catenary configuration. An extended, free-floating head is intended to remove thick-

* Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

ened oil from behind the apex of the boom. The Wylie skimmer is built around an open-ended vertical tank for oil-water separation.

The Kebab 600 is a stationary disc skimmer. A set of four rotating oleophilic discs collect oil that has already been contained. The device is intended for use when low-water-content oil recovery is critical and when the spill has been brought under control.

The Skim-Pak cluster extends the concept of the Skim-Pak skimming system previously tested at OHMSETT. Rather than a single skimming head-pump combination, six heads are coupled to a common manifold to scale up the oil recovery rate of the unit without significant reduction in recovery efficiency.

Small Business Program

Three of the devices tested — the Kebab 600, the Wylie skimmer, and the Skim-Pak cluster -- were chosen for study as part of the small business program sponsored by the OITC in November and December 1980. This 3-week program was aimed at small businesses and individuals who for economic reasons could not otherwise test at OHMSETT. The small business test programs was publicized in several trade journals and newsletters. Those interested in the program were invited to apply for part of the test time available. The OITC screened the responses and selected three for testing based on promise and innovation.

The participants were responsible for the costs of shipping their devices to and from OHMSETT and for the costs incurred by their on-site technical consultants, which the OITC required. All other costs for testing were paid by the OITC. This program and others like it provide useful information to both the businesses and the OITC. The private individuals receive the benefit of OHMSETT's years of experience in addition to the quantified performance testing. They also receive practical information on the state-of-the-art, recommendations of the staff, and perhaps most important, an opportunity to observe their equipment at work. The OITC receives an appraisal of the current state of development work in the private sector both from the equipment tested and from the many imaginative designs not selected for testing.

GLOBAL Oil Recovery Skimmer

The GORS is a modified version of the DiPerna skimmer tested at OHMSETT in 1979. The GORS was tested to determine the effectiveness of the modifications to the DiPerna skimmer. Most modifications involved the oil-collecting mouth of the device. The vacuum head of the DiPerna Sweeper was removed, and a floating weir was installed as a replacement. Three staggered rows of 51-mm angle iron were welded vertically across the bow of the skimmer to dissipate the waves before reaching the weir.

The GORS uses a 6.3 m^3 holding chamber maintained at slightly less than atmospheric pressure to draw oil over the weir. The chamber is baffled and serves essentially as a gravity oil/water separator. The heavier, water-rich layer is pumped from the bottom of the chamber to reduce the internal pressures and draw additional fluid over the weir. The floating, oil-rich layer is pumped from the top of the holding chamber to a more permanent storage area or the container is used as temporary storage until the skimmer can be unloaded.

The results of the 43 pre-modification and 38 post-modification tests indicate that the principle behind the skimmer is sound. The results also indicate that the modifications were detrimental to the overall performance of the skimmer. In almost all cases where the test conditions were repeated, the performance deteriorated. This was especially true of the wave-dissipating angle-irons, which tended to concentrate the wave energy and entrain oil rather than dissipate the wave energy.

Mechanical problems plagued the test series. These were generally the result of poor engineering, or maintenance, or both:

1. The free-floating weir did not have the center of buoyancy and center of gravity in the same vertical plane, which caused the weir to twist and jam when rising or falling. The tests were run with a man constantly in position to free the weir, but such a solution would be unrealistic for spills in the real world.
2. The GORS came equipped with six onboard pumps. The two single-diaphragm pumps that were intended to unload the oil-rich phase could not overcome a 4-m head. This head could easily be encountered when unloading into barges at sea, so the pump system is simply underdesigned.
3. Two centrifugal pumps intended to unload the water-rich phase had been exposed to the elements for too long without routine, scheduled maintenance. Much valuable test time was lost in coaxing these pumps to work. Eventually, an OHMSETT positive displacement pump was used to pump through one of the onboard centrifugals.
4. The theoretical waterline should have been calculated and the play of the weir designed accordingly.

These problems are minor and can be easily remedied with minimal investment of time, money, and effort. They are not detrimental to the concept of at-sea separation of collected oil and water, and they should be considered as flaws in concept implementation rather than as flaws of the concept itself. The limited accessibility of storage barges and tugs at a spill makes the concept attractive.

The Hydrovac Veegarm

The Veegarm is a rigid-boom oil skimmer produced and marketed by Hydrovac Systems BV of the Netherlands. A rigid arm channels the floating oil slick to a simple overflow weir. The collected fluids are then pumped to a large vessel that serves as an oil-water separator.

The Veegarm was tow-tested at speeds through 3 knots in calm water and wave conditions. Two oils of very different viscosity were used as test fluids in varying thicknesses. Fifty-six tests were performed on the skimmer over 10 test days.

The Veegarm was well designed with regard to strength, flotation, and stability. The truss that supports the oil diversion screen is constructed of rectangular steel tubing and will withstand massive forces before permanent deformation occurs. The modular design allows for easy over-the-road transportation and relatively simple air shipment.

The largest wave the Veegarm was tested in was a 0.63-m harbor chop — the only wave in which the outboard pontoon left the water surface. Although the Veegarm suffered from occasional splashover, the bottom of the screen was never exposed for direct oil loss beneath it. A slick of contained oil does form, and the headwave remains parallel to the face of the skimmer. The thickened layer of oil presented no real problems along the length of the screen, but the headwave was entrained into the water at the weir assembly at higher speeds.

Vortices that form at the ends of the weir draw some oil into the water column. The inboard vortex was of little consequence because it seldom captured oil. The outboard vortex captured more oil, but the total quantity was small compared with the total distributed and with losses from other failure mechanisms. Losses occur between the Veegarm and the support vessel hull. The slick lost at this location is generally very thick. When thick slicks are encountered in calm water, the percentage of total loss is significant.

The screen of the arm reflects incident waves, which strike the next incident waves and form a harbor chop. This effect is especially evident when the waves are short

and the arm is unable to respond to changes in the water surface level. The wave reflections are of little significance in long waves.

Wylie Skimmer

The Wylie skimmer is constructed of spare parts with minimal capital investment. The skimmer is primarily a wooden structure that uses 208-L drums for flotation. The device successfully withstood 2-knot runs without mishap. The device was designed around a road-legal trailer and was sufficiently mobile to be towed cross-country from British Columbia to New Jersey. The unit is designed to be a floating barge with an interior holding tank for preliminary oil/water separation. The tank is rectangular and has an open top and bottom. The collected fluid is intended to be of very high water content with free water separation. An electric trolling motor was used as a low-pressure pump to minimize the mixing of oil and water.

The skimmer is designed to collect oil trapped by a boom. The fluid passes from the water surface to the separation tank through a 203-mm stove pipe and flexible hose network that will induce a counterclockwise current in the separation tank. The intake to the pipe-hose network was simply a length of stove pipe mounted on a semicircular wooden float.

The device was unable to collect oil from the water surface under most conditions. Because of the OHMSETT modifications, it did collect minimal amounts of oil, but the as-built model was incapable of collection in anything but the mildest of test conditions. The wooden float that supported the suction hose formed a clear water area comprising 60% to 70% of the available oil-collecting area at the pipe. If a means of oil removal from the water surface is developed, the skimmer will be limited to the working speed of booms in a catenary configuration. Three different mounting systems for the floating intake were used.

Tests were run during which the separation tank was precharged with approximately 1 m^3 of oil. These were run to find the maximum towing speed of the device when operating if it were not boom-limited. At 1.5 knots, a large flow of oil was drawn from the separation tank. The out-the-bottom loss diminished as the tow speed decreased to the critical speed of about 1 knot. These tests were run with no attempt at further collection. The device losses through this mechanism increase when additional oil collection is attempted. Losses were apparent at 0.25 knot with additional collection.

Kebab 600

The Kebab 600 is the smallest of a family of disk skimmers marketed by Vikoma International Ltd. The unit tested came with two options: a 72-L floating reservoir and a small hand pump. The Kebab 600 weighs 12 kg and could have been positioned by a single operator. The housing is constructed of marine-grade aluminum that encloses five stainless steel disks 278 mm in diameter. The rotating disks are wiped by Teflon (PTFE) scrapers. The collected oil runs into a trough for removal. The disks are driven by a variable-speed, 24-watt DC motor. The unit tested functioned throughout the test period without mechanical problems. The marine design was adequate for the only wave used in testing (0.19 m). The test unit was provided by Strauss Engineering, Mason, New Hampshire.

The Kebab 600 could be used for oil spills, but it is restricted by the designed low recovery rate, and it would only be used to its fullest capacity in small, contained spills. A better application for a skimmer of this size and capacity could be water effluent quality control. Obvious examples of this type of application include removing oil from gravity-type separators or lagoon settling ponds.

The Kebab 600 can operate without personnel in attendance if a nonmanually-operated pump is used. An electric pump in a timed servo-cycle or a sensing probe of some sort would work well if a more readily usable holding reservoir were established. Continuous pumping or simple gravity overflow are simple solutions for industrial applications, but they do not lend themselves to spills.

The common trough may be placed in one of two positions, depending on whether the collected oil is to be pumped or gravity discharged. When in the pumping position, the wipers are not long enough to scrape the entire surface of the disk. The outside surface of the disk on each end is not scraped. Both of these problems should be remedied.

Though wave testing was not as complete as calm-water testing, the wave tests generally produced equal or better values for the oil recovery rate (ORR) and slightly lower recovery efficiency (RE) values. When the Kebab 600 faces oncoming waves, the collection trough acts much like a weir.

The minimal storage capacity of the floating reservoir is self-defeating. If the concept of local storage is continued, reservoir stability must be addressed. The reservoir was not useful during the tests.

The hand pump does not supply the necessary head for pumping high-viscosity oil, but is able to pump water the required height.

ORR increases with disk speed. Apparently, a minimum of about 20 rpm is necessary for effective collection in light oil. The ORR is higher in heavy oil than in light, but the RE is better in light. The Kebab 600 develops sufficient surface current to draw nearby oil to itself.

Skim-Pak Cluster

The Skim-Pak skimming weir was tested at OHMSETT in 1978 under OITC sponsorship. These tests led to minor modifications in the skimming head. The skimming heads in the cluster were constructed of molded fiberglass. Each head is rectangular, with two tines straddling a self-adjusting flap, which serves as a weir. The flap is intended to allow high-oil-content fluid to be collected. The skimmed oil is transferred through a 38-mm diameter hose 3 m long. These hoses are jointed at a common cylindrical manifold approximately 1 m in diameter and 0.25 m high. A 76-mm diameter PVC hose connection is located at the center of the bottom of the manifold for discharge. The unit tested was a prototype developed and provided by Douglas Engineering of Concord, California.

The Skim-Pak cluster produces a higher ORR than a single skimming head, but not in proportion to the number of heads.

The 1978 test program showed that the skimming heads are much more effective when attended with a control wand than when free floating. These tests show similar results when compared on a per-head basis. The RE cannot be maintained, since the multiple heads cannot be tended as the single head can. Wave conformance was excellent. No diving or porpoising was observed in the waves tested. A clear-water problem did occur, however. The yawing of individual heads created oil-free patches on the water surface.

Inclement weather conditions hampered the testing. Only 13 tests were conducted over the 4-day period. Ice formation within the manifold proved to be a severe problem. This ice could not be freed by simply alternating the flow direction from the pump.

The assembled cluster was difficult to maneuver, and the required facilities could not be available on boats for at-sea deployment. The fragility of the unit and the multiple hoses would prevent throwing the cluster over board for deployment. Field deployment would probably require a man to be at the water level or physically in the water.

Conclusions

Tests of the GORS showed that most modifications of the original DiPerna skimmer were detrimental to the overall performance of the device. The principle behind the GORS was sound, however.

The Veegarm skimmer was well designed with regard to strength, flotation, and stability, but significant oil losses occurred bet-

ween the skimmer and the support vessel hull in calm water.

The as-built model of the Wylie skimmer collected no oil in any but the mildest test conditions. OHMSETT modifications produced little improvement in this skimmer's performance.

The Kebab 600 could be used for oil spills, but it is restricted by the designed low recovery rate, and it would only be used to fullest capacity in a small, contained spill. Perhaps a better application for this size skimmer would be water effluent quality control.

The Skim-Pak cluster produces a higher ORR than a single skimming head, but this improvement is not in proportion to the number of heads. Difficulties were encountered in maneuvering the assembled cluster and in deploying it without special facilities that would not be available at sea.

The full report was submitted in fulfillment of Contract No. 68-03-3056 by Mason & Hanger-Silas Mason, Inc., under the sponsorship of the U.S. Environmental Protection Agency.

Michael Borst is with Mason & Hanger-Silas Mason Co., Inc., Leonardo, NJ 07737.

***Richard A. Griffiths** is the EPA Project Officer (see below).*

The complete report, entitled "OHMSETT Test Series 77: Global Oil Recovery Skimmer, Veegarm Skimming Arm, Kebab 600, Wylie Skimmer, and the Skim-Pak Cluster," (Order No. PB 84-168 293; Cost: $13.00, subject to change) will be available only from:

National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
Telephone: 703-487-4650

The EPA Project Officer can be contacted at:

Oil and Hazardous Materials Spills Branch
Municipal Environmental Research Laboratory—Cincinnati
U.S. Environmental Protection Agency
Edison, NJ 08837

☆ U S GOVERNMENT PRINTING OFFICE; 1984 — 759-015/7694

United States
Environmental Protection
Agency

Center for Environmental Research
Information
Cincinnati OH 45268

OFFICIAL MAIL
U S POSTAGE
20

Official Business
Penalty for Private Use $300

PS 0000329
U S ENVIR PROTECTION AGENCY
REGION 5 LIBRARY
230 S DEARBORN STREET
CHICAGO IL 60604