Improving the U.S. Coast Guard Viscous Oil Pumping and Lightering Capability

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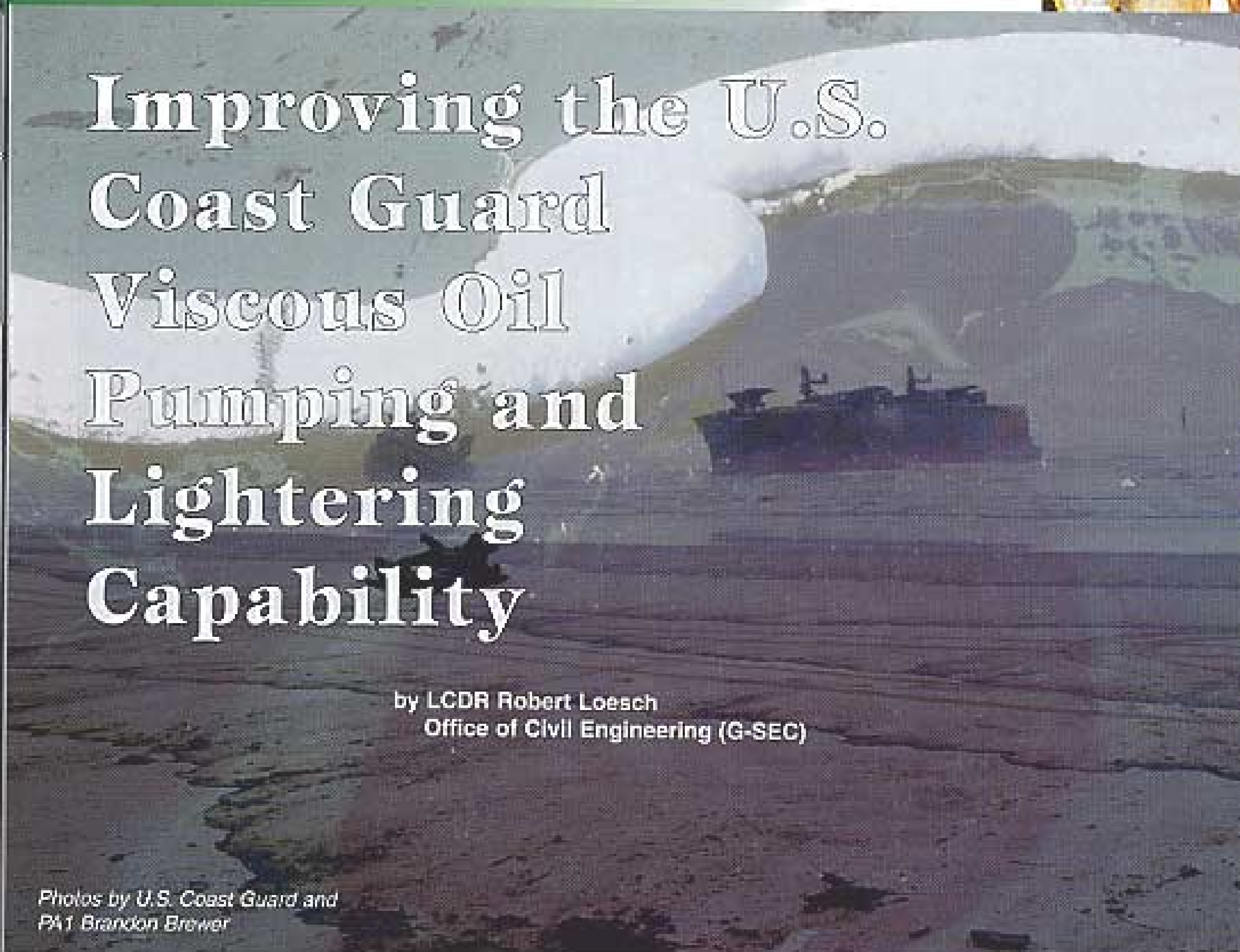


Photos by U.S. Coast Guard and PA1 Brandon Brower

The three top priorities for an Incident Commander during a pollution incident are safety of life and health, controlling the source, and containment. If the Incident Commander can accomplish these tasks early in a response, the chances for success are very good. If the source cannot be controlled and the product that has spilled or has a potential to spill cannot be contained, the chances for success drop dramatically. Pollution response recovery equipment theoretical and wave tank testing efficiencies have reached over 70%. Historical field data show that these test results are very high and actual recovery rates average only 20%. The primary reason for this small recovery rate is because the environmental conditions are usually at their worst when the marine casualty occurs.

Pollution response to leaking vessels concentrates on containment and stopping the release of oil. This is accomplished by:

1) patching the leaking tank(s),
2) transferring the contents of the damaged tank to another tank within the vessel using the vessel's installed transfer system, pumping down the

product level in the holed tank(s) and allowing water to enter the tank and create a "water bottom," or

3) removing the contents of the tank(s) from the vessel (lightering) to another vessel or temporary storage facility ashore.

From 1997 to present, the U.S. Coast Guard National Strike Force (NSF) responded to three major oil spills involving foreign freight vessels grounding which required the removal of highly viscous oil using various lightering equipment and systems. The biggest challenge to lightering viscous oil from a freight vessel occurred in February 1999, when the NEW CARISSA grounded off the Oregon coast near Coos Bay. The empty bulk wood chip carrier grounded approximately 4,400 meters in a high surf zone and slowly drifted toward a sandy beach with approximately 1,500 cubic meters of No. 6 heavy fuel onboard. Adjacent shorelines are habitat for the Snowy Plover, a bird protected by the Endangered Species Act. The vessel was consistently pounded by 5-8 meter waves and swells, endured 25 to 45 knot winds with gusts up to 70 knots, drenched with frequent rain and sleet, and impacted with 8-10 knot currents. Within four days of grounding, the vessel's material condition rapidly deteriorated with several fuel tanks holed or tidaled. Sea chest valves were clogged with heavy silt. The vessel rolled on its keel up to 20 degrees on each side. By the time the first salvage tug arrived on scene, the seas were too rough to get close enough to attempt to pull the vessel away from shore and the vessel drifted another 200 meters closer to shore. No tugs or tank barges could be moored alongside to attempt lightering the vessel. The only mitigation alternative was to burn the oil onboard the vessel. Six days after the vessel grounded, the oil was burned onboard the vessel. After the first successful burn, the vessel broke into two pieces.

Photo by PA1 Brandon Brewer

Coast Guard helps avert environmental catastrophe after the bulk carrier New Carissa ran aground February 4, 1999, one mile north of Coos Bay, Oregon and began to leak oil. The ship's remaining fuel was intentionally ignited to help prevent nearly 400,000 gallons of oil from reaching the shoreline. USCG photo by PA1 Brandon Brewer.

When burning oil onboard was no longer feasible, a survey team boarded the bow section and discovered approximately 529 cubic meters of fuel still remained onboard in the double bottom fuel tanks. By this time, the bow section was accessible from shore at low tide and was dangerously close to the Snowy Plover nesting areas. Two large salvage tugs with stronger tow lines were enroute to the vessel. With a three day forecasted break in weather and no other mitigation alternative available for eliminating the environmental risk, the Unified Command decided to attempt lightering the vessel.

Commercial and U.S. Navy Supervisor of Salvage (NAVSUPSALV) lightering equipment was available, but work crews were at least 1.5 days away. The U.S. Coast Guard NSF was granted permission to bring a work crew and equipment on scene to lighter the vessel. By this time, the oil onboard had cooled to 7 degrees Centigrade. Using the Cameron Hydraulic Handbook (published by Ingersoll-Desser Pumps), the viscosity on the No. 6 fuel oil was close to 200,000 centistokes. The crew struggled under a short time period to remove the oil before the winter storms returned to the area. Despite working in gale winds and pounding rain, the crew successfully removed approximately 415,800 liters of oil/water mixture from the vessel, and greatly increased the vessel's reserve buoyancy. U.S. Coast Guard DESMI 250 pumps were used with an in line booster pump with NAVSUPSALV's new six inch hose, and pumped the oil/water mixture over 200 meters to shore.

A few days later, the vessel was successfully pulled off the beach and headed out to sea. Relationships between Coast Guard and commercial contractors were strained during this stressful evolution. Misunderstanding between parties concerning who was in charge, and roles and responsibilities of each party sometimes hindered progress. A third of the crew had spent the night onboard when helicopter support was not available due to weather conditions. By the third day, most of the crew was exhausted due to lack of sleep, and the effects of stress. Tempers and emotions flared as each party attempted to work as a cohesive integrated lightering team. But this integrated approach broke the current paradigm that either U.S. Coast Guard runs the operation with their people and equipment, or commercial contractors ran the operation with their own people and equipment.

Most of the crew had not pumped viscous oil before, but had used the gear in training with water, or during lightering operations with light oils. U.S. Coast Guard personnel were deeply disappointed that the oil was not removed as expected. With inclement weather, lack of other resources readily available, limited logistical support, conflicts coordinating the response with commercial resources, and fighting time against further environmental damage and winter storms, the crew did the best job they could.

In the Federal On-Scene Coordinator's report (Volume I, Section 4), the emphasis of strengthening the U.S. salvage capability was strongly noted. There were only two salvage vessels on the Pacific Coast capable of re-floating a large deep draft vessel, and neither was readily available until several days after the grounding. This crisis may have been mitigated if an "adequate and timely salvage capability" had existed.

In response to the lessons learned and the concerns addresses by the Federal On-Scene Coordinator, two workshops were held in partnership with industry and NAVSUPSALV to:

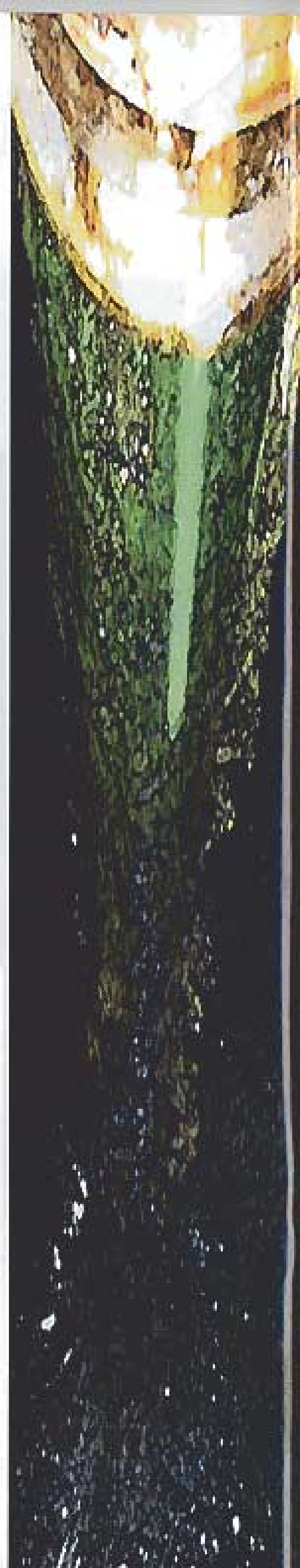
a. bring together knowledgeable individuals and field personnel (experienced or not),

b. share information and learn how best to lighter viscous oil, and

c. provide real world training and experience that would lead to major improvements in the Coast Guard, Navy, and industry's salvage, lightering, and viscous oil pumping capability and readiness.

Each workshop included classroom and lecture components, oil pumping and testing, equipment repair and training, and equipment decontamination and demobilization practice. Equipment used was pulled from existing Coast Guard, Navy, and industry inventories. Designers, manufacturers, suppliers, and users attended in partnership and team building.

The 13th Coast Guard District and Clean Sound Cooperative sponsored the first workshop. It was called the Pacific Northwest Viscous Oil Pumping Workshop and was held 13-17 September 1999 at the Chevron Asphalt Plant in Edmonds, Washington. Chevron offered the gravel lot on their asphalt plant



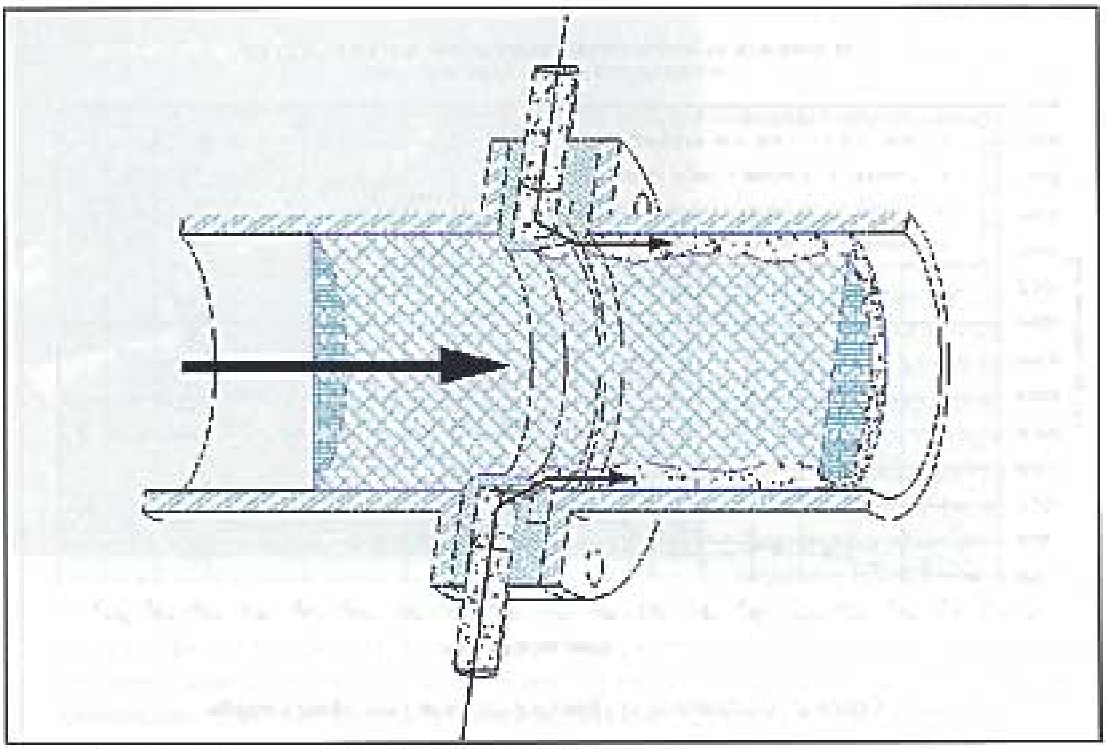


Figure 1. Heavy Fuel Oil is shown flowing through center with water injected through an annulus along the wall

facility in Edmonds, Washington, for the test location, and 64 cubic meters of asphalt/kerosene mixture for test product. Clean Sounds Cooperative provided logistical support and classroom facilities.

Coast Guard Headquarters Ocean Engineering Division sponsored the second workshop. It was held at the U.S. Mineral Management Service OHMSETT facility in Leonardo, New Jersey, from 12-17 November 1999. An additional objective of this test was to train more NSF and industry personnel with viscous oil pumping equipment with and without the water flange injection systems provided by NAVSUPSALV and FRAMO installed. Various lengths (100, 250, and 400 meters) of standard U.S. Coast Guard fuel oil transfer hose (six inch lay flat) were used to define systems capabilities and limitations. The viscosity of the oil ranged from 15,000 to 30,000 centistokes.

The results from both tests demonstrated the effectiveness of the water injection assisted transfer system as shown in Figure 1. The workshops successfully simulated a transfer operation which required moving a viscous Heavy Fuel Oil No. 6 from a grounded vessel 400 meters to shore using a DOP250, NAVSUPSALV or FRAMO water injection annulus and six inch lay flat transfer hose outfitted with HYDRSEARCH fittings. The system did not leak and the fittings held even as the hose rotated and flexed to match the gradually increased water and oil flow rates. The maximum discharge flow rate (100 cubic meter per hour) was achieved at a very low 620 KPa (90 psi) system pressure. For all tests at all distances, the system pressures are all between 10:1 and 14:1 times less than what would be expected if pumping without water injection. The optimum injection rate achieved was in the range of 5.5% during the last series of testing (see Figure 2, next page).

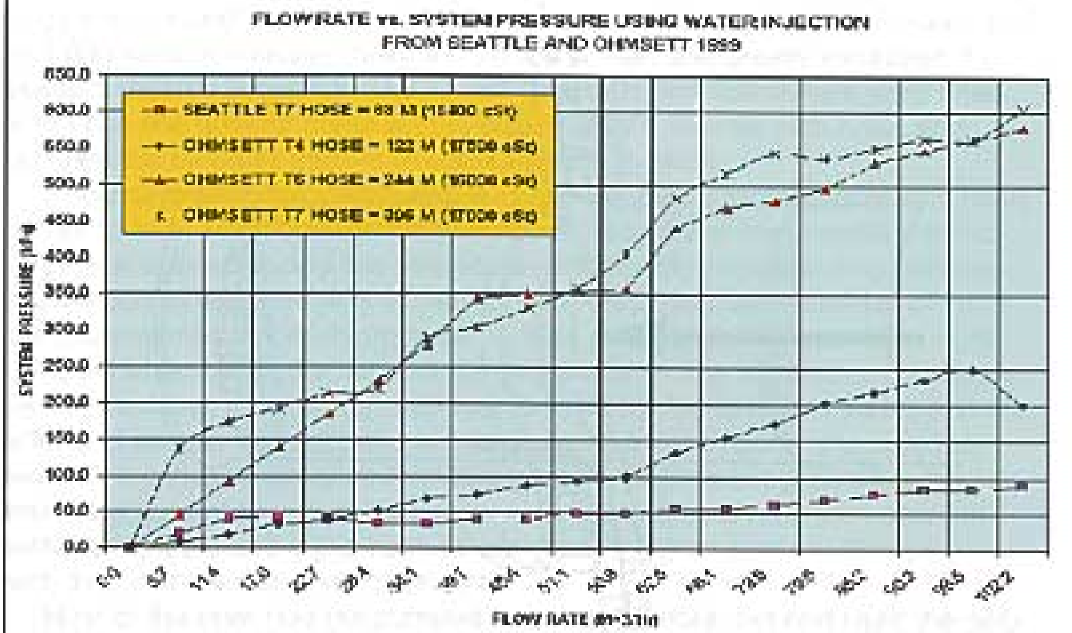
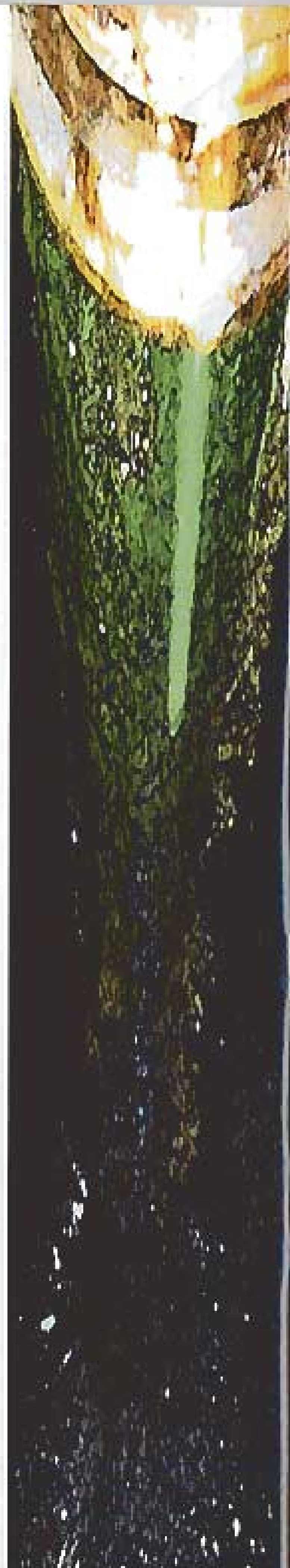


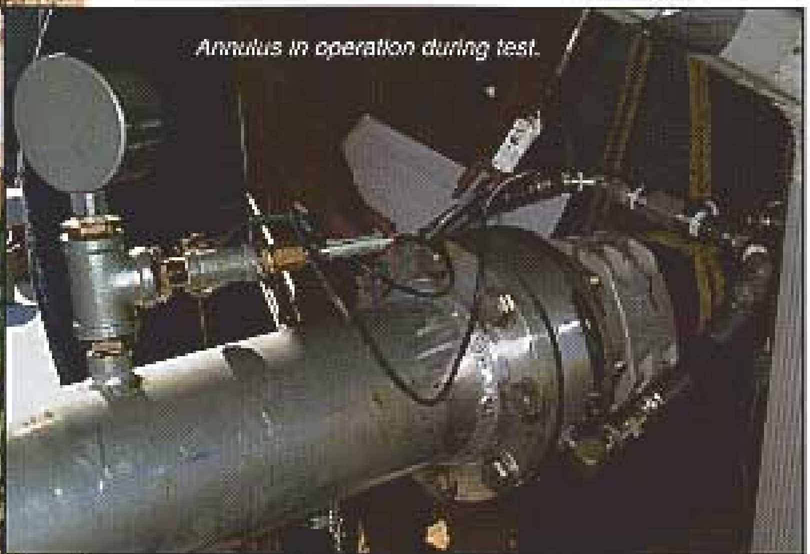
Figure 2. Comparison of Pressure Drops at Four Hose Lengths

From these workshops, we have been able to improve the U.S. Coast Guard, U.S. Navy, and industry's viscous oil pumping capability at minimal costs and without significantly increasing our existing inventories. The addition of water injection significantly increases the distance and quantity that a very viscous product can be pumped. Additional operational procedures were developed such as (1) ensuring that the water is injected first through the hose to pre-lubricate the system prior to pumping the oil and (2) bringing up the oil discharge flow rate gradually so as not to choke the water injection annulus from excessive back pressure.

The results were astonishing. The friction loss was decreased by a 10:1 ratio per 30 meters of hose at the full pumping capacity of 100 cubic meters per hour using a very small amount of water (between 4% and 6% by volume of oil pumped). The pressure dropped from the starting pressure to the operating pressure with the water injection system by approximately the same ratio. We need to verify through additional testing, but we think that the same flow rate can be maintained by ten times the test length, the pump rate can be increased by ten times the original pump rate for any given pumping distance, and a smaller prime mover can be used to transport the same volume of oil. This method would prove invaluable for pumping high viscous oil through long hose lengths.

Another success noted during the test was the use of HYDRASEARCH fittings vice the standard camlock fittings. The fittings did not leak during the entire test withstanding pumping pressure above 1,000 kPa (150 psi). The camlock fittings had a maximum rating of 520 kPa (75 psi). The HYDRASEARCH fittings allowed the hose to flex and roll as the pressures and flow rates were varied without having to break the seals to hand rotate the fittings as had been the practice when using hose outfitted with camlock fittings.

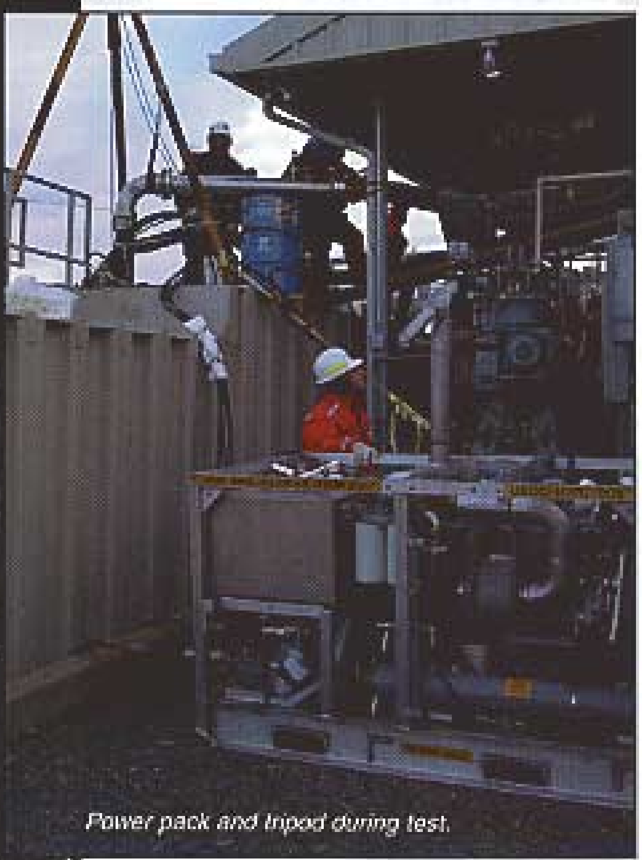




Annulus in operation during test.

Holding joint U.S. Coast Guard, U.S. Navy, and industry-wide partnership workshops is extremely valuable in improving our capabilities, increasing the knowledge of our personnel, and in reducing costs. Using viscous oil instead of water proved invaluable. Everyone learned more about their equipment's capability for pumping viscous oil with information shared equally by all. Better appreciation for wearing personnel protective equipment, then decontaminating personnel and equipment each day will assist in planning the logistical support requirements for viscous oil operations. We were able to increase our confidence level to jointly pump oil up to 50,000 centistokes that may be the difference between future failure or success.

Exceptional input and feedback was gathered from the U.S. Coast Guard, U.S. Navy, and industry field personnel who participated which suggested more tests with water injection flange through longer lengths of hose and at higher viscosities (100,000 and 200,000 centistokes) are desired.



Power pack and tripod during test.

Outstanding issues to be resolved:

Are booster water injection annuli needed to extend the range? How would a booster pump be added to the system to extend the range? Or is it best to just use intermediate transfer stations? What is the shape of the water ring after 400 meters? Is it a solid ring or column, or is the oil starting to press up against the wall at intervals as is suggested by some lab core annular flow analysis in the past? How much farther can the ring maintain itself and does this distance vary with increased viscosities? Operational procedures and job aids for various scenarios are needed by on scene response personnel from the U.S. Coast Guard, U.S. Navy, and industry to facilitate quick and effective decisions in the early hours of a crisis minimizing confusion and chaos. Future workshops will look into improvements in portable heating systems and practicing real world applications on freight

and passenger vessels that use large amounts of heavy fuel oil as their primary fuel source.

1,300 feet of transfer hose during test.

Within two weeks after the second workshop and before the 1999 winter season hit, the first water injection enhanced system (consisting of water injection flange with a water injection pump, hydraulic hoses, fittings, hard pipe with pressure gauge and 400 meters of hydrotested six inch oil transfer hose with HYDRASEARCH fittings) was received by the Pacific Strike Team. The Atlantic Strike Team and Gulf Strike Team received their new systems in May and June of 2000.

Many people have invested a lot of time, money, and energy into developing the Viscous Oil Pumping System. The following organizations and people have played a key part in this success story:

U.S. Coast Guard Headquarters (G-SEC-2)
U.S. Coast Guard Headquarters (G-MOR-3)
Thirteenth U.S. Coast Guard District (m)
U.S. Coast Guard National Strike Force Coordination Center
U.S. Coast Guard Marine Safety Office Puget Sound Prevention Division
U.S. Coast Guard Pacific Strike Team
U.S. Coast Guard Atlantic Strike Team
U.S. Coast Guard Gulf Strike Team
Canadian Coast Guard Pacific/Yukon Region
U.S. Navy Supervisor of Salvage and their engineering support contractor PCCI-GPC
U.S. Mineral Management Service and their engineering support and OHMSETT Facility Management contractor MAR, Inc.
Frank Mohn Houston, Inc.
Frank Mohn Flatoy As Oil & Gas Division
Mr. Fleming Hvidbak, Fleming Co

Heavy fuel oil is shown at full flow with a tube of water surrounding the oil.

Mr. William Nelson, University of Alaska
Hyde Products, Inc.
RO-Clean DESMI A/S
Marine Pollution Control
SINTEF
International Belt & Rubber Supply, Inc.
Case Marine, Inc.
Penco Pacific Environmental Corporation
Chevron
Clean Sound Cooperative, Inc.
Alaska Clean Seas
Alyeska Pipeline Service Company (SERVS)
Clean Islands Council
Clean Seas Cooperative
Clean Harbors Cooperative
Marine Spill Response Corporation
FOSS Environmental Services
Spiltec
Global Environmental Services
Cowlitz Clean Sweep
Delaware Bay and River Cooperative, Inc.
Burrard Clean Operations
Eastern Canada Response Corporation
Titan Maritime Industries, Inc.
Marco Pollution Control

FINAL NOTE: During the 1999-2000 Christmas and New Year's holiday season, the Coast Guard Atlantic Strike Team (AST) responded to a rail car derailment in Maine at the request of the Environmental Protection Agency Federal On Scene Coordinator (FOSC). Four rail cars had fallen over an embankment and into a frozen lake. Each rail car carried 26,000 gallons of Heavy Fuel Oil No. 6. The cars reached their final resting spot alongside the embankment at a depth of 50 feet. Air temperature on the surface was 20 degrees F with wind chill down to 0 degrees F. Water temperatures hovered around 32 degrees F. Cold water divers had to break through the ice and then cut holes into the rail cars to gain access to the oil. A response rail car brought support lodging, food, boilers, and hydraulic prime movers. Using the knowledge gained at the two workshops and with the outstanding cooperation of the FOSC and the responsible party (the railroad owner), the AST representative was able to effectively recommend the use of DESMI DOP-160 positive displacement screw pumps vice diaphragm pumps originally provided. The DOP-160 is a smaller version of the DOP-250 used in the workshops and could fit into the rail car holes. To assist the pumping, the divers used steam lances to inject steam into the cars. To reduce heat losses, the response personnel ingeniously used increased the normal DOP-160 3-inch diameter discharge hose by adding 4-inch then 6-inch diameter flexible hose sections in 20 foot increments. Discharge flow rates increased from 11,000 gallons in three days with the diaphragm pumps to 26,000 gallons per day. The fast response and lightering time ensured that the oil did not have time to cool and become very viscous and no oil was released into the environment. ■