

4.0 JVOPS WORKSHOP PROJECT BACKGROUND

The JVOPS Workshop was the culmination of a series of workshops and tests by Government and Industry that had one overall objective to make it possible to do what no response operation ever had accomplished: to pump transfer high and extremely viscous oil in an operational way, over operational distances, and at operational pumping rates.

Visionary individuals within the US Coast Guard, Canadian Coast Guard, and Industry teamed up to make this happen, supporting the project with funding and by making the required working hours available to the project.

4.1 JVOPS Workgroup Members

The decision forum in preparations for the JVOPS workshop in December 2003 was the JVOPS Workgroup, which consisted of a core group of 7 individuals:

Commander Michael D. Drieu
Chief of Response (mor)
US Coast Guard District Eight

Ron MacKay
Senior Response Officer, Charlottetown
CCG Rescue, Safety and Environmental Response

Lieutenant Commander Peter C. Nourse, PE
Special Projects Officer
USCG Response Systems Team

Craig O. Moffat, Project Engineer
GPC/PCCI ESSM Base
Williamsburg, Virginia, USA

David Cooper, P. Eng, Senior Project Manager
Science Applications International Corp.
Ottawa, Canada

Jim Mackey, Vice President
Hyde Marine, Inc.
Cleveland, USA

Flemming Hvidbak, JVOPS Lead Engineer
flemingCo environmental
Denmark

The core JVOPS Workgroup had weekly or bi-weekly telephone conferences of one to two hours during the 18 months leading up to the December 2003 testing and had meetings face to face at several occasions. The meetings often had participation by pump manufacturers that would be involved in the testing with their equipment and other individuals from the US and Canadian Coast Guards and Industry, who had interest in the project.

4.2 JVOPS Workgroup History Summary

Originally, late 2001, the workshop had been intended to take place at the US Minerals Management Service oil and hazardous materials test facility (OHMSETT) in Leonardo, New Jersey. As of December 2001 some planning had already been done by the USCG, US Navy, and one of its contractors. The test was tentatively scheduled for the fall of 2002. In connection with the IMO R&D Forum in Brest, France, March 2002, an informal workgroup was formed and a different approach to the JVOPS testing came up with stringent viscosity control, a different oil-water separation concept, and a concept for limiting the amount of required test hose without compromising the amount of test runs.

In May 2002 the Canadian Coast Guard expressed its interest in joining the project and also in May the fifth VOPS workshop took place at Cenac Towing, Inc. in Louisiana. The facility in Houma had during that workshop proved very useful for testing and with the interest in the testing, as expressed by the facility owner, as well as the in kind services that could be provided to the project by the facility, there now was an alternative to testing at OHMSETT.

On June 19, 2002 the JVOPS Workgroup had its first telephone conference on the coming workshop. The JVOPS Lead Engineer was appointed and it was decided to have the Lead Engineer develop a new test strategy and test plan that would meet the combined requirements of the US and Canadian Coast Guards. It was also decided to go for the Cenac Towing Facility in Houma to host the workshop.

The further work of the JVOPS Workgroup will be described in Chapter 5, JVOPS Workshop Preparation.

4.3 JVOPS Workshop Goals

Below has been listed the JVOPS Workshop Goals or Top Level Requirements (TLR) as defined by the US and Canadian Coast Guards with the approved adjustments made by the JVOPS Workgroup:

- a. Determine the maximum operational pumping distance possible for USCG, CCG and industry pumps to pump viscous oil or bitumen at approximately

- 200,000 cSt when assisted by the most optimal water lubrication technique available, without bulk heating. Maximum pumping distance considered will be 450 m / 1500 ft.
- b. Perform the same as in point a with a bitumen or bitumen like product of about 500,000 cSt. Maximum pumping distance to be tested will be 150 m / 500 ft.
 - c. Investigate the use of inlet water lubrication vs. discharge lubrication for USCG, CCG and industry pumps. Perform test trials with variation of inlet and discharge configurations, separately, and in conjunction. Consider use of steam or hot water via standard VOPS AWIF and flemingCo inlet water injection device. The goal was to determine optimal combination of lubrication for USCG and CCG equipment based on viscosity and pumping distance.
 - d. Investigate percentage of water lubrication required for varying pumping distances. Determine the minimum water lubrication percentage(s) required for pumping distances up to 1500' with 200,000 cSt oil. Determine for the optimal lubrication device configuration.
 - e. Investigate area of local bulk heating with existing CCG and U.S. Navy steam systems such as steam boilers and coils.
 - f. Test a revised design of a discharge side Annular Water Injection Flange (AWIF) with heated water and hot water
 - g. Investigate the reestablishment of water lubrication following system shutdown.
 - h. Verify pump supply pressures and flows to determine pump HP efficiency envelopes for DOP 160 and DOP 250 pumps to provide indications as to when HP should be increased on a product viscosity and pump distance basis.

4.4 JVOPS Test Plan – How to Meet the Goals

The JVOPS Test Plan is presented in Appendix N of this report. However – for the ease of reading – the key principles and methods to meet the JVOPS TLR have been listed below (please note that the Test Plan operates with Table 1, Table 2, etc. for each test series. However, to avoid confusion with other tables in the report context, this has been changed to Test 1, Test 2, etc.):

TLR Target a: Long distance testing with 200,000 cSt oil up to 1500 ft:

Long distance testing on 200,000 cSt oil will only be planned for a USCG DOP-250 pump c/w inlet and outlet lube flanges (Test 3). Before the long distance testing, a pre-testing (Test 0) on 100 ft 6" hose sections with a Heavy Fuel Oil (HFO) or heated

bitumen of maximum 50,000 cSt will determine the best annulus ring water injection flange (AWIF, new or old). A second pre-testing on 200,000 cSt oil (Test 1) will determine the best alternative of steam/hot water, tempered water, or cold water, inlet- and outlet lubrication combination.

A series of 300 ft test runs (Tests 2 and 4) will determine the performance relationships between the primary USCG test pump, DOP-250, and the USCG DOP-160, CCG GT-185, and participating Industry pumps when applying their respective water lubrication systems in the most optimal configuration. It will further determine the relationship between the most optimal (and probably most heat requiring) lubrication method and the best lower heat requiring method (may be preferable from an operational point of view).

The series of 100 and 300 ft test runs with the primary test pump will determine the degree of proportionality as to pump pressure requirement when increasing hose length and if lube water percentage must be increased for increased hose length. These findings will – after the long distance pump test with the DOP-250 – be used to calculate the long distance performance of USCG DOP-160, CCG GT-185, and participating Industry pumps on 200,000 cSt oil when applying best lubrication method and for Industry pumps also when applying manufacturers' recommended method (if applicable). All pumps will further be baseline tested without any flow enhancing technique applied.

In addition to the above, a further series of 100 ft testing will seek a clarification on the influence of lubrication with tempered water (same or slightly higher temperature than the pumped oil) vs. cold water (significantly colder than the oil). In many emergency lightering situations the response is initiated at a time where the oil is still warmer than the water in the surrounding sea. Responders may "shoot themselves in the foot" if it turns out that cold sea water used for hose lubrication significantly limits pumping performance. The comparative testing will determine if better performance can be obtained by adding some limited heat to the lube water (just to a level where it is not colder than the oil).

TLR Target b: Long distance testing with 500,000 cSt oil up to 500 ft:

Long distance testing on 500,000 cSt will only be planned for a CCG GT-185 pump c/w inlet and outlet lube flanges (Test 7), however, a GT-260 c/w AWI flanges, hoses and HPU will be kept ready for testing in case the GT-185 does not perform according to a defined minimum operational rate. Before the long distance testing, some pre-testing on a 50 ft 6" hose section (Test 5) will determine the best hot water inlet/outlet lubrication combination. (Previous testing at SAIC Canada/Environment Canada's test facility in Ottawa, February 2002 had verified that the GT type pumps perform best on extreme viscosity oil when hot water lubrication is applied on both inlet and outlet, but the optimal lube water percentage has not yet been found). The 500,000 cSt testing will use hot water for injection in all test runs that involve water lubrication.

A series of 100 ft test runs (Tests 6 and 8) will determine the performance relationships between the CCG primary test pump, GT-185 and participating USCG DOP-250, CCG

GT-260, and Industry pumps when applying their respective water lubrication systems in the most optimal configuration. All pumps will further be baseline tested without any flow enhancing technique applied.

The series of 50 and 100 ft runs will determine the degree of proportionality as to pump pressure requirement when increasing hose length and will determine if lube water percentage must be increased for increased hose length. These findings will – after the long distance test with the GT-185 – be used to calculate the long distance performance of USCG DOP-250, CCG GT-260, and Industry pumps on 500,000 cSt oil when applying best lubrication method, and for the participating Industry pumps also when applying manufacturers' recommended method.

TLR Target c: Testing the flemingCo inlet water/hot water AWIF vs. the standard USCG VOPS outlet AWIF and optimize water lube configuration for USCG and CCG pumps

Previous testing in Denmark and Canada verified the positive influence of inlet side water injection as long as the lube medium was steam or hot water. The 100 and 300 ft test series on 200,000 cSt oil will significantly detail the influence of inlet side vs. outlet side water injection, both for hot and tempered (cold) water. The tests will also determine whether a combination of both inlet and outlet side injection would be the most optimal and at which water injection percentages in relation to the oil pumping rate. A DOP-250 pump equipped with inlet and outlet lube flanges will be used for these tests.

TLR Target d: Determine relationship between pump transfer distance and lube water %

The series of 100 and 300 ft test runs (Tests 1 and 2) on 200,000 cSt oil will give an indication of whether the lube water percentage must be increased for increased hose length. However, since the annulus water ring may degrade or collapse only after the oil has been pumped over an even longer distance, the long distance testing up to 1500 feet (Test 3) will be used for a verification of the distance factor. A DOP-250 pump equipped with inlet and outlet lube flanges will be used for these tests.

TLR Target e: Determine the influence of Bulk Heating on pump transfer rate

In this context Bulk Heating will be understood as local heating of the bulk of oil adjacent to / in front of the pump intake (throughout this document referred to as "Local Bulk Heating") and not as heating of the total amount of oil in the test tank

The influence of Local Bulk Heating will be tested in separate testing at both test lines (200,000 and 500,000 cSt) after the completion of the test series involving water lubrication only.

Bulk heating alone, and in combinations with water lubrication, will for a USCG DOP-250 pump be tested on 200,000 cSt oil in 300 ft test runs (Test 9) and for a CCG GT-185 pump on 500,000 cSt oil in 100 ft test runs (Test 10). The use of the same baseline test hose lengths, as for the tests with only water lubrication, allows for calculations, which will provide a comparison between long distance pumping performance with best

water lubrication only method, local bulk heating/water lubrication combination, and local bulk heating only. The 300 ft baseline tests with no aid from any flow enhancing technique will further allow for a determination of the overall performance improvement factor (PIF) for each individual flow enhancing technique applied, and for combinations of them.

TLR Target f: Test of a revised design AWIF

The present discharge side AWIF in the USCG VOPS has been questioned as to even distribution of the injected water. A new AWIF has been designed, which should overcome this problem (if it is a problem). Which flange is the better will be tested in connection with the 100 ft pre-testing, using a HFO or heated bitumen with a viscosity that is low enough (max. 50,000 cSt) to ensure that the in-flow to the pumps is not the limiting factor (Test 0). Two DOP-250 pumps will be used for this testing, one equipped with the new AWIF and one with the old.

TLR Target g: Reestablishment of water lubrication following system shutdown

Bitumen pumping tests at DESMI, February 2001, conducted by flemingCo, required several re-starts after system shutdown. The viscosity was in excess of 3 million cSt, especially in the mornings after having left the bitumen filled hose for the night on the ground, subject to low temperatures. As it was observed a number of times during these bitumen pumping transfer tests, the steam/HW injection at the pump's flemingCo inlet injection flange facilitated re-start: By injecting the steam/HW while running the pump at low RPM – just enough to pump more than what flowed back (water) through its inner leaks – the hot water could “drill a hole” in the massive plug of product in the discharge hose.

Simultaneously, the part of the hot water that eventually back-flushed from the pump, heated up and liquefied the product located adjacent to the pump inlet. Therefore, gradually the transfer process could get started again. Slowly but surely the new and warmer and wetted product in the discharge line would “drill the hole” bigger, thus bringing the transfer operation back on track.

The referred re-start tests were made with 20 m (67 ft) of 6” hose only and nevertheless required several minutes of “drilling” before the product started moving again. It is therefore unknown on how long hose sections the method will work. It is also unknown if there is a difference between having lubricated with hot or cold water prior to the shutdown.

TLR Target (g) will therefore initially only be met on an emergency basis; for instance at unintended shutdowns during pre-testing with 100 and 300 ft hoses (200,000 cSt), respectively 50 and 100 ft (500,000 -1 million cSt). Time permitting, this could, prior to the local bulk heating tests, be expanded to longer distances. In all cases the relevant pressures, flows, injection rates, temperatures, and duration will be registered for later evaluation.

It should, especially for the 500,000 cSt tests, be expected that blocked hoses, for the sake of saving time, must be pulled aside and be replaced with new or properly cleaned hoses.

TLR Target h: DOP-160 and DOP-250 power requirements vs. viscosity and distance

The data acquisition (hydraulic pressure and flow) from the pre-testing and baseline testing (Tests 0, 1, and 2) and their relationships with the long distance test results (Test 3) will form the basis for a calculation of the power requirements vs. distance and viscosity for the most optimal water lubrication method. However, results from previous USCG VOPS testing should be compared with the new results in an attempt to form a more detailed picture of the influence of the viscosity on HP requirement, when water lubrication is successfully applied.

5.0 JVOPS WORKSHOP PREPARATION

The early preparations for a USCG and Industry VOPS Workshop had been going on for about a year prior to the introduction to a different method of testing (Initial workgroup meeting in Brest, France, March 2002). A couple of possible test venues had already been considered. The problems getting a suitable test oil had at that time not yet been recognized as a problem, and test dates as early as fall 2002 were planned. After the involvement of the Canadian Coast Guard in spring 2002 the workshop was renamed to the Joint Viscous Oil Pumping System workshop (JVOPS) and the JVOPS Workgroup was formed in June 2002.

Please see APPENDIX C. JVOPS Workshop Planning Summary.

5.1. Test product

In 2001, when the first considerations on the 6th VOPS workshop started, the most problematic oil spills in recent years had been marine incidents that involved heavy fuel oil. In the early preparations for the sixth viscous oil pumping system workshop it was therefore expected that it would be a matter of getting No. 6 heavy fuel oil as test oil and then chill it to the desired test viscosity. As will be described in the following sections the workgroup faced severe difficulties finding an appropriate oil for testing. Furthermore, test location, costs of the oil, and the time of the year that the testing would be carried out came to play an important role.

5.1.1 Initial Test Product Options

In the months following the decision on a revised workshop approach (fall 2002) the JVOPS Workgroup worked with different options. The potential test facility, Cenac Towing, suggested a Carbon Black product for testing, which would be conveniently available at the facility. Product samples were sent for analysis at SAIC Canada in Ottawa. The analysis indicated that the product might be suitable for USCG testing in the 200,000 cSt viscosity range under Louisiana winter conditions if moderate cooling could be applied, but would require significant cooling for the CCG testing at 500,000 cSt.

Since the CCG test viscosity requirements were based on the Canadian import of Orimulsion (derived from bitumen) from Venezuela it was therefore obvious to investigate the availability of bitumen. At the previous extreme viscosity tests in Canada and Europe the Venezuelan Orimulsion supplier, Bitor, had graciously granted test product to the projects. But as it appeared, Bitor was unfortunately not able to assist this time. Therefore the group focused on Canada who has a significant production of bitumen of its own, based on tar sand. Several sources for a 500,000 cSt test oil were unsuccessfully tried in Canada, Europe, and China until finally in March 2003 a company in Alberta, Japan Canada Oil Sands (JCOS), agreed to deliver (at market price) some of their heavy bitumen crude oil to the project.

In the meantime the search for a test oil that minimum would meet the USCG requirements went on. A source for Clarified Slurry Oil was found and samples were again sent to Canada where they were analyzed and found in the same range as the Carbon Black oil (70,000 cP @ 15 C). However, the most desirable product for the Workgroup would be a heavy fuel oil that would resemble the situation as to the viscosities in recent incidents like NEW CARISSA, PRESTIGE, and BALTIC CARRIER, namely 200,000 to 500,000 cSt at about 50 to 60 °F (10 to 16 °C). A number of oil companies and bunker suppliers were contacted in the US and the search even went as far as trying to get – via Finland – the Russian source oil from the recent heavy oil spills in Europe. In the US it was found that such very heavy fuel oil is not available and although it is available from Europe, the logistic and cost problems by shipping the relatively small amount of about 600 bbl / 100 m³ to the US for testing could not be overcome. Figure 4 shows the viscosity-temperature relationship of the oils that were found available in the US.

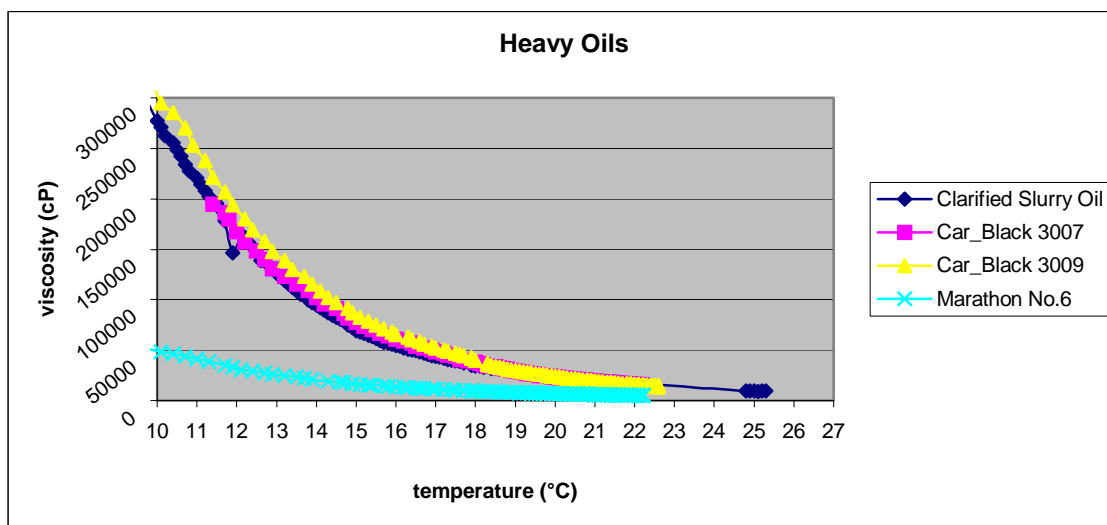


Figure 4. Possible US oil types for the USCG test section

After several months with confidence in the Carbon Black and Clarified Slurry oils they turned out not to be consistent from batch to batch as to viscosity. A significant variation could be expected and the Workgroup was concerned that none of these oils would meet the test plan requirements. This, combined with the search in vain for a suitable heavy fuel oil, made the Workgroup decide to use the same oil for both the US and Canadian test section, namely the JCOS bitumen crude oil. This oil would meet the USCG requirements at a temperature close to Louisiana winter months ambient temperatures and would require limited cooling to reach the CCG requirements.

Until one month prior to testing in December 2003 the lower viscosity section of the USCG testing (25,000 to 50,000 cSt) was still expected to be with a Carbon Black oil. The oil was even delivered to the test facility, but analysis at GPC/USN ESSM base in Williamsburg, VA, revealed a very high water content and a viscosity that was far below what had been specified. The supplier was therefore requested to remove the product.

This eventually led to the JVOPS Workgroup decision that all testing would be carried out using the Canadian JCOS oil. To meet the requirement for one test at a lower viscosity than the USCG main tests, a portion of the oil would have to be heated to about 100 °F / 38 °C.

5.1.2 JCOS Bitumen Crude Oil

The property chart with full information on the JCOS bitumen crude oil (whole crude) can be found in Appendix G. Initial analysis of samples of the oil indicated a higher viscosity than expected, however, a more in depth viscosity vs. temperature analysis revealed a pattern which can be seen in Fig. 5, which is the curve developed from the oil samples taken during the JVOPS Workshop. The viscosity characteristics would be very convenient for the workshop if the USCG target should be met in the Louisiana winter months, since the target temperature of 70 °F / 21 °C would be close to average ambient temperatures, but for testing in the warmer part of the year significant cooling of the oil would be necessary. The viscosity of approximately 500,000 cSt for the CCG test section would require an oil temperature of 61 °F / 16 °C, meaning reasonable chilling in winter months but significant cooling spring, summer, and fall.

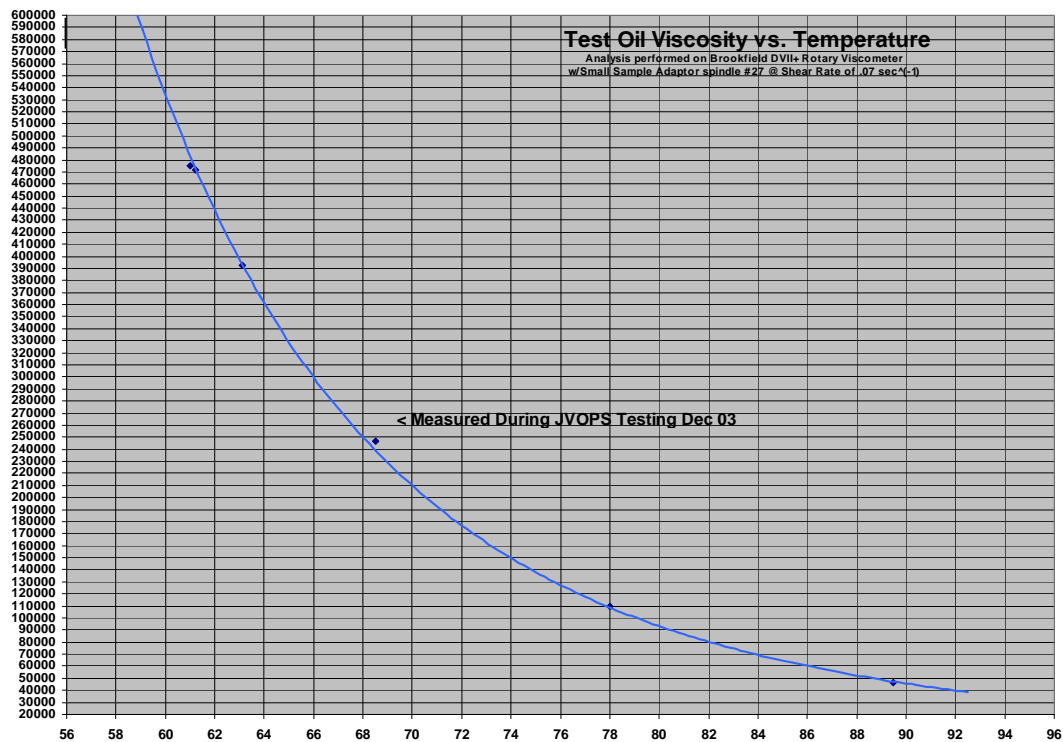


Figure 5 JCOS Bitumen Test Oil Viscosity vs. Temperature (Deg F). Prepared by GPC.

The JCOS oil has a higher density than fresh water. It is extremely sticky and therefore difficult to remove from contaminated surfaces. This sets specific requirements to the oil-water separation skimming equipment as used in these tests. The spreading of the product over the test site could be another issue. Finally decontamination of test hoses and equipment could be quite challenging.

5.1.3 Acquisition and Delivery

Under contract with the USCG, Navenco Marine in Montreal acquired 500 bbl of JCOS bitumen crude oil. The oil was shipped via railroad to Louisiana and three heated oil tank trucks handled local transportation to the test facility.

5.2 Test facility

There are a number of requirements to a test facility that must be met for an event like the JVOPS Workshop. Enough land space, heavy lift support, workshop services, nearby local suppliers of supplies and supporting equipment, an acceptance of the presence of extremely viscous oil on the property, road access for large and heavy vehicles, suitable ambient temperature conditions, and costs at a level that the project can handle.

5.2.1 Initial Test Facility Options

Before establishing the JVOPS workgroup in spring 2002 two potential test venues had been considered. The very first approach had actually been to do the testing at Marine Pollution Control, Inc. facilities in Detroit but this was disregarded after some time and the Minerals Management Service's test facility, OHMSETT, was the next choice. A test plan for testing at OHMSETT had been under preparation when the final decision – for reasons explained elsewhere in this report – was taken in favor of the offered test facility at Cenac Towing, Inc. in Houma, Louisiana.

5.2.2 Cenac Towing, Inc.

Cenac Towing is the fifth largest towing company in the U.S. and had offered the use of their facility as the JVOPS Workshop test venue and services in-kind. The company handles, as part of its activities, several different kinds of oil and waste oil and maintains a genuine, active interest in improving high and extreme viscosity oil pumping technology.

The Cenac property covers more than a dozen acres of land of which about 50 % is a nice well kept lawn. The workshop was granted the right to use the grass areas adjacent to the waterfront for setting up the test infrastructure including decontamination, storage, and welfare areas. Total test site area was 2 acres. Furthermore the facility would provide crane or cherry picker assistance whenever necessary as well as welding and machining that was required for a number of ad-hoc solutions or adjustments to equipment or structure.

5.3 Proposed Workshop Dates

The overall goals for the JVOPS Workshop were rather ambitious and there was consensus on not compromising on the viscosity targets for the test oil. Considering a testing strategy that required data acquisition to a degree that had not been applied in previous workshops, it was to be expected that some delays during the planning and preparation process could occur.

5.3.1 Pre-JVOPS Options

As mentioned earlier, in December 2000 there had been some planning on making a viscous oil pumping workshop jointly with Marathon Ashland Oil and Marine Pollution Control (MPC) in Detroit, January 2001. For various reasons this plan was abandoned. In December 2001, the testing was planned to take place in the fall of 2002 at the OHMSETT test facility in New Jersey.

5.3.2 JVOPS Workshop Postponements

With the revised approach to testing that was introduced in March 2002 and the Canadian Coast Guard joining the project in May 2002, as well as the introduction of the Cenac Towing facility in Houma as test venue, it was necessary to alter the dates for the JVOPS Workshop. Initial USCG target dates of November 2002 for the revised testing approach were postponed to January 2003. However, in September 2002 the severe difficulties obtaining suitable test oil caused a new postponement to March 2003. This was still the target until January 2003 when the Workshop first had to be moved to April / May 2003 and later in the month to early fall 2003. The availability of a suitable test oil was still pending and the construction of the custom built test tanks and other essential components for the test infrastructure were also critical.

In April 2003 the test oil had been found and the construction of tanks, water lubrication control stand (WLCS) and the swift hose add-on system (SHAS) were so well in progress that testing dates could be set to November 2003. In August 2003 the dates were in further detail determined to be the first two weeks of November. Formal invitations to interested participants within the international oil spill response community were sent out and there were made reservations for blocks of hotel rooms in Houma.

Unfortunately, in October it was necessary to postpone the Workshop to the first two weeks of December. The test oil had been delivered and was stored in the Baker backup tank for the USCG test line and in the CCG test tank. Concerns about sufficient cooling of the oil by ambient temperatures and tank side sprinkler cooling with bayou water, as well as continued delays with the construction and acquisition of essential testing equipment, had required this additional postponement.

5.3.3 Final Determination of Dates

Finally, on 13 October, the JVOPS Workgroup felt comfortable that the test oil target temperatures were under control. At that time it was estimated that approx. 90% of the heavy part of the testing infrastructure had been assembled at the test facility and that everything that was still required for a successful testing could be on site and integrated into the testing infrastructure in Houma in time for testing.

Revised notices were sent out stating the final Workshop dates with setup week from 1 through 7 December and testing from 8 through 15 December, 2003.

5.4 Participating Pump Manufacturers

One of the goals of the JVOPS Workgroup was to include in the workshop a wide spectrum of oil spill response pumping systems that would best possible cover what is represented among response organizations throughout the world. However, the number of pump systems, besides the systems of the US and Canadian Coast Guards, would have to fit into the available time for testing.

5.4.1 Initially Interested Companies

As of August 2002, Frank Mohn, Norway had expressed an interest in having their pumping system tested (besides the USCG and CCG pumps).

In September 2002 Lamor (Finland) signed up as interested in having a new PDAS pump tested. Lamor had in August 2002 acquired GT Pollution Control (UK) who at that time was manufacturing the GT-185 and GT-260 PDAS pumps.

In May 2003 the workshop testing was scheduled for November 2003, so requests for re-confirmation of participation were sent out to the pump manufacturers and other organizations that until then had expressed an interest in participation. Confirmations were received from Lamor and Framo. The preparation of the final test plan was at that time well in progress and the two manufacturers' pump systems were incorporated into the merged test timeline.

5.4.2 Final Participants

The manufacturers and pump types that would be participating in the JVOPS Workshop were finally determined:

- USCG standard transfer and lightering pumps, DOP-250 and DOP-160
- CCG standard transfer and lightering pumps, GT-185 and GT-260
- Framo, Norway, TK-125 double screw pump
- Lamor, Finland, GT-A 50 PDAS pump

5.5 Workshop Test Infrastructure

The JVOPS Workshop infrastructure covered an area of about 2 acres and involved numerous tanks, containment berms, containers, power packs, pumps, and specialized equipment. Please see Figure 6 for an overview of the layout and the main components.

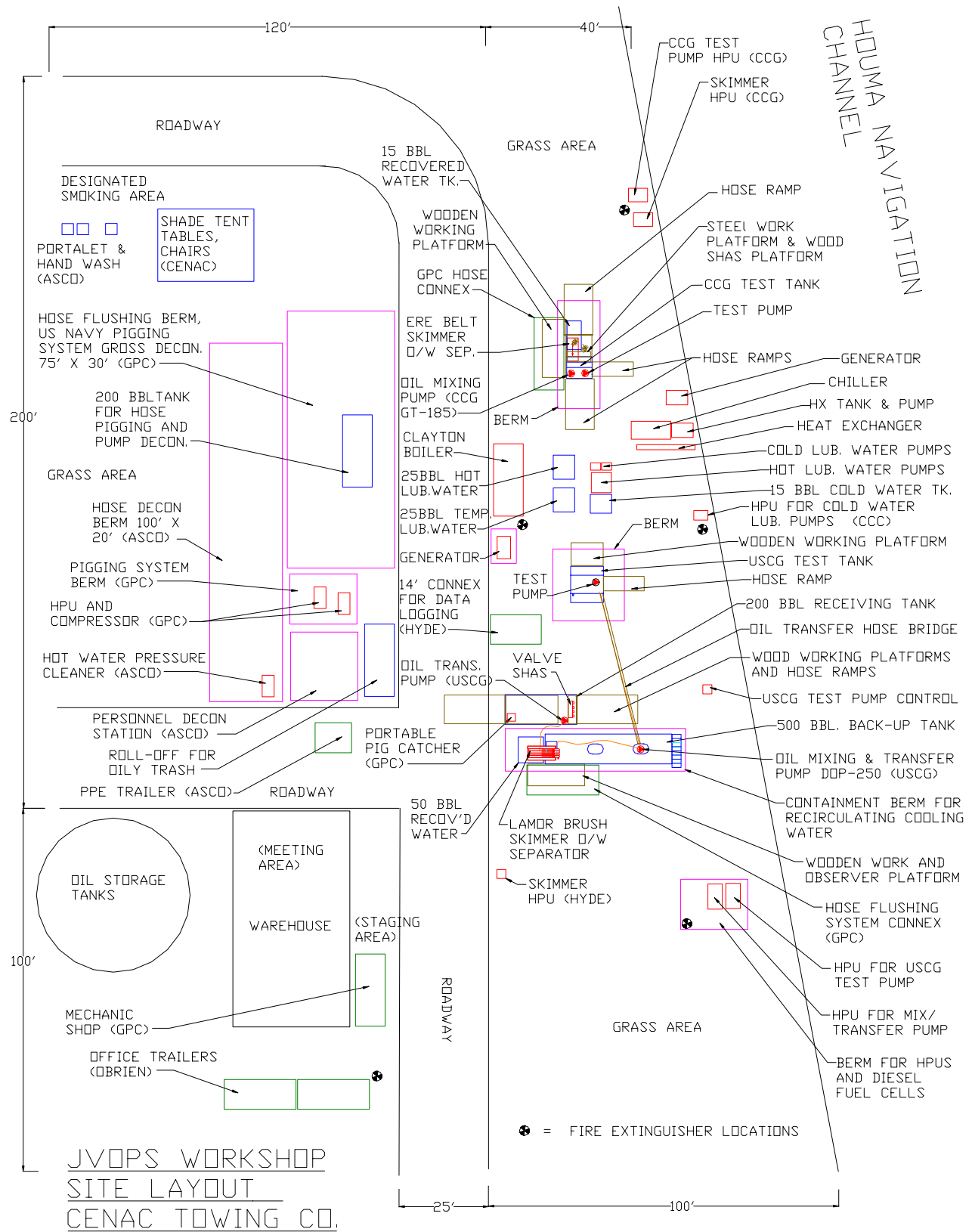


Figure 6. JVOPS Site Layout

5.5.1 Test Tanks

The two test lines (USCG and CCG) had each its own test tank, which was custom built for this specific testing. As detailed in the Technical Approach Strategy (TAS), the tanks had been designed to hold enough oil for the required tests and were shaped so that the submerged test pumps would have a level of oil over the intake to ensure an ample supply for even the longest test runs. The width of the tanks allowed for two pumps submerged in the test oil simultaneously. The tank tops were fitted with detachable gratings, which would ensure a safe work platform for the test teams while at the same time offering sufficient openings for pump deployment.

The USCG test tank (Fig. 7) could contain 120 bbl / 20 m³ of test oil. The tank had two tapered sides towards the bottom, which would ensure that least possible volume of oil would be below the intake and unavailable to the test pumps. The test oil would not be recirculated back to the test tank during testing, but would be delivered to a 200 bbl buffer tank, from where the oil and lube water mixture between testing would be transferred to the 500 bbl Baker backup tank via an oil/water separating brush skimmer. Therefore the test tank was not equipped with baffles. The tank was designed by the JVOPS Workgroup and had been manufactured by All Fabrications Inc., Houma, Louisiana under contract with CCG.



Figure 7 USCG Test Tank

The CCG test tank (Fig. 8) could contain 60 bbl / 10 m³ of test oil. The tank had one tapered side towards the bottom, which would ensure that least possible volume of oil would be below the intake and unavailable to the test pumps. Due to the expectedly lower pumping capacities on the higher viscosity oil used in the CCG test line the test oil from the CCG test tank would be recirculated back to the test tank during testing via a belt skimmer placed on the tank top. The skimmer would separate oil and lube water and deliver the test oil back to the test tank. The water would run off into a water receiving tank placed next to the test tank. To avoid re-use of already pumped and

possibly heated oil the tank was equipped with a baffle system in the used oil receiving section. The baffles could hold about 30 % of the total tank volume and would prevent immediate mixing with the (colder and higher viscosity) oil that had not yet been used. Viscosity adjustments (chilling or heating) to the oil in the test tank would take place between tests. The tank was designed by the JVOPS Workgroup and had been manufactured by All Fabrications Inc., Houma, Louisiana under contract with CCG.



Figure 8 CCG Test Tank with Sun Protection Tarp, ERE Oil-Water Separating Belt Skimmer, and Tank For Separated Water

Both test tanks were during the prep week thermal-reflective insulated with two-side aluminum reflective bubble plastic sheet.

5.5.2 Oil Backup- and Buffer Tanks

440 bbl of the total test oil volume of 500 bbl had been assigned to the USCG test line and 60 bbl to the CCG test line. As mentioned in the previous section, the CCG test tank would be used for both storage and testing. Viscosity adjustments (chilling or heating) would take place between tests.

Since the USCG test tank would not be receiving the used test oil, the oil was pumped to a 200 bbl buffer tank (Fig. 9). This tank would contain all oil and water used during a test. The 200 bbl buffer tank was of the open top container type with a large footprint vs. height and had to be lifted at one end to make it easier for the contained oil to flow to the DOP-160 pump that was used for transfer to the backup tank.

There were two reasons for using a buffer tank instead of pumping the test oil directly to the backup tank. These became apparent during the setup week from 1 to 8 December:

1. The Swift Hose Add-on System (SHAS) had been planned to be placed on the top of the backup tank. However, while on-site it became obvious to the Workgroup that this would involve a huge construction of scaffolds and platforms, which in turn brought up several safety issues. Implications would even be worse by the many hose runs that would have to be hooked up to the SHAS and by additionally required hose ramps. If the SHAS could be placed closer to ground at the end of the available 200 bbl tank all these concerns could be avoided.
2. The expectedly higher capacities at the USCG test line brought up some concern whether it would be possible to achieve a simultaneous oil/water separation that would be sufficiently efficient.



Figure 9 200 bbl Buffer Tank, USCG Test Line

The Baker backup tank (Fig. 10) was used to contain all test oil for the USCG test line. Between tests the oil and water would be pumped from the buffer tank to the Baker backup tank. To avoid lube water entering the backup tank, the oil/water from the buffer tank would be delivered on top of a brush belt skimmer placed on top of the backup tank. The skimmer would separate oil and lube water and deliver the test oil into the backup tank. The water would run off into a water receiving tank placed next to the backup tank. To avoid re-use of already pumped and possibly heated oil, the backup tank was equipped with a baffle system in the used oil receiving section. The baffles could hold about 20 % of the total tank volume and would prevent immediate mixing with the (colder and higher viscosity) oil that had not yet been used. A non standard opening had been cut in the top of the tank over the inlet side of the baffle section. The brush belt skimmer was placed so that it could scrape off oil into this opening.

Temperature sensors distributed in the backup tank would provide information on the test oil viscosity. Viscosity adjustments (chilling or heating) of the oil in the backup tank would take place between tests. A DOP-250 pump was installed close to the bottom of the tank as far away from the baffle section as possible and would serve three functions:

1. To mix the oil in the tank to ensure an even temperature (and thereby viscosity) throughout the tank. The pump would deliver the oil through a transfer hose to the inlet opening in the tank roof over the baffle section.
2. To transfer the test oil to the USCG test tank before each new test. A transfer hose was pre-positioned on a U-bar bridge between the backup tank and the test tank.
3. Should the temperatures be too low in the backup tank, the pump would provide heat to the oil by pumping in mixing mode over longer periods of time.



Figure 10 USCG 500 bbl Backup Tank (Baker). Note the tubes for tank side sprinkler chilling and to the right the USCG test tank.

The backup tank was thermal-reflective insulated 2 weeks before testing with two-side aluminum reflective bubble plastic sheet.

5.5.3 Viscosity Control System

Other than obtaining an appropriate test oil, viscosity control and adjustment were the major challenges of the JVOPS Workshop. A method of chilling the oil after testing by

discharging it into a chilled water tank for later recovery by a mechanical feeder skimmer was the initial approach. This method had previously been used for pump transfer testing with re-floated bitumen at CCG / SAIC Canada / Environment Canada in Ottawa (Ref 11). But due to the density of the JVOPS test oil, which was higher than that of water, the oil would not float on the surface. The method would require an underwater skimming technique that had not been tested before and therefore this method could be ruled out.

Conventional chilling methods using heat exchangers submerged in the oil would have a most limited efficiency since the very viscous oil would tend to “freeze”, thus creating an insulating effect at the heat exchanger coils or plates. Cooling with liquid nitrogen, that would be released from a horizontal tube near the tank bottom, was also considered but to develop this technique was in itself a new project and was after some consideration ruled out. A number of chilling companies were consulted regarding the various options before the JVOPS Workgroup found the final solution as to oil cooling.

Heating the oil was not so much considered a problem since ambient temperatures in Louisiana were expected to be of assistance. Hot water or steam supplied to submerged heating coils in conjunction with pump agitation / mixing was expected to be the only required method. As it turned out during the workshop, the heat generated solely by pump mixing was sufficient in the few cases it was required.

5.5.3.1 Chilling by Ambient Temperatures and Chiller System

The test oil was delivered on 3 October, more than 60 days prior to the first test with oil. At delivery the temperature was about 160 °F / 71 °C and there was initially some concern as to the ability – well in time for testing – to reduce the oil temperature to the target by means of ambient temperatures. Therefore some initiatives were taken to ensure sufficient chilling.

1. The two tanks containing oil (CCG test tank and USCG backup tank) were covered with tarp roofs to protect against direct sunlight.
2. A sprinkler system was installed on both tanks that could keep the tank sides wetted with water from the nearby bayou.

Temperatures inside the tanks were closely monitored via temperature sensors. 9 were placed in the USCG backup tank and 2 in the CCG test tank. Fortunately it became clear after a few days that the temperatures dropped at a satisfactory rate (See Fig. 11). After two weeks the temperatures in both tanks were close to the USCG target temperature of 70 °F / 21 °C.

Over time it was observed that, without chilling with bayou water, the oil temperature would follow average ambient temperatures with a delay of about 24 hours. This was most reassuring and confirmed that the chilling approach that had been decided on for temperature/viscosity adjustments would work: The tank wall sprinkler systems would

be supplied with chilled water from a chiller system. The large surface areas of the tank sides would work as an excellent heat exchanger.

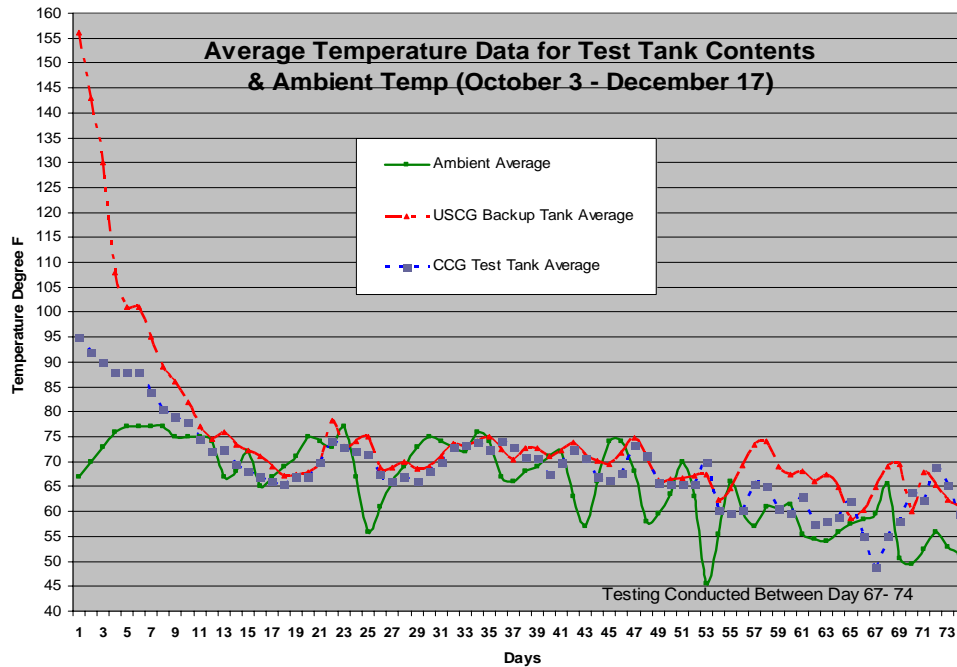


Figure 11 Test Oil and Ambient Average Temperatures from 3 October to 17 Dec.

5.5.3.2 Heating by Boiler or Pump Recirculation

As previously mentioned it was of minor concern how to heat the test oil if so required. A very powerful heat source was available with the US Navy Supsalv Clayton Boiler System (Fig. 12), and several heat exchangers from the US Navy and Titan Maritime



Figure 12 US Navy Containerized Clayton Boiler System with Power Pack

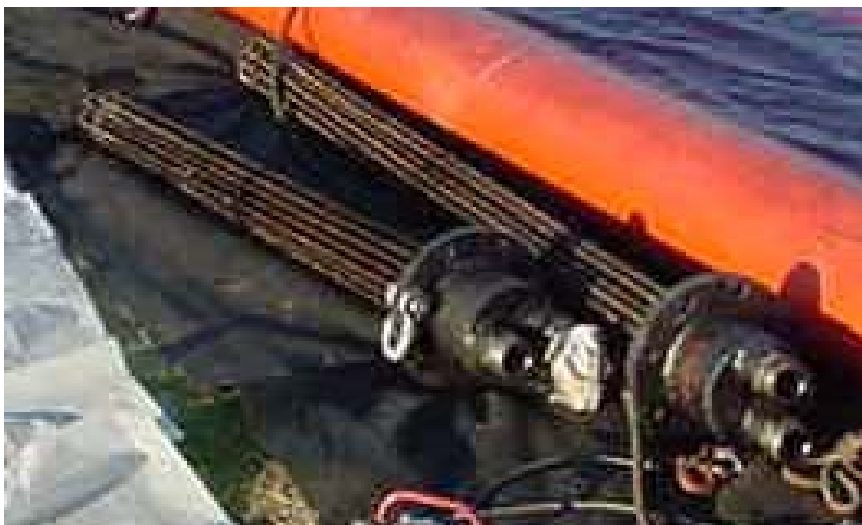


Figure 13 Titan Maritime Heat Exchangers that were used to heat the test oil for Test 0 with steam supply from the Clayton Boiler.

(Fig. 13) were available. However, for viscosity adjustments for the main tests these were never required. In the few cases, where the oil temperatures had dropped too much, sufficient heat could, as previously mentioned, be provided by using the submerged mix pumps over one or a few hours.

In preparation for the first test at the USCG test line a lower viscosity of 25,000 to 50,000 cSt was targeted. This viscosity range could only be reached by filling the USCG test tank with colder oil from the backup tank and afterwards heat it to about 100 °F / 38 °C. To do this, two Titan heat exchangers were submerged in the test oil (Fig. 14) and connected to the Clayton boiler. By interval heating the temperature target was reached within a few hours.



Figure 14 One of the two Titan Heat Exchangers in USCg Test Tank in preparation for Tests 0/1 and 0/2 with heated oil.

5.5.4 Water Lubrication System

The ability to almost instantaneously switch between different inlet and outlet lube water temperatures, switch between lubrication on inlet, outlet, or both, as well as adjust the percentage of injected water was essential for the timely conduct of the workshop testing. Several different combinations of temperature, inlet WL vs. outlet WL or both, and WL percentages had to be possible in one single test sequence without stopping the test pump and without replacing the test hose with a new for each new setting.

5.5.4.1 Water Lubrication Control Stand (WLCS)

A so-called Water Lubrication Control Stand (WLCS) was specially developed and constructed for the project (Fig. 15). The WLCS was developed as per the following requirements:

- It must be possible to switch instantaneously between inlet WL only, outlet WL only, and both inlet- and outlet WL. In any specific order.
- It must be possible to switch instantaneously between hot and cold lube water on both the inlet and outlet lube device.
- It must be possible to read both inlet and outlet lube water temperatures directly as well as electronically by data logger.
- It must be possible to read both inlet and outlet lube water flow (USgpm) directly as well as electronically by data logger.
- The WLCS must by means of adjustable check valves bleed off and return to tanks all lube water that is not being used.
- The WLCS must be portable for easy re-positioning between the two test tanks.
- The WLCS must be easy to operate.

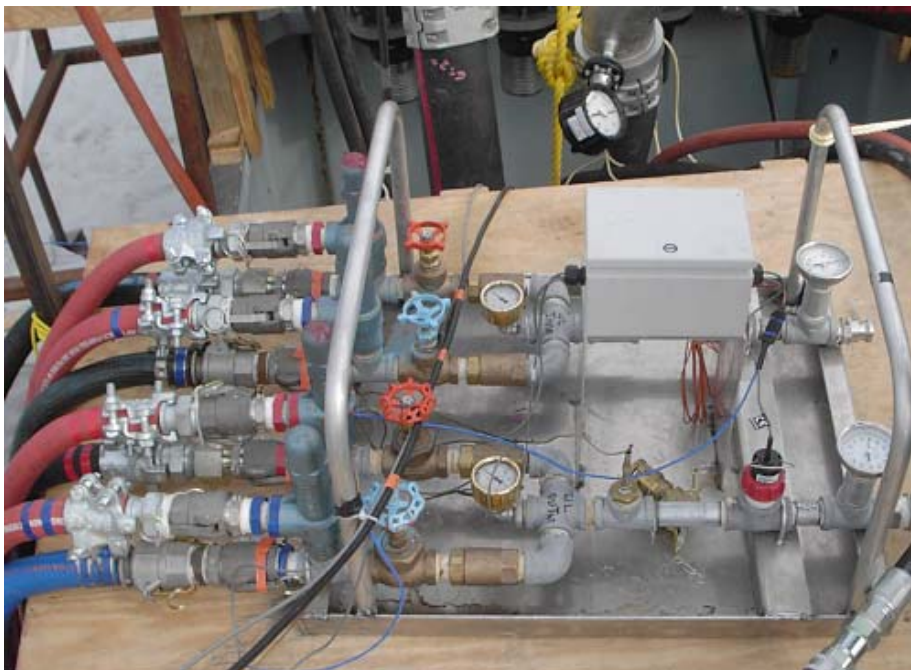


Figure 15 Water Lubrication Control Stand (WLCS). Note the supply/return hoses to the left and the two outlets to the AWIFs to the right

Meeting these requirements and placing the WLCS as close as possible to the test pump, would ensure that the switch between water temperature settings would only be delayed by the time to eject the small amount of water in the lines between the WLCS and the test pump.

The WLCS worked very well during testing and its design concept will be used in the recommended improvements to existing VOPS systems (Chapter 9).

5.5.4.2 Water Lubrication Tanks

The sources of hot, tempered, or cold water for water lubrication at the test pump would be contained in three tanks that were placed in a central position between the two test lines. See Figure 16.

Hot water: 25 bbl open top rental tank, insulated

Tempered water: 25 bbl open top rental tank

Cold water: 15 bbl open top rental tank , insulated

Bayou water was pumped to the WL tanks by a suction pump with a fine meshed suction strainer.

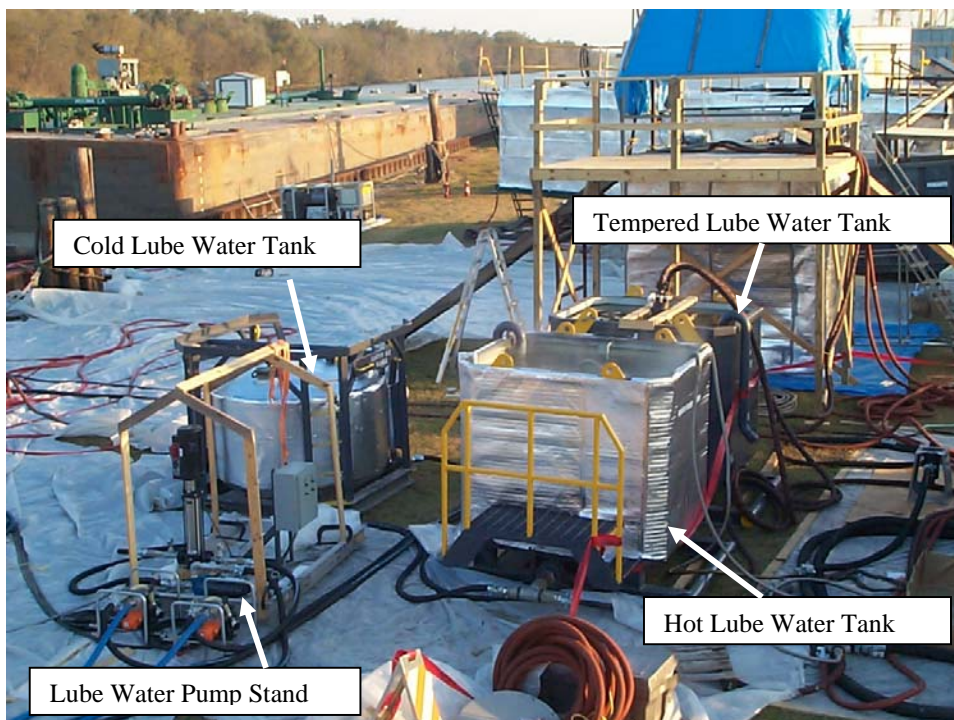


Figure 16 Water Lubrication Source Tanks and Water Lubrication Pump Stand

5.5.4.3 Water Lubrication Pumps

Four pumps were used to provide lube water to the AWIFs on the test pumps. One hot water high pressure pump and one cold/tempered water high pressure pump would provide lube water to the discharge side AWIF. One hot water low pressure pump and one cold/tempered water low pressure pump would provide lube water to the inlet side AWIF (See Figure 16). Appendix K outlines the specifications on the lube water pumps.

5.5.4.4 Lubrication Water Temperature Control

Hot water was generated by submerged USN steam coils. Steam to the coils was delivered by the USN Clayton boiler.

Tempered water was slightly heated by a small submerged Titan heat exchanger. Steam for the heat exchanger was delivered by the USN Clayton boiler.

Cold water was created by circulating the 15 bbl tank water through the chiller heat exchanger.

The water temperatures in all three WL tanks were checked manually with a submerged temperature sensor for digital readout on a handheld meter.

5.5.5 Oil / Water Separation

As mentioned in sections 5.2.1 and 5.2.2, two belt type mechanical feeder skimmers were used for oil / water separation. The technique of separating oil and water with a belt type skimmer can be seen in Figure 17. Oil and water is delivered on top of the moving belt. Water runs off via a tray under the skimmer to a used water tank, while the oil is brought upwards with the belt movement to be scraped off and dumped into the tank. One skimmer (ERE) was placed on the CCG test tank and the other (LAMOR) was placed on the USCG 500 bbl backup tank.

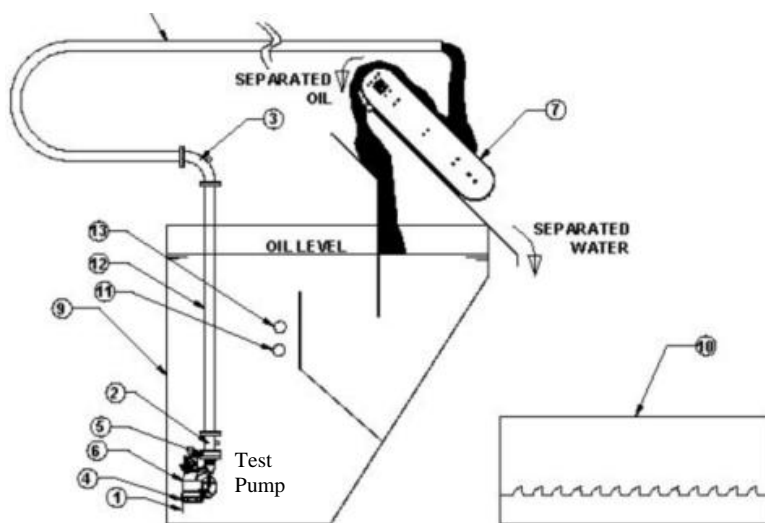


Figure 17 CCG Test Tank Operating Principle with Oil/Water Separating Belt Skimmer and Water Receiving Tank

It should be noted that none of the used skimmers have been designed for this purpose, but nevertheless they managed to meet the test plan requirement of least possible lube water in the test oil.

5.5.5.1 LAMOR Brush Belt Skimmer

The USCG test line used a LAMOR (Finland) Brush Chain Skimmer for oil / water separation (Fig. 18). The skimmer was a loan from LAMOR at no cost to the project. Only the brush conveyor (no floats) fitted with a water run-off tray was used. It was placed on the tank top at the baffle end of the backup tank. Oil/water mixture was with a DOP-160 pumped from the 200 bbl buffer tank and delivered on top of the moving brush belt. A diverter plate was placed where the oil would hit



Figure 18 LAMOR Oil/Water Separating Brush Belt Skimmer on USCG Backup Tank with Water Receiving Tank in Front

the belt to ensure spreading over all brushes and that the oil would not fall through the brushes when delivered from the transfer hose. For full information on the LAMOR Brush Belt Skimmer, see Appendix I.

5.5.5.2 ERE Belt Skimmer

The CCG test line used an ERE (Environment Recovery Equipment, Inc., Canada) Steel Belt Skimmer for oil / water separation (Fig. 19). The use of this skimmer was funded by the CCG. Only the steel belt bank (no floats) fitted with a water run-off tray was used. It was placed on the tank top at the baffle end of the CCG test tank. Oil/water mixture was from the discharge end of the test hose delivered on top of the moving belt. For full information on the ERE Steel Belt Skimmer, see Appendix I.

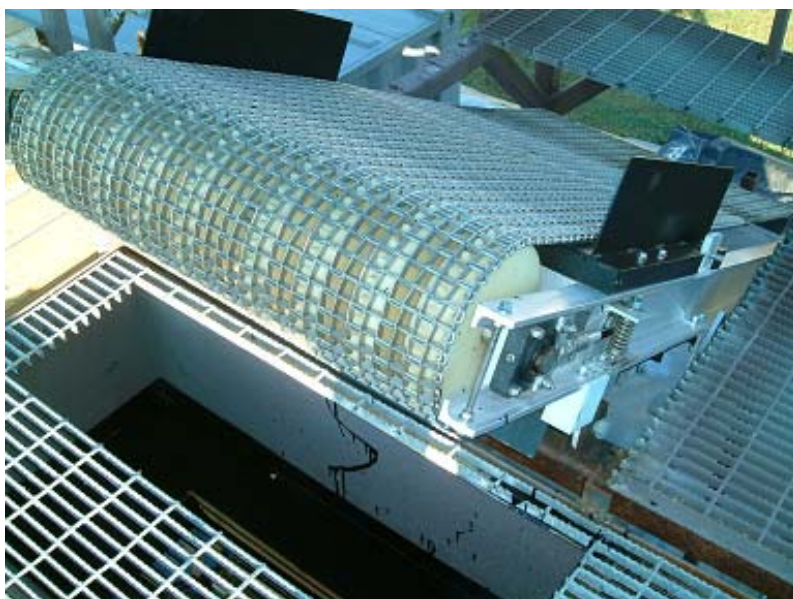


Figure 19 ERE Oil/Water Separating Belt Skimmer Mounted on CCG Test Tank. Separated oil will be scraped off into the hole in the tank top grating in front.

5.5.6 Swift Hose Add-on System (SHAS)

The original USCG test concept of long distance testing, as it appeared prior to the initial workgroup meeting in Brest, March 2002, would have required one new or clean test hose per test. The hose would have to be removed and replaced with a new/clean hose of longer length each time the pumping distance was increased. With the USCG desire of testing with a gradual increase in distance from 300 to 600, 900, 1200, and finally 1500 ft, the total hose length required for this single test would have been 4500 ft! This was more clean hose than could be made available for testing or that could be expected to be cleaned well enough during the test week.

5.5.6.1 The SHAS Idea and Why

The requirement for huge amounts of test hose – or alternatively reduced testing – brought up the idea of adding on additional test hose lengths “on the fly”. A device could be designed that would enable the test teams to add on up to 4 more lengths of discharge hose without disturbing the pumping and water lubrication processes.

5.5.6.2 The Initial Design

Several options were investigated prior to the design of the initial Swift Hose Add-on System (SHAS). It would either be required to

1. Hook on an additional hose section directly to the discharge end of the hose already in use by some rapid clamp on mechanism, or
2. Bypass the oil/lube water flow by means of a 3-way valve system while hooking on the next hose.

The concept would have to incorporate 4 parallel add-on devices in order to enable the sequential hose length extensions with four more hose sections.

Concern as to the possible disturbance of the core annular flow of the water lubrication if a 3-way valve system was used led to the design of a SHAS where the additional hose lengths could be added on by a swing-in mechanism. Once the flanged end of the next hose had been positioned against the flange of the discharging hose, some hooks would activate and hold the connection in place while four screws were tightened with pneumatic spanners.

The first SHAS based on the “swing-in” principle was constructed and can be seen in Figure 20. It was a large and heavy construction and brought up some concern whether it would be possible to mount it over the test tank (CCG) and the back-up tank (USCG). Personnel would have to operate the SHAS high over the tanks, which would require additional work platforms and safety rails. It was also a concern that the rapid hose add-on would cause some splashing of oil and water, but some screens would limit this to a minimum.

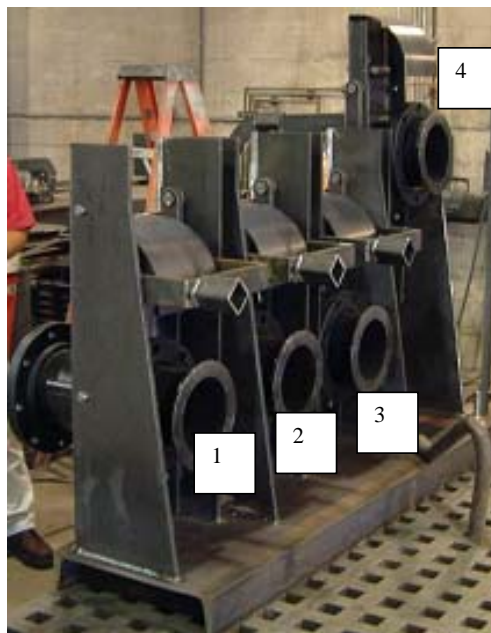


Figure 20. The Original Swift Hose Add-on System. Note that the flanges for add-on of hoses one to three have been engaged, while the flange for hose four is still not engaged.

In the first week of October 2003 (when the test oil was received, two months before the workshop) the test and holding tanks and other major components of the test infrastructure were brought in position at the test site. Coast Guard responders and the JVOPS Workgroup had now for the first time an opportunity to visualize on-site the application of the SHAS placed high over the already very high tanks. A number of questions were brought forward:

- How to carry out drum-fill pump capacity control with the SHAS engaged?
- How to ensure that the oil flow from all five SHAS outlets would land securely on the belt skimmer?
- How to mount the SHAS about 16-18 ft above ground?
- How to work on and around the SHAS?

Several constructive suggestions from the responders led to a re-consideration of the SHAS concept. A 6" 3-way valve on the SHAS inlet could move the point of drum-fill control away from the SHAS outlets and would ensure a secure and splash free add-on of hoses. In turn, however, this brought up the "old concern" about disturbing the core annular flow if the direction of flow was suddenly changed 90 degrees. With the suggested solution it could also be questioned why to use the swing-in concept at all if already fitted with a bypass system on the inlet.

5.5.6.3 The Final SHAS Design

Even though the swing-in SHAS had already been manufactured and represented certain costs it was at this late stage (October 2003) decided to compromise on the above mentioned risk of disturbing the core annular flow for the short period of time to add on a new hose (While adding on the new hose the direction of flow would by means of valves be changed 90 degrees). A SHAS based on valves only could be constructed in PVC material and would be easier and safer to operate and would be of less weight.



Figure 21 The Valve SHAS, here shown in position over the CCG Test Tank.

The hose cleaning system further consisted of a 120 ft by 20 ft containment berm, two 200 bbl open top containers, one high pressure washer, and misc. pumps for flushing with diesel fuel and with water.

The US Navy hose pigging system was never intended for oil in the high viscosity range of the JVOPS Workshop. Therefore a number of hose cleaning tests were carried out before and during the first days of the Workshop. This led to the development of an appropriate hose cleaning technique that was able to catch up with the consumption of clean test hoses.

The method finally decided upon, and which seemed to work well to clean hoses to a level that no residue could be wiped from the inside of the hose, was as follows:

1. Upon completion of pumping operation the pertinent hose section would be connected to the pig launcher at one end and connected to the pig catcher at the other end. Air alone would be blown through the hose to push a large amount of the product out.
2. A foam pig was launched and pushed through the hose by means of compressed air, thus pushing the remaining bulk of oil out.
3. The hose was disconnected and brought over to the diesel cleaning station where it was put in a closed loop and flushed with semi clean diesel for 10 to 20 minutes.
4. The hose was then pigged again to push all the semi clean diesel out. A small amount of clean diesel was injected at the diaphragm pump and circulated followed by a final pigging of the hose section.
5. The hose was then taken over to the secondary final cleaning station where it had a low-pressure hot water lance dragged through it, which applied hot water/cleaning solution to the inner wall of the hose.
6. Upon completion of the warm water cleaning solution application, the hose was manually drained and then rolled up for future use.

Important Safety Notice:

The use of compressed air for hose pigging operations involves certain safety issues. If a hose ruptures or a hose connection fails, there is a risk of a high energy explosion or that the cleaning pig could be shot out from the hose, both of which could cause serious injury or death to people. Compressed air hose pigging must be used only under strict safety precautions and with tested pigging equipment and techniques. A safer alternative is to use oil or water under pressure to drive the pig. A hose rupture or disconnect caused by a liquid under pressure could cause a spill but will result in minimal risk to personnel.

5.6 Pre-Test Work at Time of Oil Delivery

In the week from 29 September to 3 October, 2003 crews from USCG, CCG, GPC/USN ESSM base, and Hyde Marine worked together to prepare for receipt of the test oil, construct tarp shading over the tanks filled with oil, fabricate, install and test the tank cooling sprinkler system, and to train personnel from the host facility in various tasks to be carried out in the time span leading up to the Workshop setup week, 30 November to 6 December.

5.6.1 Arranging Test Tanks and Backup Tank

The primary task was to place the test tanks and back-up tank prior to receiving the test oil. However, the Test Plan requested that a strong environmental protection policy be in force. Therefore, strong plastic sheeting was first placed on the ground where the most work intensive areas would be and where the test tanks and backup tank would be placed. Containment berms were placed where the oil tanks would be placed and finally the tanks were lifted into position (Fig. 23) according to the overall test site layout (Figure 6).



Figure 23 A Cenac Towing, Inc. Crane Lifts USCG 500 bbl Backup Tank into Position

5.6.2 Mix Pump Deployment

A DOP-250 pump with high torque motor was placed in the USCG test line backup tank (Figure 24). This pump would have three primary functions:

1. To mix the oil inside the tank to obtain an even temperature distribution. Oil would be circulated from the lowest point, most far away from the baffle section, to the top inlet opening over the baffles.
2. To transfer test oil from the backup tank to the USCG test tank.
3. To apply heat to the test oil (by mixing) if so required to obtain target temperature.

A secondary purpose was to unload the baker backup tank after the workshop.



Figure 24 USCG DOP-250 Mix and Transfer Pump in Position in the USCG 500 bbl Backup Tank

A CCG GT-185 pump was to be placed in the CCG test tank during the pre test setup week early in December and would serve the purposes of mixing and heating the CCG test oil.

Tarps were placed on scaffolds over the oil tanks In order to protect the test oil from being heated by direct sun light.

A steel girder was placed as a bridge between the tank tops to carry the hose that would be used for oil transfer from the backup tank and the USCG test tank. A sprinkler system of ½-inch tubes with hundreds of small holes was mounted at the outer edges of the tank tops (Figure 10). In this way it would be possible to keep the tank sides wetted with water from the nearby bayou, thus enhancing cooling if so required in the time leading up to the workshop.

5.6.3 Placement of Oil Temperature Sensors

Before the test oil could be delivered and pumped into the CCG test tank and the USCG backup tank bulk oil temperature sensors had to be placed in these tanks. This work was carried out by teams from GPC and SAIC Canada, and the placement of the sensors can be observed in Figures 25 and 26.



Figure 25 The Two Data Logger Bulk Oil Temperature Sensors in the CCG Test Tank. They are placed close to each other in the main tank section close to the baffle wall.

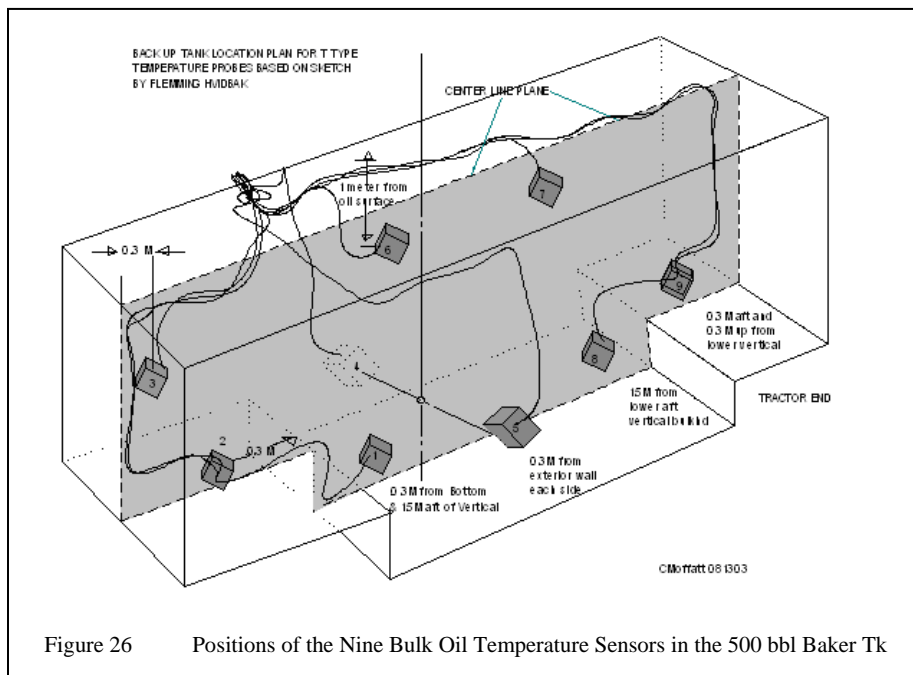


Figure 26 Positions of the Nine Bulk Oil Temperature Sensors in the 500 bbl Baker Tank

The USCG backup tank had nine probes placed strategically throughout the tank so that the average oil temperature could be determined and decisions could be made as to required cooling or heating of the oil.

The CCG test tank had initially two temperature sensors positioned close to the center of the tank. Even though test oil was not to be pumped into the USCG test tank until weeks later, two temperature probes were also placed in this tank at one side. Sensor line connectors from all probes were placed so that a manual digital meter could be used from outside the tanks when checking the oil temperatures.

5.6.4 Hose Cleaning Test

The test oil was received on 2 October and pumped into the tanks from heated tank trucks. Oil was then pumped into a section of test hose and left to cool down. After the oil had cooled down and reached a viscosity that was in the USCG target range a hose cleaning test was carried out. The purpose was to investigate what techniques could be applied to remove the oil from the hose and to clean inner hose wall for re-use in testing or for shipping. Unfortunately there was at that time not sufficient knowledge to the behavior of this very viscous oil. The equipment that was applied was merely for use on lower viscosity oils. Furthermore the test site at the time lacked sufficient storage tank facilities for hose flushing, and the availability of diesel fuel and fresh water for fine cleaning was limited. A steam pressure washer could for these reasons not be used, which in turn required that hoses and equipment had to be wiped down manually,

The problems described above created a major delay in completing the hose-cleaning test and prevented the hose from being completely cleaned. This was of major concern for the JVOPS Workgroup in the time leading up to the tests. Effective hose cleaning would be essential for the conduct of the tests as planned since there would be required far more hose than could be available as new or clean at test start. However, there was no other alternative than to plan for a new hose cleaning test during the pre test setup week when all the required infrastructure and supplies would be in place.

5.7 Pre-Testing of Pump Inflow Slippage

Since the conversion from measured hydraulic flow to pump capacity – using a pump specific factor – would be important for the initial pump capacity readings, a small test was previously carried out in November 2002 at SAIC/Environment Canada in Ottawa. The purpose was to test for possible intake slippage with a DOP-250 pump on 200,000 cSt bitumen derived from Orimulsion[®]. Without steam/hot water injection applied at the inlet of the pump, there was proportionality between hydraulic flow and product flow only up to 48 USgpm / 11 m³/h. At higher hydraulic flow (RPM) slippage was observed. This means that the pump could not take in enough product to match its displacement.

With the flemingCo steam injection flange on the inlet there was proportionality up to 110 USgpm / 25 m³/h (Figure 3). It is unknown how the proportionality would have developed at higher RPM since the available power pack could not deliver more hydraulic oil.

This information would be very important to participants in the JVOPS test since the ability to get the product into the pumps might be the factor that could result in success or failure for an otherwise suitable pump.

On 6 November 2003, one month after test oil delivery and now with the oil temperatures reaching targets, an additional test of inlet slippage of a DOP-250 pump was carried out at the Cenac test facility. This time the test was on the specific JVOPS test oil. Personnel from USCG and Hyde Marine used the mix pump installed in the backup tank to test for possible inflow slippage and exercise the so-called "drum fill" pump flow control. At an apparent pump capacity of 117 USgpm (based on hydraulic flow) the slippage was about 5%, increasing to about 11% at 275 USgpm. The inflow slippage percentages were calculated by the difference between apparent capacity less the actual measured capacity (based on time to fill a drum) in percent of apparent flow.

This test made it clear to the JVOPS Workgroup that an oil of lower viscosity should be used in the first USCG pre-test, which would compare two different discharge side AWIFs and also cold and tempered outlet lube water. Unless the group could be sure that the pump would take in 100% in relation to its displacement per revolution, this pre-test would not be valid.

5.8 Continuous Pre-Test Oil Temperature Control

Following the delivery of the test oil, it was mandatory to closely monitor the temperatures in the two oil tanks. This important work during the first month was carefully handled by the Cenac facility personnel, and from 3 November by personnel from The Gulf Strike Team. Daily reports were received seven days a week and the Workgroup had the readings compiled in a spread sheet that also included historical, actual and forecasted ambient weather conditions.

Once the oil had reached close-to ambient temperatures the spread sheet and weather forecasts would form the basis for any required action to adjust the test oil temperature (See Figure 11). The fact that the temperatures in the oil tanks seemed to follow ambient temperatures with a delay of about 24 hours was very comforting, since it indicated how efficiently chilled water cooling of the tank sides would be able to maintain the target viscosities even during warmer days.

5.9 Test Site Construction Prior to Prep Week

From 17 to 28 November 2003, prior to the prep week, a team of CCG responders did an outstanding job building up a large part of the test infrastructure (Figure 27).

- Ramps that would hold multiple test hoses between ground and tank tops.
- Work platforms next to the test tanks
- Moving arrived equipment to their pre-allocated positions
- Insulating oil tanks.

The Canadian effort was invaluable for the JVOPS Workshop timing in that the prep week before the start of the oil tests could then be more efficiently used for final adjustments, last minute changes, and for setting up equipment that had arrived late to the site.



Figure 27 The CCG Team of Responders at Work prior to the Prep Week. Here is the construction of the work platform next to the CCG Test Tank

5.10 Test Site Construction During Prep Week

At the beginning of the prep week, 1 through 7 December 2003, a large part of the test infrastructure was already in place (Figure 28). But still a significant amount of work remained to be carried out before the JVOPS testing could commence. The large number of tanks, power packs, containers, pumps, and other necessary equipment for testing was spread over three to four acres and resembled a large construction site or an oil spill response battlefield.



Figure 28 The JVOPS Workshop Test Site at the Beginning of the Prep Week

An immense effort was put forth during the week by the USCG and CCG personnel and the contractors in order to get everything organized in time for the first oil tests. The work was not easy and due to the nature and complexity of the project, equipment had to be relocated and structures modified in several cases where the test management deemed it necessary.

5.10.1 Work Platforms and Hose Ramps

Even though work platforms at the test tanks had already been built by the CCG team prior to the prep week, these had to be expanded and reorganized after arrival on-site in order to ensure an efficient and, above all, safe test area. The work platform next to the CCG test tank had to be modified twice before it could be approved for testing. A new and not previously planned platform was built over the USCG 200 bbl open top buffer tank that would receive for temporary storage the test oil from the 200,000 cSt test. The ladders on the test tanks were not considered safe, so stairs with hand rails, which were kindly provided by the facility owner, were mounted at the tanks instead.

The placement of the SHAS (see section 5.10.6 below) caused significant headaches for the test management and led to a number of additional adjustments to platforms and hose ramps. The hose ramps had to be placed so that their top levels allowed for a smooth bending of the test hoses at the angles between ramps and tank tops or SHAS platforms. Last minute changes to the test plan further required the construction of additional ramps and modifications to some of the already made up ramps.

5.10.2 Chiller and Boiler

A high capacity chiller system had been rented from Universal Industrial Refrigeration Inc. in Gonzales, LA. It incorporated the chiller, a buffer tank, and a heat exchanger, which would be connected to the test chilling loops. Power requirements were so high that a dedicated 3 PH 56KW, 480V, 84A diesel electric power pack had to be rented from the local source, Grand Rental Station, Inc. in Houma. The entire chiller station was strategically placed close to the bayou with optimal distances to cold water tank, USCG backup tank and CCG test tank, which were the subjects for chilling. Chiller tank and heat exchanger were insulated on all surfaces by the USCG and CCG responders (Fig. 29).

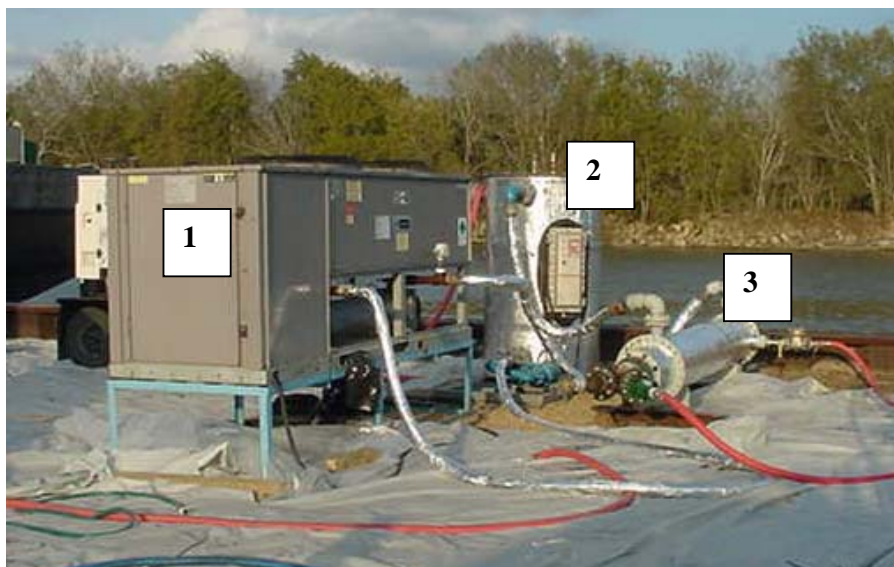


Figure 29 Chiller System consisting of 1) Chiller, 2) Buffer Tank, and 3) Heat Exchanger. Buffer tank and heat exchanger have been insulated with double sided reflective bubble plastic.

A High capacity Clayton boiler system was provided by US Navy ESSM base in Williamsburg, VA. Along with the boiler system came steam supply hoses and various US Navy /ESSM and Titan Marine heat exchangers that in conjunction with the boiler would provide heat to the hot water lubrication tank, tempered water tank, USCG test tank (for Test 0), and to the heating coils for the local bulk heating test. See Appendix F for detailed information on the chiller and boiler systems.

5.10.3 Re-arrange Tanks

On-site evaluation by the JVOPS Workgroup of the entire scenario led to decisions that some changes to the Test Plan were necessary. This included re-positioning of water lubrication tanks, and incorporating a 200 bbl open top tank buffer tank into the USCG test line. Further a construction was made so that the tank could be placed tilted to facilitate emptying the tank by means of a DOP-160 pump.

5.10.4 Thermal-Reflective Insulation on Tanks

The CCG team had already the week before covered the USCG backup tank with double side reflective aluminum bubble plastic (Fig. 30) and the CCG and USCG teams continued this work during the prep week, including insulation on cold and hot lube water tanks, and USCG and CCG test tanks.



Figure 30 USCG 500 bbl Baker Backup Tank with Double Sided Reflective Bubble Plastic Insulation. Note the tank side chilling water dripping off beneath the insulation and into the containment berm where it flows to a sump for re-circulation to the chiller system.

5.10.5 Unpacking and Outfitting Test Pumps, Deploying CCG Mix Pump.

The USCG, CCG, LAMOR, and FRAMO test pumps were unpacked. The two manufacturers' pumps were ready for testing, but since the US and Canadian Coast Guard pumps had just been taken out of a contingency, these pumps had to be fitted with AWIFs, lube water supply lines, and hydraulic, water lubrication, and discharge hose couplings as per the Test Plan specification (JVOPS Standard). This work was carried out as a joint US and Canadian effort, whereby important knowledge to each other's equipment was generated.

The teams also worked jointly on making attachment brackets for the local bulk heating coils so that they could be attached both to the DOP-250 and the GT-185 pumps.

5.10.6 SHAS Platforms

The placement of the Swift Hose Add-on System (SHAS) on each test line was one of the most significant on-site challenges for the test management and the Coast Guard responders. A number of different approaches were considered before the final and operational arrangement could be constructed. The CCG team had to suffer from these changes by three or four times breaking down what they had built for this single purpose. But they never failed being constructive and they deserve the credit for the final solution that worked very well.

The SHAS weighs about 500 pounds (Figure 31), and would have to be mounted for safe and efficient operation over the CCG test tank and shortly after over the USCG 200 bbl buffer tank. One of the challenges was to place the unit so that oil could be discharged on the ERE belt skimmer (CCG test tank) from the horizontal discharge without too much vertical drop, while at the same time being high enough over the belt to allow for the drum-fill capacity control. This would be carried out with the drum hanging from a crane and then move the drum in under the discharging oil and remove it again when full and the time to fill it had been logged.



Figure 31 The SHAS Manifold Placed over the tilted USCG 200 bbl Buffer Tank. The oil flow will follow the horizontal arrows during test runs and will by-pass downwards while a hose section is being connected to one of the horizontal outlets to the right (shown without hoses). Note the sliding rails (red arrow).

The design should also allow any of the four horizontal outlets on the SHAS to discharge on the center line of the belt skimmer. Otherwise oil might escape over the belt sides instead of being returned into the tank. At the same time it was necessary to place the unit so that the vertical by-pass discharge would be placed over the small opening in the tank top grating next to the skimmer.

The CCG team constructed a portable table with sliding rails for sideways movement of the SHAS. The table would fit consoles that were built on the CCG test tank top and over the lower end of the tilted USCG buffer tank. The rails would enable the assigned test team to move the SHAS sideways after a new hose section had been added so that (on the CCG tank) the discharging horizontal outlet from the SHAS always would be placed over the belt skimmer's center line. After use on the CCG test tank the unit could be crane lifted for decon and then further on to be placed on the console over the USCG buffer tank. The design also allowed for convenient operation of the valve handles on the horizontal and vertical valves, both when placed over the Canadian and over the US tank.

Special safety rails were fitted over the SHAS. A safety line from the rails could be attached to a harness on the SHAS operator working on top of the SHAS.

5.11 Other Test Preparations During Prep Week

There were hundreds of small and big tasks to carry out before the test infrastructure could be ready for testing and before the test teams had been thoroughly introduced to and trained in their respective responsibilities during testing. Some of these tasks were:

1. Riser hose sections for each test pump that would connect the submerged test pumps via a 90 degree elbow to the test hoses.
2. Pressure testing of riser hoses and fittings.
3. Wire slings to hold the pumps hanging in the gallows over the test oil while being hooked up to the data system, and once submerged would hold the pumps in the right level of 12 inches from the bottom of the tank.
4. Cooling water re-circulation systems for USCG backup and CCG test tank, including digging down open top drums at containment berm corners and installment of sump pumps submerged in these drums.
5. Assembling the hydraulic power supply lines.
6. Assembling the water lubrication pump stand.
7. Assembling and pre-testing the steam supply lines.
8. Assembling the water lube supply and bypass lines.
9. Install DOP-160 mix pump in USCG test tank in preparation for Test 0.
10. Install pump transfer system between 200 bbl USCG buffer tank and backup tank.

11. Acquisition from local suppliers of numerous last minute bits and pieces for which the USCG Logistics team deserves enormous credit.

5.11.1 Education and Training

In the evenings of the first two days of the prep week, all workshop team members were introduced to the background for the testing and the test strategy by the Lead Engineer. The various flow enhancing techniques that would be applied during the JVOPS Workshop were described and results from previous tests were presented. Due to the complexity of the test infrastructure to be created it was in particular important to provide information to the responders on the main test strategies. So much would depend on each individual's understanding of own tasks as well as on how they integrated into the overall purpose of the testing. As it appeared at several occasions during the setup week and especially the test week, a number creative suggestions for improvements were brought up by responders, and prompt responder interaction during testing became an important factor for the successful conduct of the workshop.

5.11.2 Control of Test Hose Lengths

There were 3300 ft of 6" lay flat discharge hose available for the workshop, out of which 2000 ft of Hydrasearch hose had been made available by the US Navy ESSM base in Williamsburg and 1300 ft by the USCG Gulf Strike Team. The hoses were present in 50 and 100 ft sections. For the sake of knowing the exact hose length that would be used in each test the Lead Engineer requested all the hoses to be control measured. USCG responders therefore had to roll out all hoses on the ground and measure the length of each individual hose section. At the same time the hose clamps that keep the hoses attached to the Hydrasearch male and female couplings at the hose ends were checked and tightened if necessary.

All hose lengths were at nominal length or deviated only a few inches from nominal length (Figure 32). The maximum deviation was found to be in the order of 1% of the hose length. The influence on the test results would therefore be beyond the accuracy of measuring for this type of testing, so it was decided that all hoses would count with their nominal hose length of 50 or 100 ft when hoses were connected to reach the total pumping distance of a given test.



Figure 32 50 ft Test Hoses very close to Nominal Length

5.11.3 Setup of Data Acquisition System

The Test Plan requirements as to data acquisition were as follows:

- All primary and direct test relevant readings (temperatures, pressures, flows) will be delivered directly into a PC based data logger (8 probes) and sensors will at both test lines be equipped with cables that are long enough to reach the central data logger station.

- Read-outs to data logger per test line:

$Q_{(hydr)}$	Hydraulic flow to pump (pump capacity equivalent)
$P_{(pump)}$	Discharge pressure of test pump
$T_{(wl\ in)}$	Temperature of inlet side lube water
$T_{(wl\ out)}$	Temperature of outlet side lube water
$Q_{(wl\ in)}$	Flow rate of inlet side lube water
$Q_{(wl\ out)}$	Flow rate of outlet side lube water
$T_{(oil/inlet)}$	Temperature of test oil at pump intake
$T_{(oil/bulk)}$	Temperature of bulk of test oil in safe distance from pump

- Back-up (or alternative) readings on analog or alternative instruments/meters for all primary test readings.
- Discharged oil temperature to be measured and registered manually, no back-up.
- Hydraulic pressure to test pumps to be measured and registered manually, no back-up.
- Temperature distribution in USCG back-up tank, USCG test tank, and in CCG test tank to be measured and registered manually, no back-up (this was prior to the tests revised so that one more bulk oil temperature sensor in each of the US and Canadian test tanks was connected to the electronic data logger system).

To meet these requirements the test site was wired with thousands of feet of thermocouple and transducer cable, all leading to the centrally placed Data Acquisition Station (Fig. 33) or to manual reading and backup reading points at various locations. This work was carried out by personnel from GPC/US Navy SUPSALV, Williamsburg, VA and SAIC Canada in Ottawa.

In the months leading up to the workshop these organizations worked to make available more than a dozen gauges and transducers, all of which had to be capable of being submersible in oil up to 12 feet of depth. Also special pipe connections, tees, caps and fittings had to be welded and fabricated to make these sensors water proof and interchangeable. The data equipment procured for the project had to be matched to sensors and transducers and each one had to be set up in a mock test at the US Navy ESSM base in underwater tanks to ensure they would perform without failure during testing.



Figure 33 The Centrally Placed Data Acquisition Station

See Appendix F for full information on Data Acquisition Equipment.

The data logger temperature probes in the USCG test tank were during the December prep week re-positioned from tank inner wall to the tank center, covering the lower and mid section of the tank. A third probe for manual reading was placed in mid layer at one side, thus adding to the picture of the temperature distribution (and thereby the oil viscosity) in the tank.

5.11.4 Hose Cleaning Test

The concerns of the JVOPS Workgroup regarding the ability to clean used discharge hoses well enough and fast enough for re-use later in the testing justified a hose cleaning test. This test was carried out early afternoon on 6 December and took place at the CCG test tank, using the CCG GT-185 mix pump and 100 ft of 6" discharge hose. At that time the viscosity of the CCG test oil was close to the target viscosity of 500,000 cSt. The GT-185 was used to fill the hose with product. It took 65 minutes to fill the hose, which means at a rate of about 2 USgpm. Since the GT-185 mix pump was equipped exactly like the CCG GT-185 test pump, namely with a new re-designed high pressure/high temperature plate wheel and sealing liners in the plate wheel casing, but without inlet and outlet AWIFs, this hose fill process was also used as baseline test (no lube water applied) for the GT-185 pump.

Once the 100 ft hose was full of oil, it was disconnected from the pump and connected to the US Navy hose cleaning system. A portable pig catcher was positioned at the CCG tank top and connected to the hose discharge end. Oil released through the catcher would discharge into the test tank. A foam pig was loaded into the pig launcher and air pressure was built up to approximately 110 psi at the air compressor before the control valve was opened to release air to the pig. The foam pig moved very slowly through the 100 ft section of hose. After approximately 15 minutes the pig broke through

the catcher end of the hose with enough force to lift the catcher off its attachment, thus causing release of oil on the top and one side of the tank, however, safely inside the containment berm. The powerful release of the pig caused some broken welds in the portable catcher.

With the majority of the oil removed from the hose it was capped at both ends and carried to the hose decon area, where attempts to remove the remaining oil were initiated by the local decon contractor. A lance was gradually pulled through the hose and pressure sprayed a hot water / detergent solution on the hose inner surfaces. This process was slow and had limited effect, and the poor result caused the GPC personnel and the JVOPS Workgroup consider an alternative procedure, which would be tested in connection with the first oil test. The proposed procedure would involve pigging and a diesel flushing process before final cleaning with the hot water / detergent solution applied under pressure.

5.11.5 Water Pumping Test

The Test Plan required one test using water at each test line prior to initiating the oil tests. The purpose was to verify that the data acquisition system would work as anticipated and to detect potential causes for leaks or other failures to equipment. The requirement for one test at each test line was during the prep week changed to one water test using the USCG buffer tank as reservoir. This would save some time and could be justified by the fact that the same data sensor devices and adaptors would be used at both test lines.

The water testing was, as per Test Plan recommendation, further expanded to incorporate a performance comparison test between the two DOP-250 pumps to be used in Test 0. It was important to this test that the pumps would perform equally well, since the comparison between the “old” and the revised design discharge side AWIF for the USCG VOPS could otherwise provide a misleading picture of the performance of the two AWIFs.

The Water Pumping Test was carried out on 9 December and the test verified that the two pumps had approximately the same sealing characteristics and that they therefore could be used for AWIF comparison testing under Test 0. See section 6.5 for details on the results of this test.

The test also served as an exercise for the operators of the Water Lubrication Control Stand (WLCS) prior to testing with oil. Water lubrication on the two pumps' discharge side was applied and was logged by the data acquisition system.

The test verified that the data acquisition system would work as anticipated, but leakage had been observed at the 90 degree elbow connecting the riser hose to the test hose. There had also been observed problems with the high pressure WL pumps (for discharge side WL), which had difficulties matching the pressure in the product discharge hose. These problems had to be addressed before the first oil tests the coming day.

5.11.6 Prep Week Modifications to Test Plan

As described in section 5.5.2, the oil pumped during the USCG tests would be discharged into the 200 bbl buffer tank instead of directly on the oil / water separating skimmer over the baffle section of the 500 bbl backup tank, as originally planned. This was due to expectedly high pump capacities that could result in a reduced quality of the oil/water separation, and due to a more convenient and safe operation of the SHAS when placed over the relatively low 200 bbl tank.

The constant concern about having enough clean hose available for testing caused some changes to the original Test Plan. It was imperative to have enough clean hose for the so-called Master Tests and for the Manufacturers' tests that all would be at the same conditions, to allow for comparison in performance. However, the long distance testing was a major requirement from the two Coast Guards and had to be completed in some way with due respect to the availability of clean test hoses.

The setup for testing had despite hard work by all crews delayed the initiation of the oil tests by one day. With some minor issues still pending after the water test on 9 December, the first oil tests would start on 10 December.

Final decision on additional changes to the Test Plan, considering the availability of clean test hose and time for testing, would await the first oil tests and additional hose cleaning testing. See more in section 6.4, Chronological Test Summary.

5.12 Logistics Staff On-Site Services

An organization of a magnitude like the JVOPS Workshop, with about 100 people involved in almost uncountable tasks during setup and testing, requires administrative and purchasing functions similar to those of a private corporation of at least the same size. It also resembles a real world response scenario where logistics forms an important part of the Incident Command System. With its always ready and patient staff the Logistics Team went the extra mile whenever additional equipment and supplies were required with the shortest possible notice. Photo copying and the printing of test plan copies, revised drawings, test sheets, and instructions to test teams were other invaluable services, and finally, but not least, the provision of food and beverages as on-site catering services saved many precious work hours to the project.

5.13 Health, Safety, and Environment (HSE)

The Test Plan required proper HSE procedures throughout set-up, tests, and break-down. A HSE Manager was appointed. In general common oil industry safety rules should be obeyed, for instance, but not limited to, use of hard hats, eye and ear protection, and safety footwear.

5.13.1 Safety and First Aid

1. All personnel and observers were made aware of all safety practices
2. Eye wash station was set up adjacent to worksite
3. Fire extinguishers were placed adjacent to all oil tanks and their presence made aware to all personnel
4. Detectors of explosive atmosphere were available with trained users and were always used in oil tanks prior to and while personnel would be working on or at the tank tops
5. Confined space entry guidelines were made aware to all personnel expected to enter tanks
6. Spine board and basket was onsite
7. Fire blanket was onsite
8. Site safety plan was in place c/w local emergency phone numbers.

The test pumps would be used without their protection grids. These grids might otherwise be an obstruction that could cause reduced pumping efficiency on viscous oil. Most oil spill pumps have been designed to cope with debris commonly found at spill sites. Their cutting capability enable them to cut off limbs like hands and feet. Therefore special safety procedures were initiated (Test Plan, section 3.6).

A JVOPS Safety Manual was developed by the HSE manager and the USCG Gulf Strike Team.

5.13.2 Environment

1. Disposable coveralls of a good quality were available to test teams and equipment- and hose handling crews.
2. A space was available with clothes change facilities, equipped to handle coveralls, hardhats and work boots stored for the night, and to store clean street clothes.
3. Personnel decon facilities (hand wash facility and boot wash station) was available.
4. Heavy mil plastic was laid down over most work intensive areas to eliminate oil transfer from boots to soil.

5. Heavy duty membranes with barriers (berms) were placed under and around all oil tanks.
6. Oil transfer hose disconnect was only to be carried out over a portable catch basin and was to limit spreading of oil to personnel and equipment.

5.14 Workshop Integrated Command Structure / Command Post

5.14.1 Command Structure

The JVOPS Workshop applied a variant of the USCG Incident Command System, which appeared to work very well through preparation phase, testing, and decontamination/break down phase. The ICS Chart can be seen in Appendix E. It should be noted that the sub command structure indicated by the red lines connecting the Lead Engineer to the direct test responsible personnel was only in force during actual test sequences. Furthermore a few personnel had to leave the workshop for other assignments after the prep week, so the ICS chart mainly include personnel on duty during testing from 10 December.

5.14.2 Command Post

The USCG Gulf Strike Team provided to the project their command post trailer, which was used by the JVOPS Workgroup and the Logistics Team. However, the GST on 8 December, after the preparation week, had to remove their trailer due to an unscheduled priority. With very short notice Erst O'Brien's Response Services, Gulf Coast Branch, provided two command trailers (Figure 34) as services in-kind for the Test Week. The command post was a valuable asset to the Workshop, which offered space for not only Logistics and the Test Management, but also for the HSE and QA leaders.



Figure 34 The JVOPS Workshop Command Post graciously provided by Erst O'Brien's Response Services.

The Test Management could under calm conditions meet and discuss progress as well as unexpected issues, and the Lead Engineer and Technical Support Engineer could work on ad-hoc adjustments to the Test Plan.

5.15 Co-Sponsorship -- General Approach

In order for this event to occur, a solid, coherent and achievable strategy was required. Neither the U.S. or Canadian Coast Guards had sufficient funding to execute a Workshop like this independently. This situation was part of the impetus behind the “co-sponsorship” strategy to plan and execute the Workshop. A voluntary matrix of project component sponsorship was established whereby participants could contribute to the event in ways that were most optimal to their organizations. Much of the co-sponsorship was in the form of “services-in-kind”. The value of many of these services cannot be understated. Additionally, on-site costs during the Test Set-Up and Test Weeks were minimized by doubling-up many of the participants in modest, local motels. To maximize testing and testing preparatory time, mid-day meals were delivered to the work site on a daily basis. This allowed the work teams to minimize off-site time. The Joint Project Agreement between the US and Canadian Coast Guards can be seen in Appendix D.

5.16 Support and Services by Cenac Towing, Inc.

The single largest contributor to the Workshop, besides the US and Canadian Coast Guards, was without any doubt the host facility, Cenac Towing, Inc.

The positive interest in the testing by the facility owner and his staff had already been manifested a long time before the Workshop, but continued without hesitation through the very last day of breaking down the test site after the successful completion of testing.

Besides the important loan of the test site to the project, Cenac provided many services-in-kind:

1. Crane support
2. Cherry picker support
3. Welding services
4. Machining services
5. Loan of valves and fittings
6. Receipt of used test oil and oil contaminated water
7. Meeting facilities

It should be noted that in many cases the support and services were provided outside of normal working hours.

The JVOPS Workgroup offers our sincere thanks to Cenac Towing for their support.