Recent Testing, Training, and Research Conducted at Ohmsett
The National Oil Spill Response Research & Renewable Energy Test Facility

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Abstract
Ohmsett - The National Oil Spill Response Research & Renewable Energy Test Facility plays a critical role in developing the most effective response technologies enabling a rapid and efficient response to an actual spill. The facility, which is operated by the U.S. Department of Interior, Bureau of Safety and Environmental Enforcement (BSEE), provides a crucial intermediate step between small-scale bench testing and open water testing of equipment by allowing testing of full scale equipment in a controlled environment. Information gathered at Ohmsett plays an essential role in the development of new technology and in the creation of more effective procedures for responding to future oil spills.

Recent programs for innovative spill recovery technologies include: Testing Prototype Stationary and Advancing Skimming Systems, Remote Detection of Spilled Oil on Surface Water, Detection and Recovery of Sunken Oil, and Testing Mechanical Devices for Recovery of Spilled Oil in Ice Conditions (a.k.a. Ice Month). While the testing will still be on-going during March 2013, we will briefly discuss the results of Ice Month during the presentation of this paper.

While much of the data collected is proprietary, this paper will summarize and discuss the methodology used during recent testing and research conducted at Ohmsett.

1 Introduction
Ohmsett, The National Oil Spill Response Research & Renewable Energy Test Facility, located in Leonardo, New Jersey, provides independent and objective performance testing of full-scale oil spill response equipment. Ohmsett helps improve oil spill response through research and development of the tools responders use, as well as allowing full-scale realistic training to response personnel. Ohmsett’s largest asset is its above-ground concrete test tank which measures 203 m long (approximately two football fields) by 20 m wide by 3.6 m deep. It is filled with 9.8 million liters of salt water that is filtered to maintain clarity, enabling the use of underwater cameras and viewing windows mounted in the walls of the tank.

The test tank is spanned by three movable bridges (carriages). The Main Bridge is used to tow full-size oil spill response equipment through the water at speeds up to 3.3 m/s to simulate towing at sea or deployment of equipment in a current. It also includes an oil distribution system that allows oil to be dispensed on the water in front of the equipment being towed or tested. The Auxiliary Bridge can be equipped with one or two of four optional test oil recovery tank modules. Two of the modules have eight each of 946 L calibrated tank sections, while the other two modules have four each of 2264 L calibrated tanks sections. All of the tank sections were designed to be differentially decanted. The test tank has a wave generator that can generate waves up to one meter in amplitude. In addition, there is an on-site oil/water chemistry laboratory. Figure 1 shows the configuration of the Ohmsett facility.
2 Background

Ohmsett is the largest facility for testing oil spill response equipment in North America. Built in 1974, it has facilitated the testing of a wide variety of spill countermeasures in a controlled, repeatable and safe environment. Initially, the focus was on the testing of containment booms and mechanical recovery skimmers. The facility has since expanded its capabilities to meet the needs of the spill research community and can now perform testing of dispersants, chemical herders, weathering, in-situ burning, pumping and separation devices, simulated pipe discharges, surveillance and detection, submerged oil detection and recovery among other countermeasures activities. Recently, a number of projects have been completed that involve Arctic and cold water conditions in which the test basin water temperature was controlled and specific ice fields were created. A searchable database of testing and R&D projects conducted at Ohmsett can be found at www.ohmsett.com/activities.html.

The U.S. Department of the Interior, Bureau of Safety and Environmental Enforcement (BSEE) manages the facility as part of its mandated requirements by the Oil Pollution Act of 1990 (OPA, 1990). In accordance with OPA ‘90, agencies represented on the Interagency Committee are to ensure the long-term use and operation of Ohmsett for oil pollution technology testing and evaluations. More information on the Interagency Committee can be found at www.iccopr.uscg.gov.

Ohmsett is an integral part of the BSEE oil spill research program and directly supports the BSEE goal of ensuring the best and safest oil spill detection, containment and removal technologies are available to protect the U.S. coast and oceanic environments. Results of BSEE funded oil spill response research can be found at http://www.bsee.gov/Research-and-Training/Oil-Spill-Response-Research-(OSRR).aspx on the database of projects.
3 Operational Testing

Ohmsett’s mission is to increase oil spill response capabilities through independent and objective performance testing of equipment and improving response technologies through research and development. Many of today’s commercially available oil spill cleanup products and services have been tested at Ohmsett either as off-the-shelf commercially available equipment, or as equipment or technology under development.

Due to its size and the capability of using real oil, Ohmsett is considered a “mesoscale” tow/wave tank facility and represents an intermediate step between small scale “bench testing” and open-water testing of equipment. It provides manufacturers and researchers the opportunity to 1) conduct proof of concept prototype testing; 2) evaluate oil recovery and oil containment capabilities; 3) evaluate sea-keeping abilities; 4) validate the performance of full-scale response equipment in dynamic conditions and; 5) evaluate the logistics of transporting and deploying equipment as well as ease of decontamination cleaning. In addition, operational testing allows response organizations to make smarter purchases through competitive acceptance testing of response equipment. This ensures that the most efficient response equipment is available for use during a spill.

3.1 Mechanical Oil Recovery

Ohmsett follows the guidelines in ASTM F2709-08 Standard Test Method for Determining Nameplate Recovery Rate of Stationary Oil Skimmer Systems (ASTM, 2008). In summary, a test area three times longer and three times wider than the skimmer is preloaded with slightly more than 76 mm of test oil and the skimmer’s performance is measured as the slick thickness diminishes from that level to 51 mm, Figure 2 and 3. Usually a preload greater than 76 mm is used to allow sufficient oil volume for the system to reach steady state and to purge the system hold-up prior to the start of the test. Recovered fluid is pumped by the system’s offload pump to recovery tanks that are approximately 4 m above the water surface.

![Figure 2  Skimmer Protocol Test Set-up](image-url)
After each test, the recovery tanks are sounded to determine the gross amount of fluid recovered. The recovered fluid is allowed to settle for 30 minutes, after which the tanks are decanted of free water and a second sounding is taken. The remaining fluid is stirred and a representative sample is obtained and sent to Ohmsett’s Oil/Water Lab to determine the amount of emulsified water in the recovered oil, and any solids present. From the test data, performance values are calculated for Oil Recovery Rate (ORR) and Recovery Efficiency (RE). To be a valid test, three runs must be performed at identical skimmer settings and each of the three runs must be within 20% of the mean, with each run achieving a minimum RE of 70%. The formulas for ORR and RE are:

**Oil Recovery Rate (ORR):**

\[
\text{ORR} = \frac{V_{\text{oil}}}{t}
\]  

Where:  
\(\text{ORR} = \text{Oil Recovery Rate, liter/min (lpm)}\)  
\(V_{\text{oil}} = \text{Volume of oil recovered, in liters (decanted and lab corrected)}\)  
\(t = \text{Elapsed time of recovery, minutes}\)

and:  
**Recovery Efficiency (RE):**
\[
RE = \frac{V_{\text{oil}}}{V_{\text{total fluid}}} \times 100
\]

(2)

Where: \( RE \) = Recovery Efficiency, %
\( V_{\text{total fluid}} \) = Volume of total fluid (water and oil) recovered

### 3.1.1 Elastec/American Marine

In May 2012, Elastec/American Marine completed performance testing of three oil recovery skimmer systems at Ohmsett. The Magnum 600 and the TDS 136, both grooved drum skimmers of different capacity and configuration, were both tested as stationary skimmers to the ASTM F2709-08 standard method. The third skimmer tested was the X150 grooved disc skimmer. This was tested in both the stationary mode as per ASTM F2709-08, and in the advancing mode using boom.

Five tests were performed using the Magnum 600, including one stationary test in waves as a qualitative observation of performance and station keeping capability. A method, defined Type II oil with nominal viscosity of 2000 cP at the prevailing temperature, was used in a test area defined by 4.7 m by 7.9 m sides. Performance values for ORR and RE were calculated from total fluid volumes collected, oil volumes corrected for free and emulsified water, and aliquot collection time. Corresponding operational parameters such as hydraulic flows and pressures were recorded.

The X150 was then tested in advancing mode. The test rig setup, Figure 4, placed the skimmer at the apex of an 18.3 m V-sweep lead boom configuration. This boom was equipped with a subsurface, ballast skirt mounted net designed to maintain a V-sweep configuration. A total of 30 tests were performed from 1 to 3 knots. The first eight tests were conducted without oil in order to demonstrate sea keeping characteristics at various operational conditions anticipated during testing. Thirteen tests were conducted with a fresh Type I oil with a nominal viscosity of 200 cP at operational temperatures; nine tests were performed with the same Type I oil with varying amounts of included or emulsified water to test collection, recovery, and transfer of this type of fluid. Performance values for throughput efficiency (TE=volume of oil collected/volume of oil encountered X 100), ORR and RE were calculated from total volumes of oil encountered, total fluid volumes collected, oil volumes corrected for free and emulsified water, and aliquot collection time.
In addition to the advancing test program, the X150 was tested statically as per ASTM F2709-08. Five tests were conducted with Type I oil and three tests were conducted with Type II oil. A test area measuring 4.7 m by 7.9 m was used. Performance values for ORR and RE were calculated from total fluid volumes collected, oil volumes corrected for free and emulsified water, and aliquot collection time.

The smaller TDS 136 skimmer was tested as per ASTM F2709-08 using a Type II oil in the 4.7 m by 7.9 m target area. A total of four repeatable tests were performed to determine ORR and RE performance data.

3.1.2 Lamor

Lamor returned to Ohmsett in early 2012 to test three of its brush skimming systems. The group included the Minimax 60 skimmer (Figure 5), the LNXG 100 prototype, and the LNXG 1000 prototype. All three systems were tested in stationary mode following the test method outlined in ASTM F2709-08. The LNXG 1000 prototype was also tested in advancing mode.
During the stationary tests for all three skimmers, a boom was rigged around the skimmers to create a 7.0 m x 7.3 m area. The test area was filled with a Type I oil to a depth of 82.6 mm. At the start of each test, recovered oil was pumped to a ‘slop’ tank until the equivalent of 6.4 mm was recovered; the volume of excess oil necessary to achieve steady state operation and assure filling of dead volume in the recovery system. At that point, the recovered oil flow was diverted to a collection or aliquot tank and timing started. The flow of recovered oil continued to the collection tank for the time it took to reduce the slick by 25 mm. At that point in time, flow was diverted back to the slop tank and the test was stopped. Again, performance values for ORR and RE were calculated from total fluid volumes collected, oil volumes corrected for free and emulsified water, and aliquot collection time.

In preparation for testing of the LNXG 1000 in the advancing-mode, the prototype was cantilevered in front to of the Auxiliary Bridge on a steel beam allowing the skimmer to be raised or lowered to the proper height. Once secured to the bridge, sweeping boom arms were fastened to the skimmer, a hydraulic power unit was connected, and the system was towed down the tank at speeds ranging from 0.5 to 4.0 knots. A Type I oil with a viscosity of 300 cP at the test temperature was dispensed on the surface of the tank near the mouth of the boom opening. The oil was distributed in front of the skimmer at a rate similar to a recovery rate anticipated to simulate steady state conditions. Oil that was recovered was offloaded during the run to elevated recovery tanks. Performance values for TE, ORR and RE were calculated from total volumes of oil encountered, total fluid volumes collected, oil volumes corrected for free and emulsified water, and aliquot collection time.

3.1.3 Maritime Development Group

Marine Development Group returned to Ohmsett in March 2012 to test their new concept in oil recovery. The MOS Sweeper system includes a series of sweeping booms to control and
guide encountered oil to a collection zone. It consists of three main components: a shallow draft sweeper (boom) designed to concentrate an oil layer by oblique deflection, a flow canal, and collecting units. The objective was to quantify the performance of the MOS Sweeper system to recover and contain spilled oil at relative current (tow) speeds from 1.5 to 3.5 knots. The test oil was Calsol 3290 a medium naphthenic lube stock with a viscosity of approximately 5,000 cP during the test.

The MOS Sweeper was rigged between Ohmsett's Main Bridge and Auxiliary Bridge (Figure 6). Oil, held in a 1,500 gallon tank on the Main Bridge, was dispensed onto the surface of the test tank, creating an oil slick in front of the system. Oil recovered by the system was pumped to recovery tanks located on the Auxiliary Bridge. A Desmi brush skimmer was used for the earlier tests and during additional tows a Z-Marine pump was used.

During the one-week test, variations of the system were evaluated for towing stability, ORR, TE, and RE in both calm water conditions and waves. Variations in system configuration included running with and without collection pool, running with and without the Desmi skimmer in place, and runs with various rigging changes to the lead booms.

When the Desmi brush skimmer was exchanged for a Z-Marine pump, a bypass system was used while the system came up to steady state. Fluid that was recovered as the system was coming up to speed was pumped up to the Auxiliary Bridge and back into the test tank behind the skimmer. Once at speed, a valve was swung to divert the flow from bypass to the recovery tanks. At the end of the run, the valve was swung back, putting the system back into bypass mode. During the test series using the Z-Marine pump, the system was towed at speeds of 1.5, 2.5, and 3.5 knots, in both calm water conditions and in waves.
3.1.4 NorLense, AS

NorLense, AS performed research and development testing of their advancing OilTrawl fast water oil recovery device. During previous testing, ideas were generated to improve the system performance and scalability for testing within the Ohmsett test basin. The objective of these tests was to quantify the recovery efficiency values of the system while encountering a consistent slick thickness at varying speeds in calm and wave conditions. The OilTrawl, shown in Figure 7, incorporates a guiding boom, an oil/water splitter, and a flexible collection tank to recover and temporarily store spilled oil.

![Figure 7 NorLense OilTrawl System](image)

Each test was performed by accelerating the OilTrawl to the test speed in which the system encountered a consistent slick thickness of approximately 6 mm. Oil distribution was started and ended so that the system encountered 100% of the slick while at test speed. Each test was comprised of two passes. At the end of each pass, oil which had escaped the system during the test run was collected from the surface and transferred into the Ohmsett recovery tanks for quantification. Efficiency values were determined by using the known volume distributed minus volume lost divided by volume distributed expressed in a percentage.

The first eight tests were performed using Sundex 790 (nominal viscosity 8,000 cP) and were performed at speeds of 1.5 to 3.0 knots in both calm and sinusoidal wave conditions. Five additional tests were performed using Hydrocal 300 (nominal viscosity 200 cP) at speeds of 1.5 to 3.0 knots in both calm and sinusoidal waves.

3.1.5 HUSSEN AS

HUSSEN AS is a Norwegian company under contract with NOFO (Norwegian Clean Seas Association for Operating Companies). Their Oil Shaver device was tested previously at Ohmsett where research and development quantitative evaluations were performed. The
HUSSEN high seas oil collection system, the subject of this testing, had undergone design modifications to enhance recovery performance and was evaluated in similar conditions as previous tests. The main objective of this test series was to quantify TE.

The system consists of two parallel inflatable booms, approximately 1 m apart, and the booms are connected along the bottom using fabric. The fabric, which is horizontal and is just below the waterline, has openings in the leading edge to allow oil to enter the channel between the booms and has a slot near the trailing edge to decant the water that collects in the channel. There are also “skis” under the leading boom to provide lift.

As the system, which is towed from a single point, is towed through an oil slick, oil passes under the leading boom, into the channel between the booms, and down to a skimmer in the aft end of the system. Just before entering the skimming unit, the oil passes over a weir and into a collection area, where the oil is collected by a skimmer and offloaded using the skimmer’s discharge pump. This system was equipped with an Elastec oleophilic drum skimmer.

The system was rigged between the Main Bridge and an auxiliary bridge, with the bridges spaced 26.4 m apart. Recovery tanks were located on the Auxiliary Bridge and oil that was collected was pumped up to the tanks to be quantified. The system was arranged so the booms were at an angle of approximately 45 degrees to the direction of tow. Ohmsett’s test tank is 19.8 m wide. Initially the tow point was located 1.8 m off the east wall; however this was shifted to 3.8 m off the wall to shift the entire system closer to the west wall to better effect as shown in Figure 8.

![Figure 8 HUSEN AS Oil Shaver](image)

Test runs were approximately 120 m long. The tow speeds ranged from 2.5 knots to 5 knots, with the majority of the runs at 3 knots. Runs 1-25 were conducted in calm conditions and Run 26 was conducted in wave conditions with a wave height of approximately 0.3 m and a wavelength of approximately 20 m.
The first six runs were performed without oil to assess the towing characteristics of the boom. For the oil collection tests, Runs 7-26, oil was dispensed onto the tank using four nozzles so that the boom would intercept the oil slick starting at the forward-most (west) side of the boom. Hydrocal 300 test oil was introduced in front of the boom as soon as the system was up to speed. The oil supply was turned off approximately 30 m before the end of the run to give the Oil Shaver boom time to direct the oil to the skimming unit and offload the oil up to the recovery tanks on the Auxiliary Bridge. At the end of the run, the skimmer was evacuated of as much oil as possible from the collection area and this fluid was offloaded prior to resetting the bridges for the next run. Fluid that was pumped up to the recovery tanks was allowed to settle for 30 minutes to allow the oil and water to separate. After this waiting period, the free water was decanted, the remaining fluid was quantified and a representative sample was sent to Ohmsett’s oil/water lab for analysis for emulsified oil and/or any solids present. These measurements were used to quantify the oil that was recovered by the system.

3.1.6 Qingdao Sunic-Ocean Marine T&S Co., Ltd

Qingdao Sunic-Ocean Marine T&S Co., Ltd tested an integrated oil skimming system at the Ohmsett Facility during the weeks of December 3, 2012 and January 9, 2013. The system consisted of a waterborne skimmer of the dynamic inclined plane (DIP) type. The skimmer was also equipped with an aft directed induction propeller. This allowed for oil collection in both the stationary and advancing modes. In the advancing mode, the skimmer was designed to be used with leading booms on either side of the skimmer mouth. These booms also presented the opportunity for towing. Oil concentration in the receiving chamber was enhanced by the application of vacuum above the collecting oil column. Collected oil off-load was accomplished using an on-board centrifugal pump.

In addition to the skimmer, booms, and necessary rigging, Sunic-Ocean employed an automatic system for level control and off-load. Included was a hydraulic system to power an induction pump for offload operations; a vacuum system to provide lift for oil concentration; and, the necessary electrical, vacuum, and hydraulic controls. The whole system was computerized to provide for automatic operation and data acquisition once the system was deployed.

During the week of December 3, 2012 a series of five stationary oil skimming tests were performed using the Sunic-Ocean system in the Ohmsett test tank. These tests were not performed to the ASTM F2709-08 protocol since the goals of the test were to gain data and experience using the system and not necessarily to meet a standard to present to a certifying authority. Instead, the skimmer was rigged in the Ohmsett tank in a way similar to an advancing mode with the entire skimmer and boom sections rigged between the main bridge forward and the auxiliary bridge aft. The bridges were spaced at approximately 13.7 m. The 6.1 m boom sections were connected at the mouth of the skimmer at a width of approximately 0.6 m. The boom sections were then connected to the tow points of the main bridge which were set at a width of 3.0 m. For tow back and stability, the stern of the skimmer was tied back to the auxiliary bridge. This setup provided an enclosed area in front of the skimmer mouth of approximately 11 m². For the purpose of stationary testing, this enclosed area was preloaded with a given volume of oil. As the test progressed, the area was replenished with a metered oil flow as skimmer recovery took place.
For all stationary tests, the oil used was Hydrocal 300. The prevailing air and water temperatures provided an oil viscosity range of 330 to 420 cSt. All tests were conducted under calm water conditions.

During the week of January 7, 2013 a series of eighteen tests were performed in the advancing mode in calm water and in waves. The rigging configuration was essentially the same as employed during the stationary tests (Figure 9) with the exception that the system was towed down the test tank at speeds from 1.5 to 3.0 knots. All tests were performed at an oil feed rate of 340 l/min. This was chosen due to the fact that the performance of the off-load pump was not being tested for this program. Therefore, a constant rate was chosen to demonstrate other performance parameters. Additionally, an initial preload speed of 0.5 knots was used at the start of each test run. After preload, the tow speed was increased to the intended test speed. The light oil used in the advancing test series was Hydrocal 300, the same oil used in the stationary series. The heavy oil used was Calsol 8240. The performance parameters for TE, ORR, and RE were determined. Other parameters that were monitored included hydraulic flow rates and pressures, vacuum development, oil discharge and transfer pressures, and wave data.

Figure 9  Sunic-Ocean Marine Skimmer Vessel

4  Research and Development
4.1  Remote Detection of Spilled Oil on Surface Water

Ocean Imaging is developing a method to remotely detect oil on surface water using a portable aerial imager. Ocean Imaging’s latest series of tests at Ohmsett used an imaging device to detect emulsified crude oil films floating on surface water.

The multispectral imagers that constitute Ocean Imaging’s technology were mounted on the Main Bridge crow’s nest, 9 m above the water’s surface (Figure 10). Twelve 1.2 m x 1.2 m square targets were assembled using gray PVC, placed on the surface of the Ohmsett tank, and tethered beneath the Main Bridge Crow’s Nest. Discrete amounts of oil were dispensed into
each of the targets to create oil slicks of various thicknesses (Figure 11). Knowing the volume of oil dispensed and the area of the slick, the oil thickness could be calculated. Tests also used three 21 m-long sections of river boom spaced 1.2 m apart to create two parallel channels in which oil could be spilled in a controlled manner without the use of the square PVC targets. Spilling oil in the channels allowed the oil to spread into films of decreasing thickness while keeping the slick beneath the Crow’s Nest for imaging. The test oil used was Alaska North Slope (ANS) crude oil. ANS was used fresh and as an oil/water emulsion.

Figure 10 The multispectral imagers were mounted on the Main Bridge crow’s nest above the water’s surface

Figure 11 Twelve targets were preloaded with various thickness of oil and placed on the surface of the test tank
As the Main Bridge passed over the targets, data was acquired from the imager, simulating data acquisition by a small plane passing over an oil spill. Tests were conducted during the day as well as in the evening, after sunset, when there was no solar heating of the test oil.

4.2 Detection and Recovery of Submerged Oil

The U.S. Coast Guard Research and Development Center conducted a series of tests at Ohmsett to evaluate the recovery capabilities of three prototype systems designed to collect heavy oils. The three companies that supplied prototypes were: Alion, Marine Pollution Control (MPC), and Oil Stop/AMPOL (Figures 12-14). Each system had to retrieve samples of oil of different quantities and thicknesses from an approximately 150 square meter plot positioned at the bottom of the testing tank. The test plot was covered with sediment and debris to stimulate a sea floor or river bed, and the oils that were used were Tesoro Decant Oil and Sundex 790. Where necessary, these oils were modified with a barium sulfate.

Figure 12 The Alion Sea Horse used a Remotely Operated Vehicle
Figure 13 The MPC model used a submarine equipped (ROV) and equipped with sonar and fluorescence polarization

Figure 14 The Oil Stop Sub-Dredge used a submersible dredge equipped with an underwater camera

5 Conclusion
The techniques and devices developed at Ohmsett have led to a greater understanding of oil spills in all environmental conditions. As the scope of projects broaden, the capabilities of the facility will be improved to meet the industry needs, such as expanded testing in simulated Arctic environment conditions and the expanded ability to efficiently generate test data.

This work has enabled the engineers to present to the ASTM Committee F20 on Hazardous Substances and Oil Spill Response recommendations for updating current standard
guidelines and the development of new standard guidelines. These recommendations have provided a means for the evaluation of performance as well as guidance in the application of response equipment and technologies.

6 Acknowledgements

The authors would like to gratefully acknowledge the assistance of the U.S. Department of Interior, Bureau of Safety and Environmental Enforcement (BSEE); Elastec/American Marine; Lamor; Maritime Development Group, NorLense, AS; HUSSEN AS, Qingdao Sunic-Ocean Marine T&S Co., Ltd; Ocean Imaging; U. S. Coast Guard Research and Development Center; and the staff of MAR, Incorporated, who operate Ohmsett under contract with BSEE.

6 References
