Oil Spill Response Research & Renewable Energy Test Facility

The Ohmsett Gazette

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Skimmers of the Future

Imagine a skimmer moving through an oil spill intuitively, with no operator, to recover the oil. That is the vision of future skimming operations with the Bureau of Safety and Environmental Enforcement (BSEE) project, *Development of Smart Skimming Technologies*. This multiple phase project investigates the development of technology packages to aid in the automation and optimization of oil skimmer recovery operations. The intention of these technologies is to ultimately replace the skimmer operator's decisions entirely with real time spill data obtained from the surface. Operating a skimmer system with accurate condition data will maximize and normalize oil recovery efforts and results.

"This research is exciting in that its goal is to give a skimmer system the ability to analyze and adjust its skimming path based on inputs received in order to maximize collection rate," commented Kristi McKinney, BSEE's project manager.

The first phase is the investigation of devices that can measure oil thickness and that can independently control skimmer operations to most effectively track and recover encountered oil without operator input. The devices can be any practical

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What's Inside

Ice Management System for Recovering Spilled Oil in Ice Infested Waters

The Desmi Brush skimmer sits inside the ice managment system that prevents ice, slush and debris from interfering with the skimmer's ability to pick up oil.

Recovery operations in ice infested waters with mechanical recovery equipment is complicated by ice, slush and debris, which interferes with the skimmer's ability to efficiently pick up oil. This problem was identified during the Bureau of Safety and Environmental Enforcement (BSEE) funded Ice Month in the winter of 2013 at Ohmsett. Ice Month skimmer evaluations were conducted with US Coast Guard and US Navy equipment in a simulated arctic environment. The objective was to identify viable technologies and equipment alternatives for use by Oil Spill Response Organizations (OSROs). As a result of the evaluation, it was recommended that an ice management system that prevents ice, slush and debris from interfering with the skimmer could potentially enhance its performance.

Continuing the collaborative research effort between BSEE and the USCG, the USCG R&D Center took the lead in soliciting the development of an ice management system. They awarded a contract to Marine Pollution Control (MPC) of Michigan to design and build a deployable device to keep ice from around the skimmer recovery zone. The newly designed ice cage was tested with two skimmers at Ohmsett during the week of March 2, 2015 in conditions similar to those used during Ice Month.

According to Kurt Hansen, project engineer for the USCG R&D Center, they wanted

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Skimmer of the future

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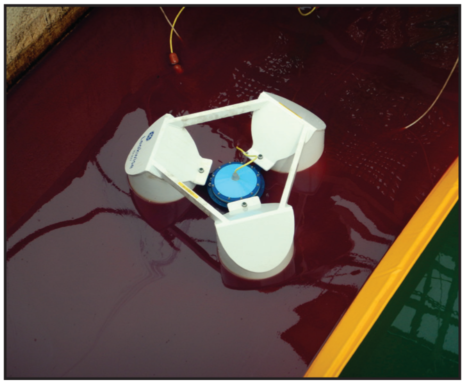
technology that can be retrofitted to at least one type of commercial skimmer. During the week of March 30, 2015, BSEE funded Alion Science and Technologies of McLean, Virginia for a series of tests to evaluate various oil thickness sensors for implementation into an oil skimmer recovery system.

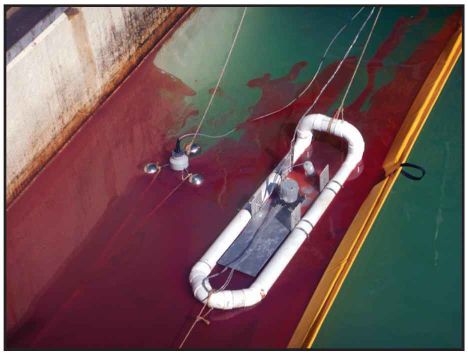
Two types of tests were conducted: Oil Slick Thickness Sensor Testing and Pipe Flow Sensor Tests.

For the first test series, thickness sensor testing was conducted to evaluate the GE Leakwise ID-227, the Arjay 2852-HCF, and the Arjay 2852-PCD/conductivity sensors. The objective was to determine function and accuracy of the sensors traveling through different thicknesses of oil on the surface of the tank. Within a boomed area in the Ohmsett tank, four individual slicks were created with clear water between each. The sensors were mounted to an adjustable towing point on the main bridge and were evaluated by advancing them at various speeds through the combination of defined oil slicks and clear water to determine each sensor's ability to detect and measure the slick thickness. For the final test in this series, the slick configurations were altered and waves were introduced.

Although the sensor performance is currently under review, according to Dr. Gregory Johnson, program manager at Alion, GE and Arjay use different technologies to assess oil thickness and at first blush both worked to varying degrees. "The biggest problem right now is more hydrodynamics than sensor technology," said Johnson, "[We need] to design a platform to ensure the sensors stay on the surface as they advance through the oil."



GE Leakwise sensor traveled within a known oil slick while measuring the slick thickness.



The Arjay sensors, 2852 HCF on left and 2852-PCD on the sled, travel from clear water into a known oil slick.

The final test was a pipe flow sensor test in which the sensor was to identify the concentration /ratio of oil to water flowing by it. Flows were provided using a pumping arrangement for controlled inputs and a drum skimmer for a more realistic flow. During the first part of this series, an Arjay Model 2852-IFA was assembled on a fixture to ensure that the probe head was continuously immersed in fluid. A known percentage of oil and water was provided in the fluid stream to evaluate the sensor's capability to measure oil and water percentages within the pipe flow. During the drum skimmer test, the sensor was located in the discharge flow where its performance was evaluated for recovery operations while encountering an oil slick.

The next steps are for Alion to design the sensor mount that will attach to the skimmer, and to complete the computer control algorithms. According to McKinney, the prototype skimmer and control software will undergo field testing as well as further testing at Ohmsett in 2016.

Ice Management system

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an ice management system that could increase the recovery efficiency performance in 70% ice coverage conditions.

The Ice Cage has a conical shape that displaces ice when the system is placed into the water. It floats separately from the skimmer and is equipped with a fence-like frame that prevents ice chunks from entering the collection zone. The ice cage was designed to work with several skimmers and was evaluated with an Elastec TDS 118G Drum skimmer and a Desmi Helix skimmer.

"This was a collaborative effort to get the potential realized," said Bill Hazel, director of Marine Services at MPC. "The need for the cone shape came out of the ice month demonstrations. So we designed around strength and floatation."

The evaluation took place in a boomed area of the Ohmsett tank which provided enough room for the skimmer and ice cage to move through the ice floes. Ice was sourced from the U.S. Army's Corps of Engineers Cold Regions Research and Engineering Laboratory (CRREL) in 40-inch x 40-inch x 8-inch thick sheets. The ice field was created by cutting the sheets into various sizes and placing them in the boomed area for evaluations in 30% and 70% ice coverage. To create the simulated oil spill, a 1-inch thick slick was distributed within the test area.

Ice coverage and slick thickness were measured and verified during the test series using two different techniques: a thermal imaging camera with processing software known as Tactical Rapid Airborne Classification System (TRACS), and a pixel counting technique using overhead digital images.

During the tests the skimmers were maneuvered and controlled using the main bridge crane. They were slowly moved through the test area in order to expose the skimmer to new pockets of oil within the ice field. The skimmers within the ice cage were evaluated for recovery efficiency, recovery rate and operational efficiency.

This project was the first at Ohmsett to explore the feasibility of this concept to ultimately increase the effectiveness of oil recovery in icy waters. The data collected during the test series is currently being evaluated and, according to Hansen, the USCG RDC is considering if additional modifications are needed for deployment in an actual spill.

Adjustable Down Draught Stationary Skimmer

During arduous testing the week of December 8, 2014, Foru-Solution BV of the Netherlands evaluated their weir style stationary skimming system at Ohmsett. Using the ASTM F2709 Standard Test Method for Determining Nameplate Recovery Rate of Stationary Oil Skimmer Systems, the skimmer was assessed for its oil recovery rate and recovery efficiencies.

The FORU (Fast Oil Recovery Unit) took shape nearly 15 years ago with engineer Wim Schuur designing a stationary skimming system for cleaning oil from the water surface. In 2000, the initial prototype was successfully tested at the Pollution Control Authority in Horten, Norway. A couple of years later, Managing Director Bert Sibinga and Technical Director Koos Tamminga came onboard and in cooperation with Schuur, modified the system creating the current model which they named FORU.

FORU is different from current weir style skimmer systems that use gravity or external mechanical devices, such as brushes or discs, to pull the oil into the skimmer. "We call the FORU an adjustable down draught system. The explanation is that we accelerate the water by the inlet perimeter to eventually pull the oil towards the vessel," explained Tamminga. "We use under pressure in the vessel. The inlet gap of 360 degrees is, in our case, very important and it is therefore adjustable."

The FORU stationary skimmer uses an adjustable down draught system that accelerates the water by the inlet perimeter to pull the oil towards the vessel. The system was tested to the ASTM F2709 Standard at Ohmsett during the week of December 8, 2014.

The objective of the week-long evaluation was to test the equipment in oil for the first time, and collect information on its recovery rate and efficiency. "Our aim for Ohmsett, was of course, the ASTM standard, but we also recognized that we had to test in oil for the first time. Of course we tested our product in fresh and salt water, but never with real oil." said Tamminga. "We wanted to take it step by step. We had to get acquainted with real oil and see the FORU work under these conditions."

During the ASTM tests, the FORU system was placed in the center of a boomed area that provided three times the footprint area of the skimmer. A 3-inch oil slick was placed within the boomed area. After the skimmer system was set to its operational speed, it was run at steady state for a short time before data collection began. The system then operated until the equivalent to 1 inch of the slick was recovered. At this point timing was stopped and the oil was left to settle in the recovery tanks until any free water was decanted. A final measurement was taken providing the total inches of recovered oil during the test.

"We proved that the principle worked, but we didn't get the rate we were looking for. It would have been nice to pass the test the first time, but that was a step too far," commented Tamminga.

With the data obtained at Ohmsett, the FORU team remains optimistic and will make the necessary adjustments to the skimming system in order to obtain the results they hope to achieve; a minimum of 70% recovery rate. "At this moment we're planning to build a test environment similar to Ohmsett in Sneek, the Netherlands," said Tamminga. "We're going to simulate the ASTM test, make the adjustments necessary to the FORU, and find the right parameters for the ASTM test. After that we will schedule a second test at Ohmsett; this time we're going to be sure we meet the ASTM standard."

Green Sponge-like Foam Absorbs Oil, Repels Water

It was a week where Mother Nature threw everything she could at the team from OPFLEX Environmental Technologies. From pelting rain, high winds and freezing temperatures, to blue skies, the team battled the elements to test the OPFLEX Technology at Ohmsett.

Designed for fast moving currents of streams, rivers, and oceans, the OPFLEX products are made from a green sponge-like foam material that absorbs and contains oil from water. This open-celled flexible foam material is made from a copolymer called ethylene methyl acrylate (EMA).

"In simple terms, EMA is non-polar. While water is polar and oil is non-polar, so oil is effectively attracted to the OPFLEX while the water is effectively repelled," explained Scott Smith, founder and inventor of the OPFLEX Technology. "I chose the EMA copolymer for its high tensile strength and elastomeric qualities that allows the OPFLEX technology to withstand fast currents, rough seas, and high winds, while maintaining its efficacy in removing oil from water in all weather conditions."

During the week of November 17, 2014 tests were performed in the Ohmsett test basin using various configurations of the sorbent materials. Configurations included rolled OPFLEX materials varying from ¼- to 1-inch thick and from 1 to 3 feet wide, a square boom, and simulated eel grass. The tests primarily focused on the overall ability to deploy various configurations of the OPFLEX products, dispensing rollers, deployment using a tow bar, and the effectiveness of the wringer system.

The first day's events evaluated the deployment, oil recovery capability, and the effectiveness of the wringer system for OPFLEX pads that were made into rolls. An oil slick was created within the boomed area along the basin wall. Using a small boat, four rolls of pads mounted on a tow beam were deployed onto the surface and towed through the slick. The evaluation showed how four sheets of product could be deployed simultaneously using a common tow beam. After passing through the slick, two of the four strips of pads were processed through the wringer system. As fluid was collected into the wringer system, it was transferred to an Ohmsett collection tank for measurement and sampling.

"The purpose of this demonstration was to illustrate and measure the efficacy of OPFLEX technology when conventional oil skimming would not be an option," Smith said.

In addition, the OPFLEX eelgrass along with reinforced belt booms attached with Velcro in roll form were used to assess its ability to protect a shoreline while containing and absorbing oil. "All OPFLEX configurations were placed through the prototype OPFLEX wringing system to measure the amount of oil recovered," commented Smith. The fluid collected during each test was analyzed in the Ohmsett oil/water laboratory for the percentage of oil to total liquid volume.

During the next couple of days, tests were conducted using various OPFLEX products in multiple configurations where some were towed by the small boat and others were left on the oil slick for a specific period of time. The products tested were: the Cube Boom, which is five sections consisting of 2-inch square cubes of OPFLEX material retained within a netted boom; 1 inch x 24 inch x 12 feet reinforced belt booms in four sections; and ¼ inch x 24 inch x 12 feet reinforced belt booms in 16 sections. For each product tested, the recovered fluid was measured for volume and efficiency in the Ohmsett oil/water laboratory.

The final two days involved multiple tests using the eelgrass deployed in the water column for a proof of concept test for removing dispersed oil in the water column. Within a boomed area of the test basin, a metal cage was used to submerge the eelgrass in the water column where it encountered an oil slick as well as dispersed diesel fuel as it was towed at .25 knots in a wave condition.

"While this proof of concept on a developmental basis proved the potential of submergible OPFLEX eelgrass, more development needs to be done around buoyancy, cell size, and design for the water column," said Smith.

Next was a series of qualitative comparisons of OPFLEX materials. The cube boom with eelgrass, the square boom, and the embedded mesh (in separate tests) were compared with more conventional sorbent

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OPFLEX eelgrass was evaluated for its ability to protect a shoreline during a week of testing at Ohmsett.

Inflatable Floating Booms Minimize Spill From Spreading

Starting out with what seemed like a crazy idea two years ago has turned into new technology that will aid oil spill cleanup operations. HARBO Technologies of Israel has developed disposable inflatable floating booms that can be prepositioned on sites where oil spills can occur for rapid deployment to contain and minimize a spill's ability to spread.

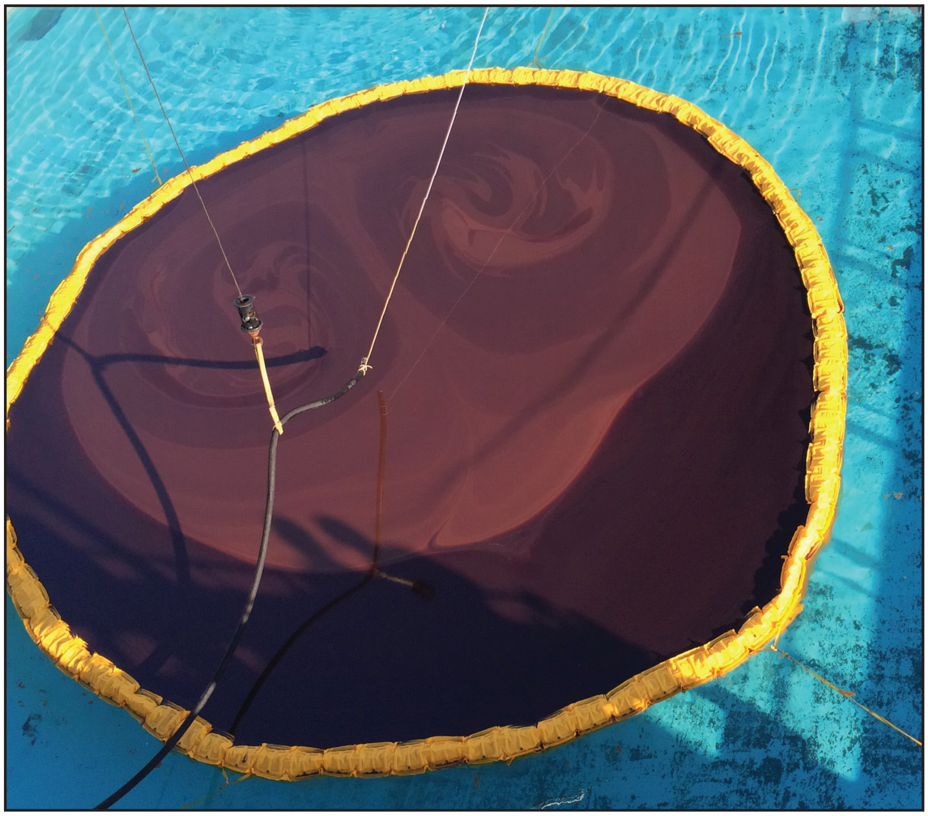
The HARBO team realized they had something different when they won first prize in the 2012 Berkeley's Start-up Competition's Energy & Cleantech track. "At this point, we understood it was time to start working on our boom," said Boaz Ur, HARBO's co-founder and chief executive officer. With Arnon Shany, chief technology officer leading the product development process, they developed a boom system that is smaller and lighter than regular boom. While not a substitute for regular boom, it is designed for offshore use to perform primary containment of oil spills and can be preinstalled at standby positions on-board large ships and rigs. The concept includes a vessel the size of a life boat that produces and deploys the offshore containment boom.

"[We wanted it to be] very simple to operate and enable non-trained oil spill professionals to contain the spill in those first few hours when it is most critical," Ur explained. "In our product development work we found that this piece is critical, since professionals on ships, rigs or at oil terminals cannot be expected to operate complex emergency equipment. So we made it simple; push button - just like a lifeboat."

The boom design is modular and assembled from cartridge rolls. The cartridge is fed into a booming machine (still under development) which inflates and injects the closed cells of the boom with air and sea water. With the geometric design, the boom behaves like an integral part of the body of water moving with the currents and waves.

"We went through dozens of prototypes, testing offshore in the Mediterranean with about four to six foot waves," said Ur. "When we were certain that our boom's capabilities exceeded our most optimistic expectations, we applied for international patents. Only then we were ready for Ohmsett."

"Even though we were quite satisfied with the results obtained at our offshore tests, we were still concerned because we could not use crude oil, so we couldn't be sure how good the boom's containment capabilities would be. Also, we wanted to test in the best facility in the industry, where the engineers will come up with testing scenarios that we didn't dream of."



HARBO modular booms are inflated, and the closed cells are injected with air and sea water. The boom behaves like an integral part of the body of water moving with the currents and waves.

HARBO tested two inflatable floating boom designs at Ohmsett during the week of October 20, 2014. The prefabricated booms were assembled and inflated with air and injected with sea water at the Ohmsett facility by the HARBO team. No other materials, ballast, wires, or chains were used for making the booms.

During testing, boom A was placed in the Ohmsett tank and tested in calm conditions with different quantities of Hydrocal 300 oil placed in the center of the boom. While observing the boom, data was collected that included: water temperature; air temperature; and air speed. Additional tests were conducted in which the boom was towed through the tank (with and without waves) in two different configurations while containing oil.

In another series of tests, boom B, weighing less than 4 oz. per foot prior to deployment, was placed in the tank where the center of the boomed area was filled with Hydrocal 300. It was evaluated with several types of waves. In addition, the boom was towed through waves and observed for oil losses. At the end of the testing, additional oil was placed in the boom and left overnight. The next day, the boom was tested in two different configurations and towed through the tank to observe for oil losses.

"HARBO succeeded to do what was considered almost impossible; to develop an immediate offshore containment boom, designed to be ready for deployment on board every potential point of failure," stated Ur. "We are now focused on the system implementation (deployment machine and vessel), as well as working on the boom production lines."

Compact Advancing Recovery System

PPR Alaska is progressing through research and product development for an advancing oil recovery system that is compact and suitable for deployment from Vessels of Opportunity. The new 300 gpm prototype unit is a much smaller version of the 2500 gpm Mega System demonstrated during the Wendy Schmidt Oil Cleanup XCHALLENGE, which was held at Ohmsett in the summer of 2011.

"This technology is [intended for use] with Vessels of Opportunity which will be scattered throughout the marine ways of passage where the majority of spills occur," said Kevin Kennedy PPR Owner. "These vessels are small to medium sized boats, not capable of deploying the Mega System efficiently. Hence, our smaller systems are perfect for these vessels because our system is light and so compact. It will be able to be stored in three fish totes, with a total weight of 1200 lbs."

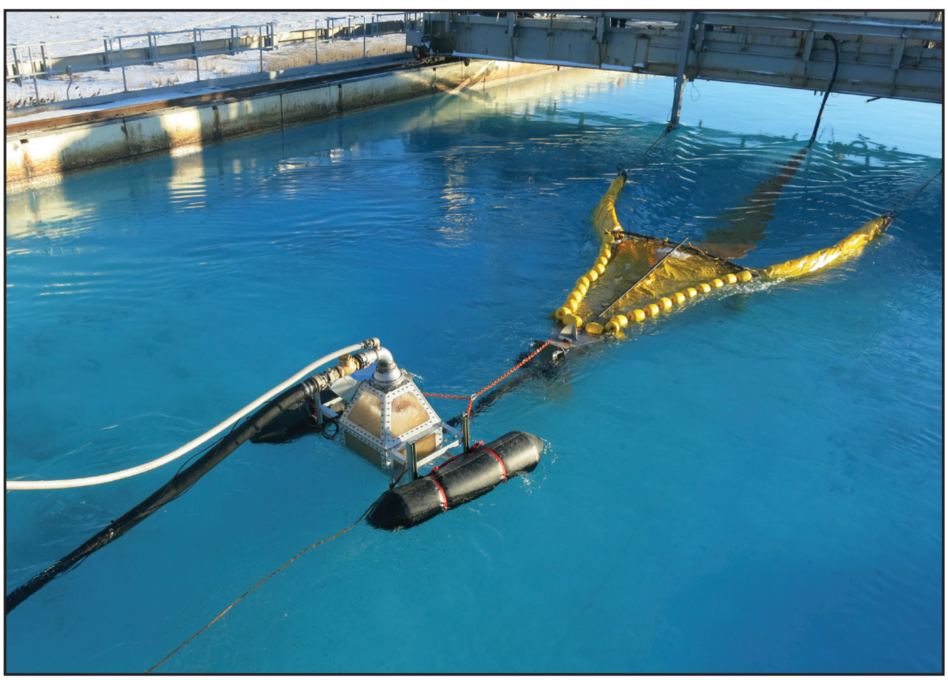
Building on his experience in the commercial fishing industry, Kennedy was able to cross over the application of using nets, trawls, and floatation in the oil recovery system. Using a lab scale tank in the PPR workshop in Anchorage, Alaska, Kennedy evaluated several different concepts prior to testing at Ohmsett in December 2014, January and February 2015.

The PPR system consists of three major components: a trawl net design built with light-weight high strength line that forms V-shaped sweeping arms to the apex; a Vortical Flow Unit (VFU) located in between the netting that takes advantage of the fluid dynamics of the oil and water mix in a pressurized state; and the vacuum pump system at the back-end that consists of a modified open and impeller-less fish pump that allows the passage of ice and debris that otherwise fouls impeller-driven systems.

"The VFU is essentially a box that traps vertical pressure created by the inflows of oil and water. The inflow strikes baffles fabricated on the interior of the VFU, which stimulates a natural vortex of the petrol within the denser water," explains Kennedy. "The differential pressure between the water and the open space within the VFU causes the vortex to rise to the surface of the contained fluid, creating a natural separation of the oil and water. At this point a vacuum pump transfers it into the container tanks on the vessel."

During several evaluations at Ohmsett, a series of tests focused on achieving high oil recovery efficiencies with the 300 gpm prototype unit. Tethered between the main and auxiliary bridges, the skimmer system was towed at speeds between 1 and 3 knots through the water while encountering an intentional oil slick. The tests were conducted with Calsol and Hydrocal test oils of various encounter rates in calm water and waves. The unit was evaluated for oil recovery rates and throughput efficiencies, as well as sea keeping abilities.

"After our last testing at Ohmsett, the system proved the concept that oil skimming can be accomplished without mechanical means [within the on-water portion of the recovery device]," said Kennedy. "We are currently working on raising our oil recovery efficiencies to match our throughput efficiencies. We believe with one or two more tests, we can accomplish 90% throughput efficiencies and 90% oil recovery efficiencies using no mechanical means. We also learned that the system, as tested, actually worked in ice laden waters and at temperatures below -10^{o} Celsius."



The Vortical Flow Unit of the PPR recovery system creates a natural seperation of the oil and water.

OPFLEX Technology

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booms in choppy sea conditions.

According the Smith, the team plans to take what was learned at Ohmsett and include the most efficient OPFLEX product designs into their commercial product lines. "The oil spill industry is unique because of the extent and diversity of the various economic and environmental stakeholders. We must use education, communications, and continued testing, like that done at Ohmsett, to help move the industry forward with more effective technologies to remove oil in all weather and sea conditions. This is the only way we are going to better protect and preserve our water ways and sensitive ecosystems."

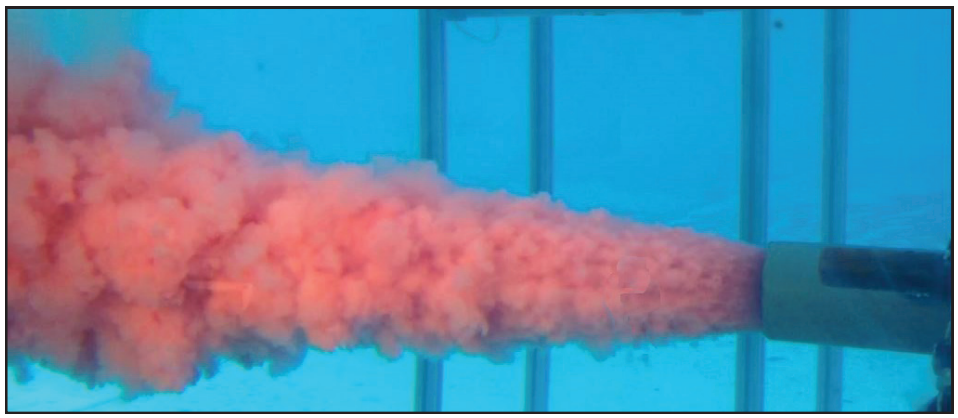
Technology for Measuring Submerged Oil/Gas Leaks

The ability to quickly and accurately calculate flow rates from subsea oil and gas leaks or blowouts is information essential for effective response operations. During a Bureau of Safety and Environmental Enforcement (BSEE) sponsored large-scale test in October 2014, the National Energy Technology Laboratory (NETL) performed a series of tests to further develop the concept of using a high speed camera mounted on a ROV, with accompanying software, that is able to rapidly analyze the leak and calculate flow rates by tracking the physical features of the plume.

In order to accomplish this research, Ohmsett personnel developed a subsurface jetting system that could produce flow rates of known velocities that would simulate a subsea leak or blowout. Using two different oil jets (1-inch and 3-inch) mounted to a heavy steel structure and placed in front of a test basin viewing window, the team was able to create subsurface oil flows up to 885 gallons per minute and jet velocities up to 125 feet per second. The window provided clear visibility of the intentional release in which all independent test parameters were controlled and documented for confirmation of the analysis software's accuracy.

Through funding provided by BSEE, researchers at NETL have been able to develop and advance this technique towards being a field ready tool. With the technology's current state of development, if a blowout were to occur, an accurate estimate of the discharge rate could be calculated within two days of receipt of ROV video of the leak. Work is still ongoing between NETL and UC Berkeley to fully automate the technique and decrease the calculation times even further.

Instrumentation to locate and analyze a leak is mounted to a frame for testing.



The Ohmsett staff was able to create subsurface oil flows up to 885 gallons per minute and jet velocities up to 125 feet per second.

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USCG Academy Cadets Tour Ohmsett

On April 14, 2015 cadets from the US Coast Guard Academy in Groton, Connecticut, toured the Ohmsett facility during the USCG Oil Spill Response Technician (OSRT) training. The cadets are enrolled in the Petroleum and Oil Spill Science class at the Academy where they are introduced to the basic concepts and terminology of oil spill response technology.

Ohmsett senior engineering technician Rich Naples provided them with an overview of the facility's oil spill response research and testing capabilities, a tour of the oil/water chemistry lab, as well as the test basin and wave generator.

"It is important that they understand the need for a continuing research, development, test, and evaluation effort to ensure that the technology is available and up to the task when a major spill occurs," commented Pete Tebeau, marine science instructor at the USCG Academy. "Ohmsett has played a key role in this RDT&E process; I think the cadets left the facility with an appreciation for this," Tebeau commented.

As part of the tour, the cadets were able to observe the OSRT training and talk to the instructors about the operational and logistical complexity of deploying spill response equipment in the field.

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Ohmsett is managed by the Bureau of Safety and Environmental Enforcement (BSEE) through a contract with MAR Incorporated.

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