Characteristics, Behavior, & Response Effectiveness of Spilled Dielectric Insulating Oil in the Marine Environment

Solicitation Number: M08PS00094
Award Number: M09PC0002

For

U.S. Department of the Interior
Bureau of Ocean Energy Management, Regulation and Enforcement
(BOEMRE)
Herndon, VA

By

Louisiana State University
Department of Environmental Sciences
1285 Energy, Coast, and Environment Building
Baton Rouge, Louisiana 70803

MAR Incorporated
P.O. Box 473
Atlantic Heights, NL 07716

June 2011

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ABSTRACT

Offshore wind power is a rapidly emerging form of renewable energy generation that is now being proposed in the United States (US). America's first offshore wind farm, the Cape Wind project, is scheduled to begin construction in 2010. The Cape Wind project, located on Horseshoe Shoal in Nantucket Sound, will consist of 130 wind turbine generators (WTG) connected to a centralized electrical service platform (ESP). The Cape Wind project has the potential to spill roughly 67,000 gallons of dielectric fluids and oils into the marine ecosystem. In August 2006 the Cape Winds Associates LLC released the finding from a model study designed to estimate the trajectories of mineral oil spills from an ESP and calculate probable estimates of area coverage and minimal transit time for the oil slick. The spill trajectory model predicted the coasts of Cape Cod and Martha's Vineyard would be severely impacted, possibly affecting many federally protected birds, turtles, and marine mammals. As a result, Bureau of Ocean Energy Management, Regulation and Enforcement **(**BOEMRE) recommended a thorough study be conducted to determine the dispersibility and biodegradability of dielectric fluid (MIDEL 7131) in the marine environment.

Laboratory dispersibility and biodegradation tests were conducted at Louisiana State University (LSU) in Baton Rouge, Louisana. Large-scale skimmer and dispersibility tests were performed at the Ohmsett wave tank facility in Leonardo, New Jersey. Dispersant effectiveness was evaluated using the Swirling Flask Test (SFT), Baffled Flask Test (BFT), and Warren Springs Laboratory Test (WSLT) at various temperatures (4ºC and 22ºC), dispersant types (Corexit 9500 and 9527), and dispersant-to-oil ratios (DOR 1:10 and 1:20). At 4°C, the SFT did not achieve greater than 21.1% effectiveness. The BFT and WSLT were comparable in effectiveness, ranging from 35.3 to 45.8% dispersant effectiveness at 4°C. At 22°C, the SFT never achieved greater than 45.7% effectiveness. The BFT and WSLT were comparable in effectiveness, ranging from 71.8 to 84.7% dispersant effectiveness at 22°C. All dispersant tests results indicated there was slightly higher dispersant effectiveness when MIDEL 7131 was dispersed at DOR 1:20, compared to DOR 1:10. It can be observed in figure 3 that the overall MIDEL 7131 biodegradation rate is higher for product + nutrient than nutrient alone. The seawater control treatments averaged a 9.47% decrease over the 28 day test period. The nutrient and nutrient + product treatments averaged 50.0% and 78.0% MIDEL 7131 concentration decreases,

respectively. The Ohmsett skimmer tests utilized rope mop, drum, and disc skimmer systems in determining the oil recovery rates (ORR) and recovery efficiency (RE) of two (2) reference oils (diesel and hydrocal) and MIDEL 7131 test fluid. The disc skimmer exhibited the highest ORR for MIDEL 7131 at 6.4 gpm. The rope and drum skimmer had an ORR of 1.7 and 5.0 gpm, respectively. Further evaluation of MIDEL 7131 using Ohmsett's wave tank system to determine the effectiveness of Corexit 900 was conducted. This report describes experiments to study the effect of different variables such as DOR, temperature, and dispersant type on dispersant effectiveness of MIDEL 7131.

INTRODUCTION

The Cape Wind project, located on Horseshoe Shoal in Nantucket Sound, will consist of 130 wind turbine generators (WTG) connected to a centralized electrical service platform (ESP). Electrical power from the individual wind turbine units will be routed through four (4) step-up transformers on the ESP to reduce loss of voltage in transmission. The ESP will contain approximately 40,000 gallons of dielectric insulating oil and approximately 2,000 gallons of assorted oil-based fluids (diesel fuel, lubricating oils, etc.) stored on site for facility maintenance. The Cape Wind project would contain an additional 25,000 gallons of dielectric insulating oil in the 130 wind turbines (190 gallons per turbine). Worst case scenario, the Cape Wind project has the potential to spill roughly 67,000 gallons of oils and fluid into the marine ecosystem. The dielectric insulating fluid used in the ESP and turbines is typically a mineral oil, but vegetable-based oils (soybean oil) may also be used.

Several concerns have been raised by regulatory agency and environmental conservancy groups as to the environmental effects of a possible oil spill due to accidental vessel collision or natural catastrophe. The two (2) main concerns addressed were probability of oiling and the minimum transit time of the oil to areas and resources at risk. An oil spill trajectory analysis study funded by Cape Winds Associates LLC indicated a release from an ESP would severely impact the central and western area of the Cape Cod coast and the east and northeast coasts of Martha's Vineyard [1]. The shortest transit times for each of the multiple oil spill scenarios ranged from 4.8 to 11.3 hours. Nantucket Sound is home to many different species of wildlife, including federally protected birds, turtles, and marine mammals. The Sound is also located in a geographical region known as the Atlantic Flyway, one of the largest migratory bird routes in the world.

Numerous toxicological and biodegradation studies have been performed on mineral and vegetable-based oils over the last decade [2,3,4,5,6]. The recent increase in fuel costs has sparked an interest in alternative fuel options, such as vegetable-based biodiesels. These biodiesels have oil properties and characteristics (e.g. specific gravity and toxicity) similar to the dielectric transformer oils used on ESPs. Mineral and vegetable-based oils display low direct toxicity because they do not contain the water–soluble and multi-ringed polynuclear aromatic hydrocarbons (PAH) typically found in petroleum-based oils. Due to their low toxicity and usage, little research has been performed on the response options available to cleanup a spill of dielectric fluids on the marine environment. New concerns of direct contact oiling of marine birds and mammals and persistence in the environment have risen with the proposed installation of wind turbines and ESPs off the northeastern and mid-Atlantic US coastlines. Model studies have showed significant adverse environmental and economic impacts to Nantucket Sound and surrounding areas, including impacts to wildlife and shellfish from a spill incident.

Should this extremely unlikely spill event occur, what would the fluid be like that would leak out into the ocean? How would the dielectric insulating oil be removed from our oceans and shorelines? How persistent are these oils in the marine environment? The answers to these questions are unknown, but must be addressed prior to startup of the Cape Wind project. The residences of this region are still mindful of the fuel oil spill that occurred in 2003 near Buzzards Bay, MA. The single-hulled Bouchard No. 120 barge, bound for the oil-fired Mirant power plant in Sandwich, spilled approximately 98,000 gallons of No. 6 residual fuel oil after striking rocks near the entrance to Buzzards Bay. The toxic and persistent fuel oil impacted wildlife, shellfish beds and beaches in Buzzards Bay several years following the spill [7].

Due to its non-hazardous nature, little research has been performed on the fate and effect of spilled insulating fluids and mineral oils. LSU performed an online literature review and governmental database search for ESP, dielectric insulating fluids, and mineral oils. The results concluded there is little or no relevant research information concerning the weathering behavior, and window of opportunity for using short-term response options for removal of spilled dielectric fluids in the marine environment. Research publications from the National Park Service and USEPA Environmental Fate & Effects Division have determined mineral oils not to be acutely toxic [8]. Toxicity data is available, but it is general and non-conclusive.

In 2004, Cape Wind Associates LLC contracted with Applied Science Associates, Inc. (ASA) to perform an analysis to estimate the trajectories of oil spills and calculate probable estimates of area coverage and minimal travel time [1]. ASA developed a modeling tool, OILMAP, that was used to simulate these processes. In conjunction with another model, HYDROMAP, ASA was able to produce a model that allowed course grid resolution in the areas offshore the coasts of Massachusetts and Rhode Island and finer resolution in Nantucket Sound. A total of 100 dielectric insulating oil spills were simulated with varying seasons and wind conditions. The simulations yielded the following area oiling results:

- If a spill were to occur, there is >90% probability that oil will travel towards Cape Cod and Martha's Vineyard;
- The model results indicate the central and western area of the Cape Cod coast and the east/northeast coasts of Martha's Vineyard are the most vulnerable;
- The shortest times for each of the scenarios range from 4.8 to 11.3 hours.

Rapid increases in fuel and production costs have forced US utilities to investigate many new alternative sources that were overlooked less than 10 years ago. Southeast New England and mid-Atlantic coastal zones have all the regional ingredients to become a global leader in offshore renewable power: strong offshore winds, a major project that is in the process of being permitted, multiple port facility access, a skilled workforce for labor and manufacturing, and a rich maritime tradition. Cape Wind's model predictions have estimated the net energy production delivered to the regional power grid to be in the 1,600-1,800 GWh/year range. This annual electrical production rate is equal to power generated from 113 million tons per year heavy oil power plant or 570,000 tons per year coal power plant. Because its biological diversity is unique, protection of Nantucket Sound and future turbine powered coastal zones is important. The goals of this project were devised to provide a valuable source of information regarding the installation and operation of wind-powered structures within the region. The information acquired from this study will help BOEMRE, USCG, and NOAA to safeguard our natural resources from possible spills involving dielectric insulating fluids and mineral oils along our nation's coastlines. Results from this study will aide federal and state planning and management personnel when designing coastal use permits for future offshore wind generation systems.

OBJECTIVE

The objective of this research project was to provide a comprehensive study and analysis of the weathering behavior, dispersibility, and the window of opportunity for using short-term response options for removal of spilled dielectric fluid in the marine environment. The studies were conducted using MIDEL 7131(pentaerythriol fatty acis ester), a widely used dielectric fluid in European turbine power systems. The goals of the proposed project were achieved through a series of three (3) tasks: (1) a series of laboratory flask studies to determine weathering characteristic; (2) a laboratory flask study to measure the effects of long-term weathering and biodegradation on dielectric insulating fluid in the marine environment; (3) a series of field studies to accurately determine capabilities/limitations of conventional response tools for removal of dielectric fluids from the marine environment. In this study, biodegradation and bench top dispersibility studies were conducted at Louisiana State University's (LSU) Department of Environmental Sciences (DES) Response and Chemical Assessment Team (RCAT) laboratory in Baton Rouge, Louisiana. Large-scale tank tests, using Corexit 9500, were conducted at the Ohmsett wave tank facility in Leonardo, New Jersey.

STUDY APPROACH

The inception of the Cape Wind Project has sparked much interest in the behavior and fate of dielectric insulating oil in the marine environment. In order to provide a comprehensive analysis of the possible fate and effects of spilled dielectric insulating oil, LSU and BOEMRE has conducted a collaborative one (1) year project to provide a detailed literature review and scientific information on the characteristics, weathering behavior, and window of opportunity for using short-term response options for removal of spilled dielectric fluids in the marine environment. The goals of this project were achieved through a series of laboratory and field-scale studies conducted at research facilities in Baton Rouge, Louisiana (LSU) and Leonardo, New Jersey (Ohmsett). The Ohmsett facilty is the only facility where full-scale oil spill response equipment testing, research, and training can be conducted in a marine environment with oil and fluids under controlled environmental conditions (waves, temperature, oil types). The facility provides an environmentally safe place to conduct objective testing and to develop devices and techniques for the control of oil and hazardous material spills. The facility is maintained and operated by the Bureau of Ocean Management, Regulation and Enforcement (BOEMRE) through a contract with MAR, Incorporated of Rockville, Maryland. The flask and bioremediation studies were conducted at LSU facilities, while the oleophilic skimmer tests and dispersant studies were carried out at the Ohmsett research facility.

MATERIALS & METHODS

Artificial Weathering of Dielectric Fluid

MIDEL 7131 was artificially weathered in order to simulate evaporative losses typically encountered following a spill at sea. Typically, dispersants are applied to the oil during the 6-12 hour window of opportunity following the initial spill. Approximately 500-ml of dielectric fluid was placed in a preweighed 1000-ml Pyrex beaker in a fume hood with a controlled air flow system and allowed to evaporate. The weight of the fluid and beaker were recorded at the start of the experiment. Triplicate density measurements were determined by weighing known volumes of fluid at the beginning and end of the experiment. Average initial density results were compared to published literature (M&I Material Ltd). Temperature (20-22°C) and air flow (~ 0.8 m/sec) within the fume hood was monitored and recorded during the experiment. The artificial weathering process was concluded after 96 hours. This "weathered" dielectric fluid was used as the starting material for all the experiments. The weathered fluid was stored in multiple glass bottles in a secured refrigerator (4°C) prior to use.

SFT and BFT Experiments

A series of bench-scale laboratory studies were performed to determine the dispersibility of dielectric fluid in the marine environment. Past research has determined the swirling flask dispersant effectiveness test (SFT), baffled flask dispersant effectiveness test (BFT), and Warren

Springs Laboratory test (WSLT) to be the most effective tests for determining product dispersibility. Table 1 gives an overview of the sample treatments and analytical determinations performed during the laboratory flask dispersibility studies.

Table 1. Dispersant Study Sampling and Analysis Matrix

Treatment	No. of samples at sampling temperature		Total No. of analytical determinations	
	40°F	72°F	GC/MS	Gravimetric
Control	4	4	8	8
Corexit 9500				
DOR=10	4	4	8	8
DOR=20	4	4	8	8
Corexit 9527				
DOR=10	4	4	8	8
DOR=20	4	4	8	8

Salinity = 30-32 PPT
DOR = Dispersant to oil ratio

Materials

Two differently designed flasks were utilized for the SFT and BFT experiments. Modified 150-ml glass Erlenmyer flasks with open top were used in all swirling flask tests. A side spout was added to the swirling flasks to enable sampling of the water without disturbance of resurfacing oil. The baffled flask tests used modified 150-ml baffled trypsinizing flasks with screw caps at the top and a glass stopcock near the bottom of the flasks. An orbital shaker (Lab-Line Instruments Inc, Melrose Park, IL) with variable speed controls (40-400rpm) and an orbital motion of 1 in. was used to provide agitation in the test flasks. A Brinkmann Eppindorf repeater pipetor (Fischer Scientific, Pittsburg, PA) capable of accurately dispensing 5 µl of dispersant and 100 µl of oil was used with the flask studies. Glassware used in the tests consisted of a 250-ml graduated cylinder, 125-ml separatory funnel with Teflon stopcock, Pasteur pipettes, and 50-1000 µl gas tight syringes. Natural sea water was collected from Grand Isle, Louisiana (salinity=33 ppt) and used in all SFT and BFT. A dielectric fluid sample, MIDEL 7131 (M&I Material Ltd), was provided by BOEMRE. The physical and chemical properties for MIDEL 7131 are shown in Table 2.

A 250-ml separatory funnel was used to determine the efficacy of the dispersant in the Warren Spring Laboratory Test. A Burrell Wrist Action Shaker, model 75 (Burrell Scientific, Pittsburgh, PA) was used to agitate MIDEL 7131 and water mixture during testing. Additional glassware used in the Warren Spring Laboratory tests consisted of a 250-ml graduated cylinder, 100-ml separatory funnel with Teflon stopcock, Pasteur pipettes, 5-ml glass syringe, and 50-1000 µl gas tight syringes. Natural sea water was collected from Grand Isle, Louisiana (salinity=33 ppt).

Table 2.MIDEL 7131 Properties

Physical State:	Organic liquid
Odor:	Faintly sweet
Melting Point/Freezing Point:	-57°C
Boiling Point:	>300°C
Flash Point (Closed Cup):	260°C
Flammability:	Non flammable
Vapour Pressure at 20°C:	<0.01 Pa
Relative Density at 20°C:	970 Kg/m^3
Water Solubility:	<1 mg/L
Partition Coefficient, log K_{ow} :	>6.74
Auto-ignition Temperature:	No auto-ignition expected
Viscosity at 40°C:	28 mm^2/sec

Methods

SFT and BFT Dispersant Effectiveness Tests:

The weathered MIDEL 7131 and dispersant solutions were premixed at a volumetric ratio of 1:10 and 1:20 (SFT and BFT tests) in a 40-ml amber vial and mixed vigorously prior to each tests. A 100 µl volume of MIDEL 7131 or MIDEL 7131 -dispersant mixture was dispensed using Eppendorf repeating pipette onto the surface of 120-ml natural seawater in either the side spout flasks (SFT) or baffled trypsinizing flasks (BFT). For each sample, four (4) replicates were prepared. The flasks were then placed on the orbital shaker and mixed for 20 minutes at a rotational speed of 200 rpm. After 20 minutes, the orbital was turned off and the flasks were place on the laboratory bench and allowed to remain stationary for an additional 10 minutes. Following the equilibration time period, approximately 2-3 ml of water sample was drained from the individual side spout or stopcock flasks and discarded. A 30-ml volume of water sample was then drained from the flasks into a 50-ml volumetric cylinder. The 30-ml water sample was then transferred to a 125-ml separatory funnel and extracted three (3) times with 5-ml hexane aliquots and drained through a sodium sulfate funnel (H_2O removal) into a 40-ml amber vial. The extract was then adjusted to a final volume of 25-ml and stored in a 4°C refrigerator until the time of analysis. Natural seawater blanks were prepared with each batch of SFT or BFT treatment samples tested. The preparation and extraction of the seawater blanks followed the same experimental protocol as the SFT and BFT treatments, but lacked addition of MIDEL 7131 or dispersant. The seawater blanks were used to correct for potential error from existing contaminates in the seawater sample before reagents are added. All experimental treatments were conducted in a temperature controlled room at the desired temperature (40 and 70°F ± 1°F). For each sample, four (4) replicates were prepared. Gravimetric analysis was not performed on the SFT and BFT due to small volume of MIDEL 7131 spiked.

Warren Spring Laboratory Effectiveness Tests:

The experimental treatments were conducted in a temperature controlled room at the desired temperature (40 and 70°F ± 1°F). For each sample, four (4) replicates were prepared. The unstoppered separatory funnel was placed on the wrist action shaker and clamped securely. Approximately 250-ml of natural seawater was added to the separatory funnel. Using the 5-ml glass syringe, a 5.0 ml aliquot of MIDEL 7131 was added to the surface of the natural seawater. After one (1) minute, a specific amount of dispersant (DOR= 1:10 or 1:20) was evenly distributed to the surface of the separatory funnel. The control treatments were spiked with MIDEL 7131 only. The stopper was securely fastened to the separatory funnel and the entire apparatus was allowed to stand for 2.5 minutes. The separatory funnels were then mechanically shaken for approximately 2 minutes and allowed to stand for 1 minute. The stopcock was opened and 50 ml of water was drained into a graduated cylinder. The 50-ml water sample was then transferred to a 125-ml separatory funnel and extracted three (3) times with 20 ml hexane aliquots and drained through a sodium sulfate funnel into a 100-ml volumetric flask. The graduated cylinder was rinsed with 20 ml of hexane and rinsate was passed through the sodium sulfate funnel into the flask. The sodium sulfate funnel was thoroughly washed with hexane and then the volumetric flask was filled to the mark with hexane. The flask was then stoppered and shaken well. The preparation and extraction of the seawater blanks followed the same experimental protocol as the MIDEL 7131 -dispersant treatments, but lacked addition of MIDEL 7131 or dispersant.

Gravimetric Analysis:

Gravimetric analysis is the initial method to evaluate the effectiveness of an oil or bioremediation agent for oil spill response. The disappearance of oil and significant decreases in total oil residue weight versus a control is a strong indicator of materials biodegradability. Gravimetric analysis was performed by taking 15 ml from the final extract and placing in a pre-weighed 40-ml glass vial. The vial was placed beneath a purified nitrogen stream and allowed to evaporate to dryness. The residual weight of the MIDEL 7131 was measured three (3) times and recorded.

Bioremediation Study

This bioremediation effectiveness testing protocol (CFR, 1999) was designed to determine oils ability to naturally biodegrade by quantifying changes in the oil composition resulting from biodegradation. The protocol determines changes in the materials composition through the use of GC/MS, gravimetric and microbial enumeration determination. The sample preparation procedure extracts the oils into hexane and the analytical method uses a high resolution GC/MS and gravimetric analysis to determine the overall biodegradability of the test oil. Microbial enumerations are performed at each sampling period using a microtiter Most Probable Number (MPN) determination. The bioremediation protocol consists of an experimental shaker flask setup with a specific set of microbiological and chemical analyses that are performed on individual oil or product samples. Treatments typically include a control, nutrient, and product samples. An EPA National Contingency Plan (NCP) approved product, Oil Spill Eater II (Oil Spill Eater International, Corp.), was include in the experimental design. Bioremediation testing on Oil Spill Eater II (OSE II) has proven it to be effective at degrading highly-saturated crude oils in the laboratory. The following test flasks (labeled with unique identifiers) were prepared and set up on an orbital shaker at day 0 to reflect the following treatment:

Table 3. Bioremediation Study Sampling and Analysis Matrix

Treatment	No. of samples at sampling times			Total No. of analytical determinations		
	Day 0	Day 7	Day 28	Microbial Counts	GC/MS	Gravimetric
Control	3	3	3	9	9	9
Nutrient	3	3	3	9	9	9
Product*	3	3	3	9	9	9

Control = Oil + Seawater
Nutrient = Oil + Seawater + Nutrients
Product = Oil + Seawater + Nutrients + Product
*A NCP approved product, OSE II

A detailed description of the test procedure can be found in the Code of Federal Register Title 40, Chapter 1 Part 300.

Materials

The bioremediation studies used 250-ml Erlenmeyer flasks to determine MIDEL 7131's ability to degrade in the marine environment. An orbital shaker (Lab-Line Instruments Inc, Melrose Park, IL) with variable speed controls (40-400rpm) and an orbital motion of 1 in. was used to provide agitation in the test flasks. A Mettler model PM600 balance (Mettler-Toledo, Inc., Columbus, OH) was used to determine mass of material accurate to 0.01 mg. A Brinkmann Eppindorf repeater pipetor (Fischer Scientific, Pittsburg, PA) capable of accurately dispense material during the preparation of culture media and nutrient solutions. Glassware used in the tests consisted of a 250-ml graduated cylinder, 125-ml separatory funnel with Teflon stopcock, Pasteur pipettes, and 50-1000 ul gas tight syringes. Natural sea water was collected from Grand Isle, Louisiana (salinity=33 ppt) and used in all SFT and BFT. A dielectric fluid sample, MIDEL 7131 (M&I Material Ltd), was provided by BOEMRE. The MIDEL 7131 used during the bioremediation study was prepared as described in the Artificial Weathering of Dielectric Fluid section of this report.

An Agilent Technologies-7890A gas chromatograph (GC) interfaced to an Agilent Technologies 5975 Inert XL mass selective detector (MSD) operated in electron ionization mode (70eV) with helium as a carrier gas was used determine MIDEL 7131 concentrations in analytical standards and samples. An Agilent Technologies 7683B series injector was used to inject the standard and samples extracts. The MSD scanned the mass range (50-550 amu) every 3 seconds. The GC oven contained a HP-5MS (30 m, 0.25 mm i.d., 0.25 µm film thickness) and was programmed to ramp in temperature from 60°C (1.5 min.) to 280°C at 20°C min^{-1}, and then at 4°C min^{-1} to 300° (52.5 min.).

Methods

Nutrient and Bioremediation Agent Preparation:

A mineral nutrient solution was added to designated treatments to prevent nutrient-limitation within treatments. The initial stock salt and mineral solutions were prepared, pH adjusted, and autoclaved as specified in EPA 40 CFR Pt. 300, App. C. The final concentrate solution was prepared by adding designated volume of solutions to non-sterile natural seawater and made up to a 1000-ml volume immediately prior to testing. The bioremediation agent, OSE II, was prepared as specified on the package labeling.

Bioremediation Study Setup:

The test flasks were prepared and set up on a gyratory shaker at day 0 according to the experimental design displayed in table 4. Approximately 100 ml of natural seawater was poured into the individual flasks, followed by the addition of 0.5 g (515 µl) MIDEL 7131. Care was taken to minimize splashing oil on sides of glassware and preventing microbial contamination. The flasks were shaken at 200 rpm at 20ºC until removed for sampling at the designated time. The control and treatment (nutrient and product flasks) were sampled three (3) times over a 28-day period. The entire flask was sacrificed for analysis; a 0.5-ml aliquot was removed from each flask for the microbiological analysis and the remainder of each flask was used for the chemical analysis.

The viability of the hydrocarbon degrading microbial cultures was determined at each sampling time using a microtitter MPN determination. This is used as an indicator of the relative change of the biomass. The test method relies on monitoring growth response as an indication of healthy or enhanced microbial activity as compared to the control treatment. After 0, 7, and 28 days of incubating on the rotary shaker, a 0.5-ml aliquot was removed from each flask for the microbial analysis. Detailed information relating to the preparation of media and microbial enumeration is located in 40 CFR Ch. I, PT. 300, App. C.

After 0, 7, and 28 days of incubating and rotating on the orbital shaker, the appropriate flasks were sacrificed for chemical analysis. Following removal of microbial sample, the entire contents of the flasks were transferred to a 250-ml separatory funnel. The treatment flask was thoroughly rinsed with a 50-ml aliquot of DCM and rinsate poured into the appropriate separatory funnel. A 100-µl aliquot of surrogate standard (2,000 µg/ml d10-phenanthrene and 5α-androstane solution) was added to each flask. The 250-ml separatory funnel was capped and gently shaken for approximately three (3) minutes and placed on a ring stand. The water/solvent mixture was allowed to stand for 15 minutes or until the water/solvent phase separated. The first 10 ml of DCM extract was drained into a 20-ml vial and retained for gravimetric analysis. The remaining DCM extracted was drained through a sodium sulfate drying funnel into a 250-ml flat bottom flask. The flask containing the DCM extract was placed on a Rotovapor R-114 concentrator unit (Buchi Corporation, New Castle, DE) and concentrated to a volume of approximately 10 ml. The DCM extract was exchanged to hexane with the addition of approximately 30 ml of pesticide grade hexane. The hexane exchanged extract was concentrated to a volume of approximately 5 ml and removed from the Rotovapor unit. The hexane extract was transferred to a 15-ml micro-extraction thimble. The flat bottomed flask was rinsed with approximately 10 ml hexane and rinsate transferred to the micro-extraction thimble. A 3-ball micro Snyder column was attached to the thimble and the apparatus was placed in a hot water bath. The hexane extract was concentrated to a volume less than 0.5 ml and immediately removed from the water bath. The extract was drawn into a Pasteur pipette and rinsed along sides of extraction thimble. The final volume was adjusted to 1.0 ml and extract was transferred to a 2.0-ml autosampler vial. A 10-µl aliquot of internal standard (1000 µg/ml d8-naphthalene, d10-acenaphthene, d12-chrysene, and d12-perylene solution) was spiked into extract and vial was immediately capped and stored in 4ºC refrigerator until analysis.

The gravimetric analysis was performed by taking a 10-ml aliquot removed prior to the final GC/MS extraction procedure and placing in a 20-ml pre-weighed vial. The vial was placed beneath a steady stream of purified nitrogen and extract was concentrated to dryness. The residue was weighed three (3) times and weight was recorded in log book. Results from the gravimetric analyses of the MIDEL 7131 with bioremediation agent, MIDEL 7131 with nutrient, and MIDEL 7131 control were statistically compared at respective times to determine if advisable to continue GC/MS analyses.

MIDEL 7131 Standard Calibration Preparation:

The dielectric fluid calibration standards used during this study (dispersibility and bioremediation tests) were prepared according to the methodology used in previously published methods (U.S. EPA, 1996). For all GC/MS analysis, standard solutions of dielectric fluid were prepared with MIDEL 7131 neat sample. A dielectric fluid with dispersant calibration standard was not prepared due to the GC/MS system's ability to separate and differentiate the DIF and dispersant components. A stock solution of MIDEL 7131 stock solution was prepared by adding 2.5-ml of weathered dielectric fluid into a 25-ml class A volumetric flask and filling to volume with pesticide grade dichloromethane (Mallinckrodt, St. Louis, MO). Specific volumes of 260, 130, 52, 26, 13, and 3.0 µl of weathered MIDEL 7131 stock solution were added to 30-ml of natural seawater in a separatory funnel and extracted three (3) times with 5-ml of dichloromethane (DCM) and passed through a sodium sulfate funnel to remove water. The combined final extract volume was adjusted to 50-ml and transferred to two (2) amber 40-ml glass vials for storage in a 4°C refrigerator. The dielectric fluid standard solution and MIDEL 7131 plus dispersant standard solution final concentrations are displayed in Table 4.

Table 4. MIDEL 7131 Standard Solutions*

Volume of stock solution added to seawater (µl)	Total amount of MIDEL 7131 in standard (mg)	Final extract volume (ml)	Final MIDEL 7131 concentration (µg/ml)
260	25	50	500
130	12.5	50	250
52	5	50	100
26	2.5	50	50
13	1.25	50	25
3	0.31	50	5

* Assuming an oil density of 0.97 g/ml and an extraction efficiency of 100% for MIDEL 7131 from the natural seawater.

Sample Analysis:

The GC/MS system was calibrated and operated using a modified EPA method 8270. A five-point MIDEL 7131 calibration standard curve was prepared by analyzing 5, 25, 50, 100, 250, and 500 μg ml^{-1} concentration levels on the GC/MS system. At the beginning of each analysis period, the MS system was tuned using PFTBA to verify the system's stability and sensitivity. Once the initial calibration was established, a daily calibration standard (250 µg/ml) was analyzed prior to analyzing instrument blanks and unknown treatment extracts. All standard, blank, and sample treatment extracts were injected using a volume of 1 ul with injector in splitless mode. If required, samples extracts were diluted with hexane so extract concentrations were within the GC/MS calibration range.

Ohmsett MIDEL 7131 Field Study

The MIDEL 7131 field study consisted of a week-long series of tests at Ohmsett, the National Oil Spill Response Research and Renewable Energy Test Facility, located in Leonardo, New Jersey. The primary goal of the study was to determine the dispersibility of DIF using COREXIT® 9500 and determine the capabilities and limitations of common response tools, namely oleophilic skimmers. Full-scale dispersant testing was conducted in Ohmsett's main test tank and mechanical recovery testing was performed on the deck of the main tank using three (3) types of oleophilic skimmers: a drumskimmer, a disc skimmer, and a rope-mop skimmer.

Oleophilic Skimmer Testing

The mechanical recovery testing followed the test protocol outlined in the American Society for Testing and Materials (ASTM) F 2709-08 – *Standard Test Method for Determining Nameplate Recovery Rate of Stationary Oil Skimmer Systems*. The MIDEL 7131 DIF used during the oleophilic testing was dyed red to increase visibility while making measurements. In addition to MIDEl 7131, two (2) comparison oils (Hydrocal lube oil and diesel) were tested during the mechanical recovery portion of the test. The objective of the mechanical recovery testing was to quantify the Oil Recovery Rate (ORR) and Recovery Efficiency (RE) for each of the three (3) test oils using each of the drum skimmers. A detailed description of the mechanical recovery tests can be found in Appendix A of this report.

Wave Tank Dispersant Effectiveness Testing

The second phase of the Ohmsett field study was a full-scale dispersant study, conducted in the main test tank. Effectiveness of the dispersant tests was determined by physically measuring floating DIF on the water surface. In addition to physical measurements, a LISST 100 particle size analyzer was utilized to confirm the presence of DIF in the water column and to characterize the oil drop distribution. Prior to the dispersant tests, a control run was performed without the application of COREXIT® 9500 to the slick. Natural dispersion was observed and the DIF that remained on the surface of the wave tank after 30 minutes was corralled, collected, dewatered, and quantified. During the two (2) dispersant tests, COREXIT® 9500 dispersant was applied to the DIF slick at a dispersant-to-oil ratio (DOR) of 1:20. Following application of dispersant to entire DIF slick, the main bridge of wave tank was brought to a stop, then run back in the direction of the slick so the LISST 100 could record oil droplet size and in-water oil concentration. A detailed description of the wave tank and dispersant tests can be found in Appendix B of this report.

RESULTS AND DISCUSSION

Figures 1 and 2 show the GC/MS results obtained for the SFT, BFT, and SWLT tests at 4° and 22°C. It can be seen that dispersant effectiveness was significantly lower for both Corexit 9500 and Corexit 9527 at the lower test temperature. The average dispersion of MIDEL 7131 controls ranged from 0.054 to 3.00 % for all tests. Corexit 9500 exhibited a higher average dispersant effectiveness over Corexit 9527 for all flask tests. At 4°C, the SFT did not achieve greater than 21.1% effectiveness. The BFT and WSLT were comparable in effectiveness, ranging from 35.3 to 45.8% dispersant effectiveness at 4°C. At 22°C, the SFT never achieved greater than 45.7% effectiveness. Once again, the BFT and WSLT were comparable in effectiveness, ranging from 71.8 to 84.7% dispersant effectiveness at 22°C. Due to the large amounts of MIDEL 7131 used for testing, gravimetric analyses were performed on the WSLT. The WSLT gravimetric results (Tables A7-A8) were comparable to GC/MS results at both temperatures. All tests results indicated there was slightly higher dispersant effectiveness when MIDEL 7131 was dispersed at DOR 1:20, compared to DOR 1:10. Tabular results from the dispersant effectiveness tests can be viewed in Appendix A, tables A1-A8.

It can be observed in figure 3 that the overall MIDEL 7131 biodegradation rate is higher for product + nutrient than nutrient alone. The seawater control treatments averaged a 9.47% decrease over the 28 day test period. The nutrient and nutrient + product treatments averaged 50.0% and 78.0% MIDEL 7131 concentration decreases, respectively. In general, it was observed that the numbers of oil degrading bacteria increased with time in the MIDEL 7131 contaminated treatments. The increase in bacteria populations was more pronounced in both the nutrient and nutrient + product treatments. Figure 4 shows the increase in bacteria numbers for the three (3) different tests treatments (control, nutrient, nutrient + product). The curves within figure 4 are representative of the growth phases (exponential, stationary, and death) observed in bacteria growth kinetic studies. The bioremediation study results for MIDEL 7131 were slightly lower than those advertised by the manufacturer (89% at 28 days). The increase in manufacturer's biodegradation results was due to use of enriched microbial inoculum during testing. Tabular results from the bioremediation tests can be viewed in Appendix A, tables A9-A13.

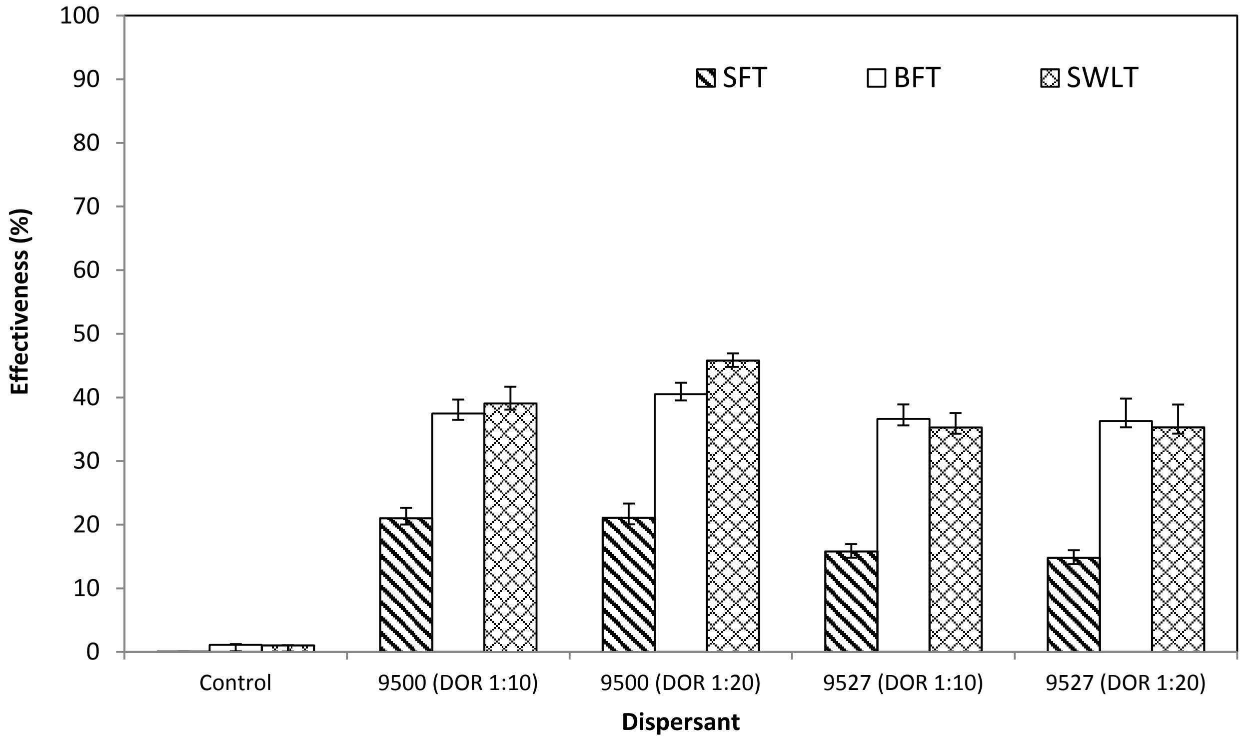

Figure 1. Avg. Dispersant Effectiveness for SFT, BFT, and SWLT Tests at 4ºC (GC/MS)

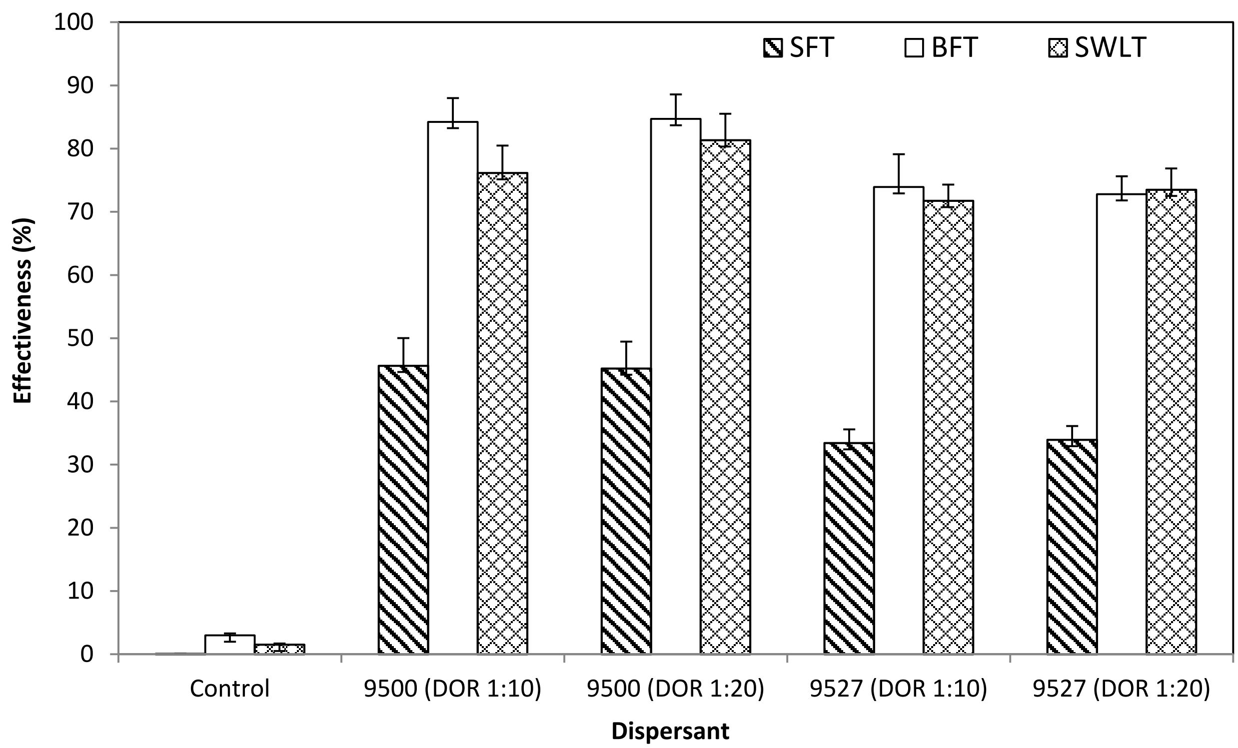

Figure 2. Avg. Dispersant Effectiveness for SFT, BFT, and SWLT Tests at 22ºC (GC/MS)

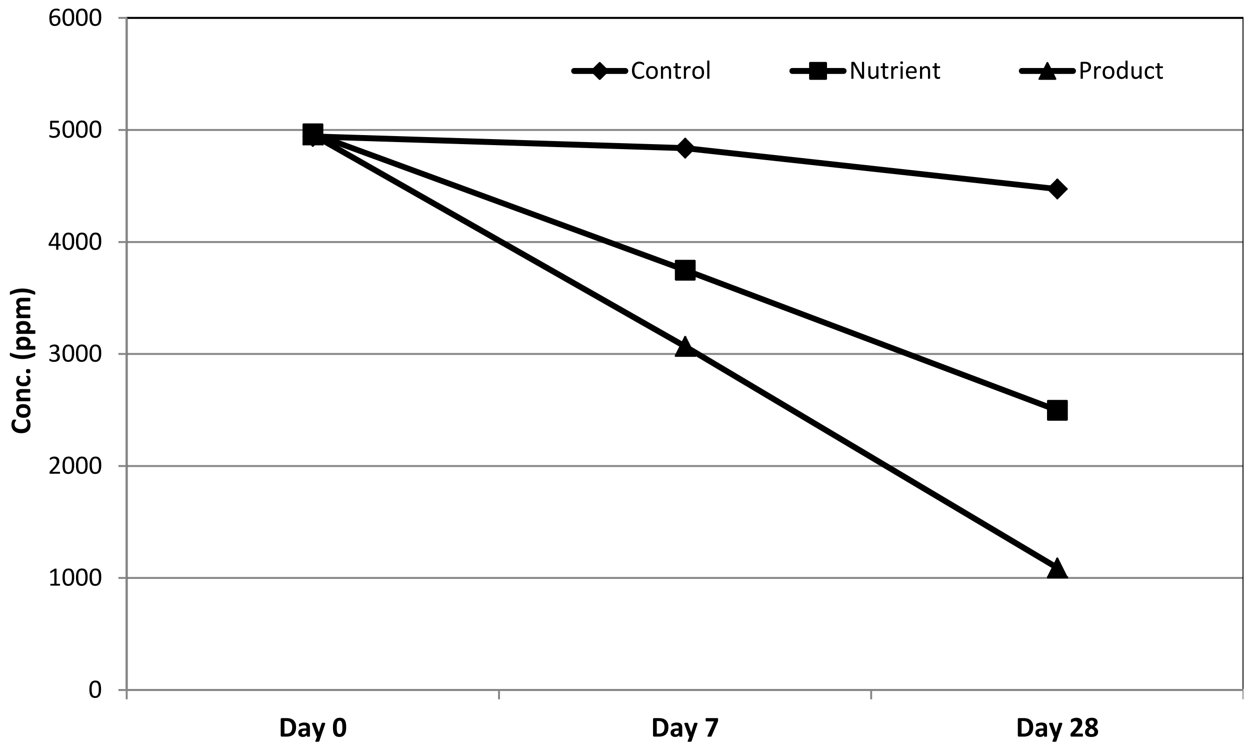

Figure 3. Average MIDEL 7131 Concentration for Bioremediation Tests (GC/MS)

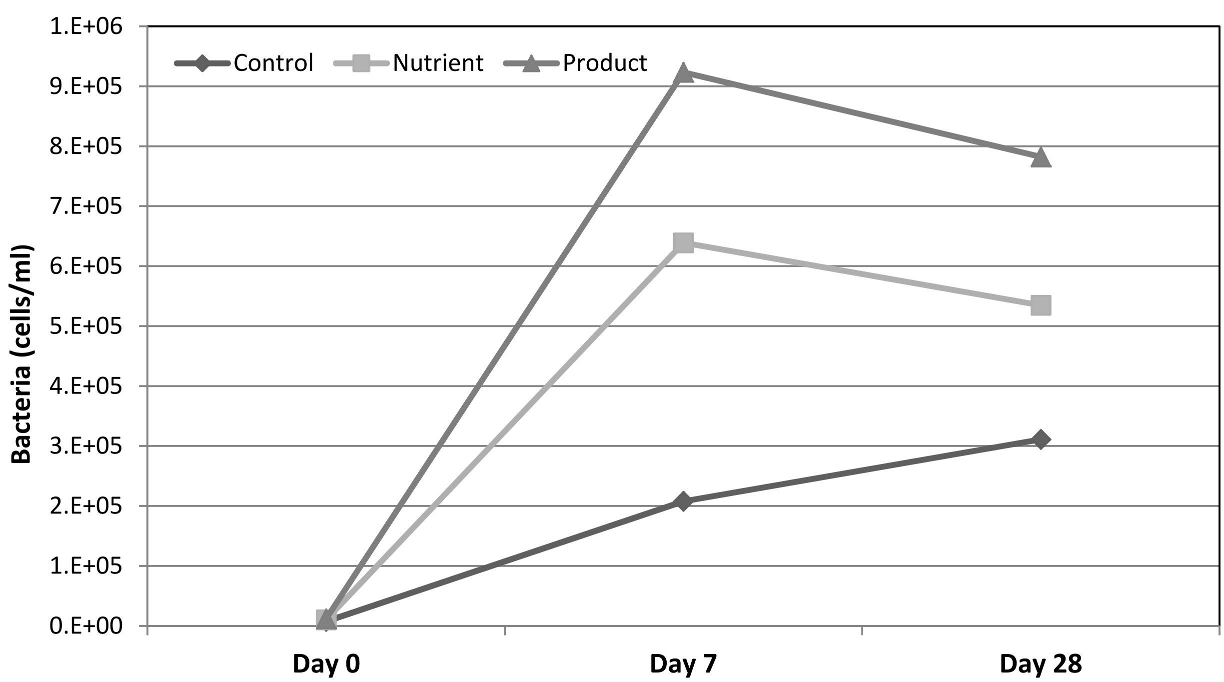

Figure 4. Average Bacterial Count for Bioremediation Tests (MPN)

Tables 5 and 6 show the results obtained for the Ohmsett field tests. The skimmer tests were performed in a steel-framed fabric tank on the deck of Ohmsett's main test tank as per the ASTM F 2709-08 test protocol. The skimmer tests (see table 5) employed two (2) reference oils (diesel and hydrocal) that bracketed the lower and upper viscosity range of the test oil. The disc skimmer exhibited the highest ORR for MIDEL 7131 at 6.4 gpm. The rope and drum skimmer had an ORR of 1.7 and 5.0 gpm, respectively. Results from the Ohmsett dispersant efficiency tests are shown in table 6. The control run indicated that MIDEL 7131 has a natural dispersant rate of approximately 25%. MIDEL 7131 dispersant run #1 and #2 had a dispersant efficiency rating of 100 and 99%, respectively. A complete summary of the Ohmsett field study is located in Appendix B.

Table 5. Oil Recovery Rate (ORR) for Ohmsett Skimmer Tests

Skimmer	ORR (gpm)		
	Diesel	Midel 7131	Hydrocal
Rope Mop	0.5	1.7	2.6
Drum	0.7	5.0	10.2
Disc	1.0	6.4	8.3

Table 6. MIDEL 7131 Dispersant Efficiency Rate for Ohmsett Wave Tank Tests

Treatment	Released (gallons)	Recovered (gallons)	Dispersant Efficiency Rate (%)
Control	23.5	17.5	25
Run #1	25.0	0.00	100
Run #2	25.5	0.25	99

CONCLUSION

The SFT gave very poor results with dispersant effectiveness less than 21% and 46% at a temperature of 4° and 22°C, respectively. For the BFT and WSLT, the dispersant effectiveness achieved was significantly higher for MIDEL 7131. The increase in DOR also resulted in a considerably increase in dispersant effectiveness. The bioremediation study results indicated that MIDEL 7131 is highly biodegradable and addition of microbial inoculum significantly enhances the fluid's biodegradation kinetics. The Ohmsett field study showed that MIDEL 7131 could be effectively removed from the water's surface using a disc skimmer recovery system. The wave tank study reinforced the results from the flask dispersant effectiveness studies, concluding that MIDEL 7131 is nearly 100% dispersible in the marine environment at the tested conditions. However, further evaluation of MIDEL 7131's bioremediation kinetics and breakdown products need to be conducted. Additional research is required for the detection of spilled dielectric fluids in the marine environment. Due to lack of color and fluorescence, detection and monitoring of MIDEL 7131 would be difficult under normal sea conditions.

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APPENDIX A

LABORATORY FLASK STUDY

Table A1. SFT - Dispersant Effectiveness Test at 4°C (GC/MS)

Dispersant	DOR	% Effectiveness of the replicate samples R1	R2	R3	R4	Average % Effectiveness	Coeff. Of Variation
Control	-	0.048	0.053	0.055	0.061	0.054	9.91
Corexit®9500	1:10	20.3	22.6	22.1	19.1	21.0	7.70
Corexit®9500	1:20	18.9	19.7	23.9	21.8	21.1	10.7
Corexit®9527	1:10	16.2	15.3	17.2	14.5	15.8	7.36
Corexit®9527	1:20	14.3	13.6	16.4	14.9	14.8	8.05

Table A2. SFT - Dispersant Effectiveness Test at 22°C (GC/MS)

Dispersant	DOR	% Effectiveness of the replicate samples R1	R2	R3	R4	Average % Effectiveness	Coeff. of Variation
Control	-	0.066	0.073	0.081	0.074	0.074	8.35
Corexit®9500	1:10	48.1	49.6	39.7	45.2	45.7	9.57
Corexit®9500	1:20	43.1	48.2	40.3	49.3	45.2	9.40
Corexit®9527	1:10	36.2	31.1	32.6	33.8	33.4	6.45
Corexit®9527	1:20	35.7	35.1	30.8	34.1	33.9	6.44

Table A3. BFT - Dispersant Effectiveness Test at 4°C (GC/MS)

Dispersant	DOR	% Effectiveness of the replicate samples R1	R2	R3	R4	Average % Effectiveness	Coeff. Of Variation
Control	-	1.12	1.24	1.16	0.951	1.12	10.9
Corexit®9500	1:10	40.1	38.3	35.1	36.4	37.5	5.84
Corexit®9500	1:20	39.4	41.5	38.7	42.5	40.5	4.38
Corexit®9527	1:10	35.5	34.3	39.6	37.1	36.6	6.26
Corexit®9527	1:20	38.0	31.4	36.3	39.5	36.3	9.69

Table A4. BFT - Dispersant Effectiveness Test at 22°C (GC/MS)

Dispersant	DOR	% Effectiveness of the replicate samples R1	R2	R3	R4	Average % Effectiveness	Coeff. of Variation
Control	-	2.98	2.84	3.41	2.75	3.00	9.76
Corexit®9500	1:10	80.1	83.5	89.2	84.1	84.2	4.46
Corexit®9500	1:20	83.1	86.4	89.1	80.2	84.7	4.58
Corexit®9527	1:10	70.2	75.6	69.4	80.5	73.9	7.00
Corexit®9527	1:20	72.8	71.6	76.7	70.1	72.8	3.88

Table A5. WSLT - Dispersant Effectiveness Test at 4°C (GC/MS)

Dispersant	DOR	% Effectiveness of the replicate samples R1	R2	R3	R4	Average % Effectiveness	Coeff. of Variation
Control	-	0.895	1.13	1.20	0.973	1.05	13.3
Corexit®9500	1:10	41.2	40.5	39.2	35.4	39.1	6.62
Corexit®9500	1:20	46.3	45.5	47.0	44.4	45.8	2.44
Corexit®9527	1:10	38.5	35.1	33.3	34.2	35.3	6.44
Corexit®9527	1:20	38.1	38.5	31.2	33.4	35.3	10.1

Table A6. WSLT - Dispersant Effectiveness Test at 22°C (GC/MS)

Dispersant	DOR	% Effectiveness of the replicate samples R1	R2	R3	R4	Average % Effectiveness	Coeff. of Variation
Control	-	0.067	0.058	0.070	0.072	0.067	9.27
Corexit®9500	1:10	78.2	76.2	80.1	70.1	76.2	5.69
Corexit®9500	1:20	81.2	75.6	85.4	83.1	81.3	5.15
Corexit®9527	1:10	69.5	72.1	75.2	70.2	71.8	3.55
Corexit®9527	1:20	70.4	75.5	77.2	70.9	73.5	4.58

Table A7. WSLT - Dispersant Effectiveness Test at 4°C (Gravimetric)

Dispersant	DOR	% Effectiveness of the replicate samples				Average % Effectiveness	Coeff. Of Variation
		R1	R2	R3	R4		
Control	-	1.44	1.59	1.48	1.86	1.59	11.9
Corexit®9500	1:10	43.5	49.1	43.1	38.5	43.6	9.97
Corexit®9500	1:20	36.9	47.3	50.1	46.7	45.3	12.7
Corexit®9527	1:10	46.8	36.9	35.4	37.1	39.1	13.4
Corexit®9527	1:20	40.5	41.1	34.5	36.4	38.1	8.38

Table A8. WSLT - Dispersant Effectiveness Test at 22°C (Gravimetric)

Dispersant	DOR	% Effectiveness of the replicate samples				Average % Effectiveness	Coeff. Of Variation
		R1	R2	R3	R4		
Control	-	2.64	2.78	2.43	3.33	2.80	13.8
Corexit®9500	1:10	90.1	77.9	81.4	65.2	78.7	13.1
Corexit®9500	1:20	84.2	80.4	88.9	84.7	84.6	4.11
Corexit®9527	1:10	83.4	73.8	67.8	74.6	74.9	8.58
Corexit®9527	1:20	85.1	78.2	80.2	71.9	78.9	6.93

Table A9. Bioremediation Study Average DIF concentration

Treatment	Day 0		Day 7		Day 28	
	Conc. (ppm)	% Loss	Conc. (ppm)	% Loss	Conc. (ppm)	% Loss
Control	4941	–	4837	2.12	4473	9.47
Nutrient	4966	–	3749	24.5	2497	50.0
Product	4957	–	3068	38.1	1090	78.0

Table A10. Bioremediation Study Analytical Results (GC/MS)

	Treatment	Concentration (ppm)				Std. Deviation	Coeff. of Variation
		R1	R2	R3	Average		
Day 0	Control	4914	4978	4932	4941	33.0	0.67
	Nutrient	4978	4936	4985	4966	26.5	0.53
	Product	4975	4925	4971	4957	27.8	0.56

	Treatment	Concentration (ppm)				Std. Deviation	Coeff. of Variation
		R1	R2	R3	Average		
Day 7	Control	4735	4880	4895	4837	88.4	1.83
	Nutrient	3655	3849	3742	3749	97.2	2.59
	Product	2910	3238	3056	3068	164.3	5.36

	Treatment	Concentration (ppm)				Std. Deviation	Coeff. of Variation
		R1	R2	R3	Average		
Day 28	Control	4401	4793	4226	4473	290.3	6.49
	Nutrient	2621	2548	2322	2497	155.9	6.24
	Product	991	1251	1028	1090	140.7	12.90

Table A11. Bioremediation Study Average Bacteria Count (MPN)

Treatment	Average Bacteria (cells/ml)		
	Day 0	Day 7	Day 28
Control	7505	207674	310925
Nutrient	10263	638881	534675
Product	11747	923247	782218

Table A12. Bioremediation Study Microbiology Results (MPN)

	Treatment	Concentration (ppm)				Std. Deviation	Coeff. of Variation
		R1	R2	R3	Average		
Day 0	Control	8072	7129	7313	7505	499.9	6.66
	Nutrient	9549	10791	10450	10263	641.7	6.25
	Product	11440	12100	11701	11747	332.4	2.83

	Treatment	Concentration (ppm)				Std. Deviation	Coeff. of Variation
		R1	R2	R3	Average		
Day 7	Control	200588	190109	232325	207674	21982.0	10.58
	Nutrient	619463	633015	664165	638881	22921.1	3.59
	Product	923838	954929	890974	923247	31981.6	3.46

	Treatment	Concentration (ppm)				Std. Deviation	Coeff. of Variation
		R1	R2	R3	Average		
Day 28	Control	332387	301056	299333	310925	18606.3	5.98
	Nutrient	526512	565516	511996	534675	27678.0	5.18
	Product	764660	796774	785221	782218	16266.2	2.08

Table A13. Bioremediation Tests Average Mass Decrease

Treatment	Avg. Mass Decrease (%) Day 0	Day 7	Day 28
Control	–	6.33	10.0
Nutrient	–	14.7	52.3
Product	–	17.7	67.7

Table A14. Bioremediation Study Gravimetric Results

	Treatment	Weight (g)				Std. Deviation	Coeff. of Variation
		R1	R2	R3	Average		
Day 0	Control	0.10	0.10	0.10	0.10	0.000	0.00
	Nutrient	0.10	0.10	0.10	0.10	0.000	0.00
	Product	0.10	0.10	0.11	0.10	0.006	5.59

	Treatment	Weight (g)				Std. Deviation	Coeff. of Variation
		R1	R2	R3	Average		
Day 7	Control	0.091	0.096	0.094	0.09	0.003	2.69
	Nutrient	0.091	0.086	0.079	0.09	0.006	7.06
	Product	0.081	0.085	0.089	0.09	0.004	4.71

	Treatment	Weight (g)				Std. Deviation	Coeff. of Variation
		R1	R2	R3	Average		
Day 28	Control	0.087	0.095	0.088	0.09	0.004	4.84
	Nutrient	0.044	0.048	0.051	0.05	0.004	7.4
	Product	0.029	0.034	0.037	0.03	0.004	12.12

APPENDIX B

OHMSETT SKIMMER & WAVE TANK STUDY

EXECUTIVE SUMMARY

Project: TO 469 - Dielectric Fluid Study at Ohmsett (2010)

Contact: M. Scott Miles
Environmental Engineer/Chemist
Louisiana State University
Department of Environmental Sciences
Response & Chemical Assessment Team - RCAT
1261 Energy, Coast, & Environment Building
Baton Rouge, LA 70803
Cell: (225) 936-5261
Office: (225) 578-4295
Fax: (225) 578-4286
Email: msmiles@lsu.edu

Test Dates: April 12 – 16, 2010

Offshore wind farms, such as the Cape Wind project, are proposed off the coasts of the United States. The Cape Wind project, which is scheduled to begin construction this year in Nantucket Sound, will consist of over one hundred wind turbine generators. Each wind turbine is approximately 450 feet high and the turbines will link to a centralized electrical station. It is estimated that the system will contain over 60,000 gallons of dielectric fluid, and researchers at Louisiana State University's (LSU) Department of Environmental Science (DES) are studying the characteristics, weathering behavior, and window of opportunity for using short-term response options for removal of spilled dielectric fluids in the marine environment.

LSU's DES coordinated a week-long series of tests at Ohmsett, the National Oil Spill Response Research and Renewable Energy Test Facility, located in Leonardo, NJ. The primary scope of this project was to determine the dispersibility of dielectric insulating fluid using COREXIT®

9500 and determine the capabilities and limitations of conventional response tools, namely oleophilic skimmers.

Full scale dispersant testing was conducted in Ohmsett's main test tank and mechanical recovery testing was conducted on the deck of the main tank using three types of oleophilic skimmers: a drum skimmer, a disc skimmer, and a rope-mop skimmer. In addition to testing Midel 7131 dielectric fluid (which was dyed red for visibility), two comparison oils were used during the mechanical recovery portion of the test. The two other test oils were Hydrocal (a medium viscosity lube stock) and diesel. Mechanical recovery testing followed the test protocol outlined in the American Society for Testing and Materials (ASTM) F 2709-08 – *Standard Test Method for Determining Nameplate Recovery Rate of Stationary Oil Skimmer Systems.*

ASTM F 2709-08 details the test protocol for skimmers; however, the protocol was utilized to test the recoverability of Midel 7131 as compared to two conventional petroleum products; diesel and Hydrocal. Mechanical recovery with drum, disc, or rope mop skimmers relies on the oleophilic nature of a skimmer's drum, disc, or rope mop surface. As an oleophilic drum, disc, or mop encounters oil, oil adheres to the drum, disc, or mop and is mechanically scraped off. Recovered oil flows into a sump where it is offloaded using an on-board hydraulically powered transfer pump, except in the case of the rope mop skimmer, which uses a gravity-drain sump.

The objective was to quantify the Oil Recovery Rate (ORR) and Recovery Efficiency (RE) for each of the three test oils using each of the three skimmers. A 102" x 100" x 30" steel-framed fabric tank with a capacity of 1000 gallons (which fills at approximately 45 gallons/inch, allowing for rounded corners and flexible curvilinear sidewalls) was erected on the deck of Ohmsett's main test tank, and a canopy was placed over the fabric tank to minimize solar heating of the test oil. The tank was filled with approximately 18" of water, which had a salinity of 32 parts per thousand (ppt). Prior to each test, oil was transferred into the portable tank to create a slick slightly greater than 3" thick, measured using a floating sight gage. Per the ASTM standard, tests were to start with a slick thickness of slightly more than 3 inches to purge recovered fluid in the cargo line from the previous test and to allow the system to reach steady-state recovery. Skimmer ORR and RE measurements were taken as the slick thickness declined from 3 to 2 inches. Qualifying tests were run three times and test results were considered valid if the values were within 20% of the arithmetic mean.

The two performance measurements were:

Oil Recovery Rate (ORR): Total volume of oil recovered by the device per unit of time (typically expressed as gallons per minute).

Oil Recovery Efficiency (RE): The ratio, expressed as a percentage, of the volume of oil recovered to the volume of total fluid (oil + water) recovered.

Oil was recovered into 55 gallon drums. At the start of the test, flow was diverted to a 'slop' drum to purge oil that was in the cargo line from the previous test. When approximately 2" (12 gallons) of oil was collected in the slop tank, flow was diverted to a 'collect' drum and timing began. Skimmer rpm was measured by counting drum/disc/rope revolutions, manually noting the time with a stopwatch, and adjusting the equipment to maintain consistent speeds from one test to another. When approximately 40 gallons had been recovered, flow was diverted back to the slop tank and timing ceased.

Oil temperature during the tests ranged from 46 °F to 62 °F. The Midel 7131 had a viscosity of 160 cP at 52 °F, roughly midway between the viscosity of diesel, 16 cp, and the viscosity of Hydrocal, 400 cP. Similarly, the Oil Recovery Rate for the Midel 7131 was roughly midway between the recovery rates of diesel and Hydrocal for each of the skimmers. With the rope mop skimmer the ORR of diesel was 0.5 gallon per minute (gpm); Midel 7131 had an ORR of 1.7 gpm, and Hydrocal had an ORR of 2.6 gpm. Using the drum skimmer, diesel was recovered at 0.7 gpm; Midel 7131 was recovered at 5.0 gpm; and Hydrocal was recovered at 10.2 gpm. With the disc skimmer, diesel was recovered at 1.0 gpm; Midel 7131 was recovered at 6.4 gpm; and Hydrocal was recovered at 8.3 gpm.

The second phase of the test was a full-scale dispersant test, conducted in the main test tank. Ohmsett's main test tank, which is 667 ft long and 65 ft wide, is spanned by three moveable bridges. The Main Bridge supports: a bridgehouse, where the bridge drive controls are located; an oil storage tank, which is connected to a calibrated metering pump for dispensing oil onto the water surface of the test tank; and a pallet mounted pump system for dispensing controlled amounts of dispersant via a set of nozzles mounted on a rail, the rail deployed approximately 30" above the water surface of the test tank.

The test method was to start Ohmsett's wavemaker, laydown the oil to create a slick and finish applying dispersant to the slick just as the waves began breaking. Ohmsett's wavemaker was set to a 3" stroke, the wave damping beaches were in the 'up' position, and the wavemaker was set to a frequency of approximately 35 cpm (adjusted as needed to compensate for wind conditions) to produce waves that were occasionally breaking. When wave conditions were on the verge of breaking, the Main Bridge was accelerated to test speed, generally 0.5 - 1.0 kt depending upon the wind. Once at speed, the oil distribution manifold was opened and oil flowed onto the surface of the tank creating an oil slick. Once the proper amount of oil was on the tank (generally 20 gallons) the oil distribution manifold was closed.

A control run was performed where dispersant was not applied to the slick. There was some natural dispersion observed and the oil that remained on the surface of the tank after 30 minutes was corralled, collected, dewatered, and quantified. 23.5 gallons had been released and 17.5 gallons were collected, for a natural dispersion rate of approximately 25%.

During the two dispersant tests, COREXIT® 9500 dispersant was sprayed on the oil slick at a dispersant-to-oil ratio (DOR) of 1:20. Dispersion was rapid throughout the slick. After dispersant was applied to the entire slick, the Main Bridge was brought to a stop, then run back in the direction of the slick so a LISST 100 particle size analyzer could record data on oil drop size and in-water oil concentrations. These measurements were made to confirm the presence of oil in the water column and to characterize the oil drop size distribution. High concentrations zones correspond to the time that the LISST sensor was in the dispersed oil cloud. When the end of the oil slick/plume was reached, the Main Bridge reversed direction to continue towing the equipment through the oil slick/plume. The test tank water temperature during the dispersant test was approximately 63 °F.

Following the test, the tank was skimmed of residual oil. Nearly all of the oil had dispersed, with no recoverable oil present after the first test, and approximately a quart of recoverable oil present following the second test. The oil dispersed into a cloud of particularly small oil droplets. Normally, the addition of cellulose to the tank's filtration system is sufficient to remediate the tank water, but after two weeks, water clarity had not returned and it was necessary to use activated carbon to remove the oil from the water.

Midel 7131 appears to be readily recoverable using conventional mechanical skimming devices, with recovery rates similar to petroleum products of similar viscosity. Midel 7131 was readily dispersible using COREXIT® 9500 under these test conditions.

TO 469 – LSU Dielectric Fluid Skimmer Test Log

EQUIPMENT NAME: DRUM

DATE 4/13/10 :

TEST #	DATE & TIME	OIL DEPTH (INITIAL/FINAL)	OIL TEMP (SURFACE& SAMPLE)	Rcvr Tank #	Collect Time	Int. Depth	Final Depth	NOTES
1	4/13/10 10:45	≃ 3/4 INCH HYDROCAL IN 1000 GAL TEST TANK 18" SEAWATER 32 PPT	54°F	55 GAL DRUM #1	4:06.15	24 EVEN		~~450~~ 400 PSI @ WOT HPU ~~(illegible)~~ 10 RPM/20 SEC 10 RPM/19 SEC 2" LINE 10' LINE (SUCTION) 1" LINE 50' LINE/DISCHARGE DISCHARGE LINE ELEVATION 13' ~~ABOVE~~ ABOVE DECK (13') 0 → 2½ SLOP
					4 MIN 6.15 SEC			
2	4/13/10 11:15	≃ 3" HYDROCAL INITIAL	53°F	55 GAL DRUM #2	3:59.12	24 1/8		400 PSI @ WOT HPU 10 RPM/18.9 SEC SLOP 2½ - 8¾
3	4/13/10 11:30	≃ 3" HYDROCAL INITIAL	52°F	55 GAL DRUM #3	3:57.12	24 EVEN		400 PSI @ WOT HPU 10 RPM/17.5 INITIAL (SEC) 10 RPM/18.9 FINAL (SEC) SLOP 8¾ - 18½

TO 469 – LSU Dielectric Fluid Skimmer Test Log

EQUIPMENT NAME: DISC **DATE** 4/13/10 :

TEST #	DATE & TIME	OIL DEPTH (INITIAL/FINAL)	OIL TEMP (SURFACE& SAMPLE)	Rcvr Tank #	Collect Time	Int. Depth	Final Depth	NOTES
4	4/13/10 13:50	≃3/4 LIGHT HYDROCAR	53°	~~55~~ GAL #4				50' 3/4" DISCHARGE LINE DISCHARGE LINE LOOPS 13' ABOVE DECK ABORT TEST DISCHARGE FLOW STOPPED. SLOP 18 3/4 – 22 1/4
5	4/13/10 14:39	≃3" HYDROCAR	52°	55 GAL DRUM #5	4:52.52	23 3/4		700 PSI DISC ~~1500~~ PSI PUMP 1150 PSI PUMP 10 RPM/9.9 SEC SLOP ~~22~~ 22 1/4 23 7/8
6	4/13/10 15:03	≃3" HYDROCAR	52°	55 GAL DRUM #6	4:43.58	24 1/8		700 PSI DISC 1150 PSI PUMP 10 RPM/9.8 SEC SLOP 5 3/4 – SLOP 7 1/2

TO 469 – LSU Dielectric Fluid Skimmer Test Log

EQUIPMENT NAME: Disc **DATE** 4/13/10 :

TEST #	DATE & TIME	OIL DEPTH (INITIAL/FINAL)	OIL TEMP (SURFACE& SAMPLE)	Rcvr Tank #	Collect Time	Int. Depth	Final Depth	NOTES
7	4/13/10 15:15	≃3" Hydrocal	52° F	55 GAL Drum D7	4:36.26	24 Even		700 PSI Disc 1150 PSI Pump 50' 3/4 Discharge Line Looped 13' Above Deck 10 RPM/9.8 SEC Slop 7 1/2 → 9 1/4

TO 469 – LSU Dielectric Fluid Skimmer Test Log

EQUIPMENT NAME: ROPE MOP **DATE** 4/14/10

TEST #	DATE & TIME	OIL DEPTH (INITIAL/FINAL)	OIL TEMP (SURFACE& SAMPLE)	Rcvr Tank #	Collect Time	Int. Depth	Final Depth	NOTES
8	4/14/10 9:08	≃3" HYDROCAL	49° F	55 GAL DRUM 8	15:42.35	24 1/2		GRAVITY DRAIN FROM ROPE MOP SUMP TO COLLECT DRUM NOT ELEVATED TO 3.5 METERS 45 SEC / 1 ROPE REVOLUTION (25' ROPE)
9	4/14/10 9:37	≃3" HYDROCAL	46° F	55 GAL DRUM 9	15:58.83	24 3/8		GRAVITY COLLECT 46 SEC / 1 ROPE REVOLUTION
10	4/14/10 10:10	≃3" HYDROCAL	47° F	55 GAL DRUM 10	16:17.29	24		GRAVITY COLLECT 45 SEC / 1 ROPE REVOLUTION

TO 469 – LSU Dielectric Fluid Skimmer Test Log

EQUIPMENT NAME: ROPE MOP **DATE** 4/14/10 **:**

TEST #	DATE & TIME	OIL DEPTH (INITIAL/FINAL)	OIL TEMP (SURFACE& SAMPLE)	Rcvr Tank #	Collect Time	Int. Depth	Final Depth	NOTES
11 11:40	4/14/10 11:40	≃3" DIESEL	49°	55 GAL DRUM 11	15:03.10	4'/4		GRAVITY DRAIN FROM ROPE MOP SUMP TO COLLECT DRUM RECOVERY HALTED AT 15 MIN DUE TO LOW RECOVERY RATE 46 SEC / 1 ROPE REVOLUTION (25' ROPE)
12	4/14/10 12:05	≃3" DIESEL	49°	55 GAL DRUM 12	15:02.18	4'/8		GRAVITY COLLECT RECOVERY HALTED @ 15 MIN 46 SEC / 1 ROPE REVOLUTION
13	4/14/10	≃3" DIESEL	50°	55 GAL DRUM 13	15:00 SEC	4'/2		GRAVITY COLLECT RECOVERY HALTED @ 15 MIN 45 SEC / 1 ROPE REVOLUTION

TO 469 – LSU Dielectric Fluid Skimmer Test Log

EQUIPMENT NAME: Disc

DATE 4/14/10 :

TEST #	DATE & TIME	OIL DEPTH (INITIAL/FINAL)	OIL TEMP (SURFACE& SAMPLE)	Revr Tank #	Collect Time	Int. Depth	Final Depth	NOTES
14	4/14/10 13:40	≃3" DIESEL	61°	55 Gal Drum 14	~~15:01.83~~ 15:01.83	10 1/2		400 PSI DISC 250 PSI PUMP 50' 3/4" DISCHARGE HOSE LOOPED 13' ABOVE DECK TEST HALTED @15 MINUTES 10 REVOLUTIONS/9.5 SEC DISC
15	4/14/10 14:00	≃3" DIESEL	62°	55 Gal Drum 15	15:00.80	9 EVEN		400 PSI DISC 300 PSI PUMP 10 REV/9.5 SEC DISC
16	4/14/10 14:26	≃2 3/4 DIESEL ≃2 1/4 FINAL	62	55 Gal Drum 16	15:01.16	~~8 1/2~~ 8 1/2		400 PSI DISC 225 PSI PUMP 11" FINAL SLOP 10 REV/9.5 SEC DISC

TO 469 – LSU Dielectric Fluid Skimmer Test Log

EQUIPMENT NAME: DRUM

DATE 4/14/10

TEST #	DATE & TIME	OIL DEPTH (INITIAL/FINAL)	OIL TEMP (SURFACE& SAMPLE)	Revr Tank #	Collect Time	Int. Depth	Final Depth	NOTES
17	4/14/10 15:05	≃3" DIESEL	60° F	55 GAL DRUM 17	~~15:00.93~~ 15:00.90	6 3/4		2" SUCTION LINE (10') 1" LINE 50' → ELEVATE 13' ABOVE DECK ESTIMATED WATER DEPTH 17" 200 PSI DRUMS 200 PSI PUMP TEST HALTED @ 15 MINS 10 REVOLUTIONS (DRUM)/19.9 SEC
18	4/14/10 15:23	≃3" DIESEL	59° F	55 GAL DRUM 18	15:01.12	6 1/8		200 PSI DRUM 200 PSI PUMP TEST HALTED @ 15 MIN 10 REVOLUTIONS/19.9 SLOP FINAL 11 3/8
19	4/14/10 15:42	≃3" DIESEL	56°	55 GAL DRUM 19	15:00.69	6 3/8		250 PSI DRUM 200 PSI PUMP TEST HALTED @ 15 MIN 10 REVOLUTIONS/20 SEC

TO 469 – LSU Dielectric Fluid Skimmer Test Log

EQUIPMENT NAME: Rope mop   **DATE** 4/15/10 **:**

TEST #	DATE & TIME	OIL DEPTH (INITIAL/FINAL)	OIL TEMP (SURFACE& SAMPLE)	Rcvr Tank #	Collect Time	Int. Depth	Final Depth	NOTES
20	4/15/10 8:45	3" MIDEL 7131 OIL DYED RED	52°F	55 GAL DRUM #20	15:00.33	15 1/8		FASTTANK DRAINED AND REFILLED W/TANK WATER 32.0 PPT (17.3°C) ~~50°F~~ 53°F W/ DIAL THERMOMETER 18" WATER TEST HALTED @ 15 MIN 45 SEC/1 REVOLUTION 25' ROPE GRAVITY FEED FROM ROPEMOP SUMP TO COLLECT TANK
21	4/15/10 9:25	3" MIDEL 7131	51°F	55 GAL DRUM 21	15:02.36	15 1/2		GRAVITY FEED TEST HALTED @ 15 MIN 45 SEC / 1 REVOLUTION 25' MOP
22	4/15/10 9:50	3" MIDEL 7131	52°F	55 GAL DRUM 22	15:06.26	15 1/4		GRAVITY FEED TEST HALTED @ 15 MIN 45 SEC/ 1 REVOLUTION 25' MOP

Task Order TO 469

Date 4/15/10

Test Number 23

Time 13:20

Air Temp/Wind Speed/Wind Direction 70.2 4.3 mph 352°

Water Temp (Bottom/4 ft/Surface) 51°F SURFACE w/ DIAL GAGE THERMOMETER

Wavemaker Settings 6" STROKE (12" TOTAL) 35 CPM 16.5°C @ 4' BEACHED UP

Waves Started 13:22

Waves Breaking 13:23

Waves Cease 13:52

Oil Used MIDEL 7131 Temp 72.5°

Oil Initial Level 3.60 V = 93.5 GAL 1:00.8 MIN

Oil Final Level 2.94 V = 70.0 (1:00.8)

Oil Quantity 23.5 GAL DISTRIBUTED

Oil Laydown Rate and Duration 1.0 KT

Oil Laydown Bridge Position 301.5' → 404.8'

Herder

Dispersant NONE - CONTROL RUN Temp ~~72.5°~~ 75.5

Dispersant Nozzles used and array

Dispersant Initial Level

Dispersant Final Level

Dispersant Application Time

Dispersant Application Bridge Speed

Data Run Bridge Position ~~479.1~~ (479') @ 0.5 KT NORTH → 198'

Data Run Bridge Position 198' → 442'

Data Run Bridge Position 442' → 120'

Data Run Bridge Position 120' → 418'

Data Run Bridge Position

Test Notes LAYDOWN OIL UNDER CALM CONDITIONS
RUN WAVES 30 MIN
WAVES DOWN
START SKIMMING IMMEDIATELY
COLLECT TO 55 GAL DRUM

Task Order TO 469

Date 4/15/16

Test Number 24

Time ~~14:50~~ 14:55

Air Temp/Wind Speed/Wind Direction

Water Temp (Bottom/4 ft/Surface) 17.1°C @ 4FT 32.4PPT

Wavemaker Settings 6" STROKE (12 ACTUAL) 35 CPM

Waves Started 14:58

Waves Breaking 15:01

Waves Cease 15:28

Oil Used MIDDLE 7131 Temp 72°F

Oil Initial Level 2.94 VOLTS → 70.0 GAL

Oil Final Level 2.25 45.0 GAL

25.0 GAL DISTRIBUTED

Oil Quantity

Oil Laydown Rate and Duration 1.0 KT

OIL APPLICATION TIME

Oil Laydown Bridge Position 300' → 408 @ 1456 65 SEC

Herder

Dispersant 9500 Temp 70.5°

Dispersant Nozzles used and array 8004 5 USED 2' APART (8' TOTAL)

Dispersant Initial Level 6.75" = 6.82 GAL

Dispersant Final Level 4.25" = 4.29 GAL

2.5 GAL DISPERSANT

Dispersant Application Time 1:12.5 MIN

Dispersant Application Bridge Speed 1.6 KT

Data Run Bridge Position 315' → 164' 15:03

Data Run Bridge Position 164' → 404'

Data Run Bridge Position 404' → 133'

Data Run Bridge Position 133' → 376

Data Run Bridge Position

Test Notes NO OIL RECOVERABLE → ≃100% DISPERSION

Task Order TO 469

Date 4/15/10

Test Number 25

Time ~~15:46~~ 15:49

Air Temp/Wind Speed/Wind Direction

Water Temp (Bottom/4 ft/Surface) 17.3°C @ 4'

Wavemaker Settings 6" STROKE (12" ACTUAL) 35 CPM

Waves Started 15:53

Waves Breaking 15:58

Waves Cease 16:26

Oil Used MIDER 7131 Temp 73°

Oil Initial Level 2.25 V → 45.0 GAL

Oil Final Level 1.55 V 19.5 GAL

25.5 GAL DISTRIBUTED

Oil Quantity

Oil Laydown Rate and Duration 1.0 KTS 60 SEC 15:52

Oil Laydown Bridge Position 314' ⟷ 420'

Herder N/A

Dispersant 9500 Temp 81°

Dispersant Nozzles used and array

Dispersant Initial Level 4.25" = 4.29 GAL

Dispersant Final Level 2.25" = 2.27 GAL

2.0 GAL DISPERSANT

Dispersant Application Time 1:06.9 (77 SEC)

Dispersant Application Bridge Speed 1.0 KT

Data Run Bridge Position 497 → 172'

Data Run Bridge Position 172' — 465'

Data Run Bridge Position 465' → 171

Data Run Bridge Position 171' – 412'

Data Run Bridge Position

Test Notes LAYDOWN OIL & DISPERSANT SIMULTANEOUSLY (CALM CONDITION)
START WAVES → RUN FOR 30 MINUTES
STOP WAVES
SKIM TANK & COLLECT – (MINIMAL) APPROX 1 PT DARK OIL LIKELY OFF WALLS & BOOM

TO 469 – LSU Dielectric Fluid Skimmer Test Log

EQUIPMENT NAME: DISC

DATE 4/16/16 **:**

TEST #	DATE & TIME	OIL DEPTH (INITIAL/FINAL)	OIL TEMP (SURFACE& SAMPLE)	Rcvr Tank #	Collect Time	Int. Depth	Final Depth	NOTES
26	4/16/10 8:30	≃3" MIDEL 7131	50°	55 GAL DRUM 26	5:20.49	24 1/16		700 PSI DISC 1100 PSI PUMP 50' 3/4" DISCHARGE HOSE LOOPED 13' ABOVE DISC APPROX 17" SEC WATER 32 PPS 10 REVOLUTIONS/9.7 SEC DISC
27	4/16/10 9:00	≃3" MIDEL	45°	55 GAL DRUM 27	6:30.29	18 EVEN		SPECTRA DYE POWDER REDUCE RECOVERY TO 30 GAL/RUN DUE TO SHORT SUPPLY ~~OF~~ OF MIDEL 7131 DISCHARGE PUMP SUCKING AIR 10 REVOLUTIONS/9.1 SEC → 15 SEC DISC SPEED
28	4/16/10	≃3" MIDEL		55 GAL DRUM 28	4:57.16 4:57.16	18 EVEN		550 DISC 650 PSI PUMP PUMP SPEED LIKELY TOO LOW & OVERFLOWING SUMP 10 REV/9.8 SEC

TO 469 – LSU Dielectric Fluid Skimmer Test Log

EQUIPMENT NAME: DRUM

DATE 4/16/10 **:**

TEST #	DATE & TIME	OIL DEPTH (INITIAL/FINAL)	OIL TEMP (SURFACE& SAMPLE)	Rcvr Tank #	Collect Time	Int. Depth	Final Depth	NOTES
29	4/16/10 9:40	≃3" MIDEL	47°F	55 GAL DRUM 29	6:14.09	18 EVEN		2" LINE 10' SUCTION 1" LINE 50' DISCHARGE ELEVATED 13' ABOVE DRUM 400 PSI PUMP 400 PSI DRUM 10 REVS/19.8 SEC – 19.9 SEC
30	4/16/10 9:53	≃3" MIDEL	47°F	55 GAL DRUM 30	6:06.93	18 1/4		400 PSI PUMP 400 PSI DRUM 10 REV/19.9 SEC
31	4/16/10 10:08	≃3" MIDEL	48° F	55 GAL DRUM 31	6:18.84	18 1/4		400 PSI PUMP 400 PSI DRUM 10 REVS/19.8 – 19.9 SEC

TO 469 – LSU Dielectric Fluid Skimmer Test Log

EQUIPMENT NAME: DISC

DATE 4/16/10 :

TEST #	DATE & TIME	OIL DEPTH (INITIAL/FINAL)	OIL TEMP (SURFACE& SAMPLE)	Rcvr Tank #	Collect Time	Int. Depth	Final Depth	NOTES
32 ~~10:55~~ 11:05	4/16/10	≃ ~~3~~ 2½" MIDDLE	47°F	55 GAL DRUM #32	3:02.69	12⅛		800 PSI PUMP 700 PSI DISCS 50' 3/4 DISCHARGE ELEVATED 50' ABOVE DECK 10 REVOLUTIONS/9.9 SEC
33 11:15	4/16/10	≃ 2" MIDDLE	46°F	55 GAL DRUM #33	3:10.26	12 EVEN		OUT OF FRESH TEST FLUID 800 PSI PUMP 700 PSI DISCS 10 REV/9.8 SEC
34 11:25	4/16/10	≃ 1½ MIDDLE 18½" TOTAL FLUID DEPTH PRIOR TO TEST	47°F	55 GAL DRUM #34	3:22.65	12¼		800 PSI PUMP 700 PSI DISC 10 REV/9.8 SEC

T-469	LSU DIELECTRIC FLUIDS TESTING							
POP:	4/12-4/16/10							
PRE-TEST / PRE-LOAD OILS:								
Date	ID	OIL TYPE	Description	Visc (cPs) @	T(°C) &	ρ @	T °C	% H2O
4/13/10	469-01	HYDROCAL 300	Minimax	440	12.0	0.907	19.0	7.80
4/13/10	469-02	HYDROCAL 300	Preload Test 7	360	12.0	0.907	19.2	7.50
4/14/10	469-03	DIESEL		13	12.0	0.843	20.0	-
4/14/10	469-04	DIESEL	Preload Test 17	19	12.0	0.844	20.0	-
4/15/10	469-05	MIDEL 7131	Preload Test 20	158	12.0	0.967	19.5	-
4/16/10	469-06	MIDEL 7131		161	12.0	0.968	19.5	-
4/19/10	469-07	MIDEL 7131	MB Tank	246	12.0	0.967	20.2	0.20
4/19/10	469-08	MIDEL 7131	MB Tank	129	12.0	0.967	20.3	0.10

RECOVERED OILS:								
Date	ID	OIL TYPE	Test / Tank	% H2O				
5/26/10	469-09	HYDROCAL 300	1 / DRUM	0.7				
5/26/10	469-10	HYDROCAL 300	2 / DRUM	0.7				
5/26/10	469-11	HYDROCAL 300	3 / DRUM	3.0				
5/26/10	469-12	HYDROCAL 300	5 / DISC	1.5				
5/26/10	469-13	HYDROCAL 300	5/ DISC DUP	1.2				
5/26/10	469-14	HYDROCAL 300	6 / DISC	0.7				
5/26/10	469-15	HYDROCAL 300	7 / DISC	6.8				
5/26/10	469-16	HYDROCAL 300	8 / MOP	0.7				
5/26/10	469-17	HYDROCAL 300	9 / MOP	0.5				
5/27/10	469-18	HYDROCAL 300	10 / MOP	0.2				
5/27/10	469-19	DIESEL	11 / MOP	-				
5/27/10	469-20	DIESEL	12 / MOP	-				
5/27/10	469-21	DIESEL	13 / MOP	-				
5/27/10	469-22	DIESEL	14 / DISC	-				
5/27/10	469-23	DIESEL	14 / DISC DUP	-				
5/27/10	469-24	DIESEL	15 / DISC	-				
5/27/10	469-25	DIESEL	16 / DISC	-				
5/27/10	469-26	DIESEL	17 / DRUM	-				
5/27/10	469-27	DIESEL	18 / DRUM	-				
6/1/10	469-28	DIESEL	19 / DRUM	-				
6/1/10	469-29	MIDEL 7131	20 / MOP	-				
6/1/10	469-30	MIDEL 7131	20 / MOP DUP	-				
6/1/10	469-31	MIDEL 7131	21 / MOP	-				
6/1/10	469-32	MIDEL 7131	22 / MOP	-				
6/1/10	469-33	MIDEL 7131	23 / TANK/CONTROL	0.4				
6/1/10	469-34	MIDEL 7131	26 / DISC	-				
6/1/10	469-35	MIDEL 7131	27 / DISC	-				
6/1/10	469-36	MIDEL 7131	28 / DISC	-				
6/1/10	469-37	MIDEL 7131	29 / DRUM	-				
6/1/10	469-38	MIDEL 7131	29 / DRUM DUP	-				
6/1/10	469-39	MIDEL 7131	30 / DRUM	-				
6/1/10	469-40	MIDEL 7131	31 / DRUM	-				
6/1/10	469-41	MIDEL 7131	32 / DISC	-				
6/1/10	469-42	MIDEL 7131	33 / DISC	-				
6/1/10	469-43	MIDEL 7131	34 / DISC	-				

OHMSETT OIL RECOVERY LOG: W.O. # 469

Date	TEST#	DEVICE	FLUID DEPTH (in) TOTAL INITIAL	FLUID DEPTH (in) AFTER DECANT	SAMPLE TEMP.	SAMPLE NO.	NOTES
	Pre Load	Mini Max				1	VISC DENS Hydrocal
	Pre# 7	DISC				2	VISC DENS Hydrocal
4.14.10	Pre 11	MOP				3	VISC DENS DIESEL
	Pre 17	DRUM				4	VISC DENS DIESEL
							Duplicate Sample
4.15.10	Pre 20	MOP				5	VISC DENS MIDEL 7131
4.16.10	Pre 27	DISC				6	VISC DENS MIDEL
4.19.10	MB TANK					7	VISC DENS MIDEL
	MB TANK					8	VISC DENS MIDEL
5.26.10	1	DRUM		24 1/2		9	BS&W HYDROCAL
	2	DRUM		24 1/4		10	BS&W Hydrocal
	3	DRUM		24 1/8		11	BS&W HYDROCAL
	5	DISC		23.5		12	BS&W HYDROCAL
							Duplicate Sample
	6	DISC		24 1/2		14	BS&W HYDROCAL
	7	DISC		23 1/8		15	BS&W HYDROCAL
	8	MOP		23 3/4		16	BS&W HYDROCAL
	9	MOP		24 1/4		17	BS&W HYDROCAL
5.27.10	10	MOP		24		18	BS&W HYDROCAL
	11	MOP		5 1/2		19	BS&W DIESEL
	12	MOP		4 1/4		20	BS&W DIESEL
	13	MOP		4 1/2		21	BS&W DIESEL
	14	DISC		10 1/4		22	BS&W DIESEL
							Duplicate Sample
	15	DISC		9		24	BS&W DIESEL
	16	DISC		8 1/4		25	BS&W DIESEL

* Sample No.= Test No.– Recovery Tank No. / Type of Sample (G-Grab, S-Stratified) i.e. 1-4G

*All OILS Recovered IN 55Gal Drums

OHMSETT OIL RECOVERY LOG: W.O. # 469 PAGE 2 OF 2

6-1-10

TEST#	DEVICE	FLUID DEPTH (in) TOTAL INITIAL	FLUID DEPTH (in) AFTER DECANT	SAMPLE TEMP.	SAMPLE NO.	NOTES
17	DRUM		7 1/2		26	BS&W DIESEL
18	DRUM		6		27	BS&W DIESEL
19	DRUM		6 1/4		28	BS&W DIESEL
20	MOP		15 1/4		29	BS&W MIDEL
20	MOP				30	Duplicate Sample
21	MOP		15 1/8		31	BS&W MIDEL (7/31)
22	MOP		15 1/4		32	BS&W MIDEL (7/31)
23	Control		10 1/8		33	BS&W MIDEL (7/31)
24	No Recovery		0		0	No Recovery (MIDEL 7/31)
25	No Recovery		0		0	No Recovery (MIDEL 7/31)
26	DISC		23 5/8		34	BS&W (MIDEL)
27	DISC		17 3/4		35	BS&W MIDEL
28	DISC		18		36	BS&W MIDEL
29	DRUM		18 1/2		37	BS&W MIDEL
29	DRUM				38	Duplicate Sample
30	DRUM		18		39	BS&W MIDEL
31	DRUM		18 1/4		40	BS&W MIDEL
32	DISC		11 3/4		41	BS&W MIDEL
33	DISC		11 3/4		42	BS&W MIDEL
34	DISC		12		43	BS&W MIDEL
						Duplicate Sample

* Sample No.= Test No.– Recovery Tank No. / Type of Sample (G-Grab, S-Stratified) i.e. 1-4G

PHOTO/VIDEO LOG

W.O. # 469 LSU Dielectric

CAMERA Panasonic DVR

PAGE 1 OF ___

DATE TIME	TAPE #	TEST #	DESCRIPTION	COUNT START	COUNT STOP
4-13-10	1	1	Drum Skimmer Hydro Cal	Ø	4:36
4-13-10	1	2	Drum Skimmer Hydro Cal	4:36	9:36
4-13-10	1	3	↓ ↓ ↓ ↓	9:36	12:46
4-13-10	1	4	Disc Skimmer Hydro Cal ("Abort")	12:46	15:05
4-13-10	1	5	Disc Skimmer Hydro Cal	15:05	20:00
4-13-10	1	6	↓ ↓ ↓ ↓	20:00	24:57
4-13-10	1	7	↓ ↓ ↓ ↓	24:57	29:17
4-14-10	1	8	Rope Mop Hydro Cal	29:17	45:45
4-14-10	1	9	↓ ↓ ↓ ↓	45:45	1:01:25
4-14-10	2	10	↓ ↓ ↓ ↓	Ø	8:55
4-14-10	2	11	Rope Mop Diesel	8:55	27:25
4-14-10	2	12	↓ ↓ ↓ ↓	27:25	29:50
4-14-10	2	14	Disc Skimmer Diesel	29:50	34:08
4-14-10	2	15	↓ ↓ ↓ ↓	34:08	36:17
4-14-10	2	16	↓ ↓ ↓ ↓	36:17	39:26

PHOTO/VIDEO LOG

W.O. # 469 LSU Dielectric

CAMERA Nikon

PAGE 2 OF ____

DATE TIME	TAPE #	TEST #	DESCRIPTION	COUNT START	COUNT STOP
4-13-10		1	Drum Skimmer Hydro Cal	1240	1231
4-13-10		2	Drum Skimmer Hydro Cal	1231	1223
4-13-10		3	↓ ↓ ↓ ↓ ↓	1223	1216
4-13-10		4	Disc Skimmer Hydro Cal ("ABort")	1216	1212
4-13-10		5	Disc Skimmer HydroCal	1212	1208
4-13-10		6	↓ ↓ ↓ ↓	1208	1201
4-13-10		7	↓ ↓ ↓ ↓	1201	1196
4-14-10		8	Rope Mop Hydro Cal	1240	1231
4-14-10		9	↓ ↓ ↓ ↓	1231	1222
4-14-10		10	↓ ↓ ↓ ↓	1222	1219
4-14-10		11	Rope Mop Diesel	1219	1214
4-14-10		12	~~Disc Skimmer~~ Rope Mop ~~Diesel~~ Diesel	1214	1214
4-14-10		14	Disc Skimmer Diesel	1214	1208
4-14-10		15	↓ ↓ ↓ ↓	1208	1206
4-14-10		16	↓ ↓ ↓ ↓	1206	1194

PHOTO/VIDEO LOG

W.O. # 469 LSU Dielectric

CAMERA Panasonic DVR

DATE TIME	TAPE #	TEST #	DESCRIPTION	COUNT START	COUNT STOP
4-14-10	2	17	Drum Skimmer Diesel	39:26	42:16
4-14-10	2	18	↓ ↓ ↓ ↓	42:16	46:26
4-14-10	2	19	↓ ↓ ↓ ↓	46:26	
4-15-10	3	20	Rope Mop Midel 7131	Ø	4:56
4-15-10	3	22	↓ ↓ ↓ ↓	4:56	8:37
4-15-10	3	23	Control Run Midel 7131	8:37	29:53
4-15-10	3	24	Midel 7131	29:53	47:37
4-15-10	4	25	Midel 7131	Ø	16:36
4-16-10	4	26	Disc Skimmer Midel 7131	16:36	19:20
4-16-10	4	27	Disc Skimmer Midel 7131	19:20	22:14
4-16-10	4	28	↓ ↓ ↓ ↓	22:14	25:54
4-16-10	4	29	Drum Skimmer Midel 7131	25:54	30:00
4-16-10	4	30	↓ ↓ ↓ ↓	30:00	34:01
4-16-10	4	31	↓ ↓ ↓ ↓	34:01	38:15

PHOTO/VIDEO LOG

W.O. # 469 LSU Dielectric

CAMERA Nikon

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DATE TIME	TAPE #	TEST #	DESCRIPTION	COUNT START	COUNT STOP
9-14-10		17	Drum Skimmer Diesel	1194	1192
9-14-10		18	↓ ↓ ↓ ↓	1192	1190
9-14-10		19	↓ ↓ ↓ ↓	1190	1188
9-15-10		20	Rope Mop Midel 7131	1188	1178
9-15-10		21	↓ ↓ ↓ ↓	1178	1173
9-15-10		22	↓ ↓ ↓ ↓	1173	1170
9-15-10		23	Control Run Midel 7131	1170	1154
9-15-10		24	Midel 7131	1154	1142
9-15-10		25	Midel 7131	1142	1131
9-16-10		26	Disc Skimmer Midel 7131	1240	1238
9-16-10		27	Disc Skimmer Midel 7131	1238	1235
9-16-10		28	↓ ↓ ↓ ↓	1235	1233
9-16-10		29	Drum Skimmer Midel 7131	1233	1230
9-16-10		30	↓ ↓ ↓ ↓	1230	1228
9-16-10		31	↓ ↓ ↓ ↓	1228	1229

PHOTO/VIDEO LOG

W.O. # 469 LSU Dielectic

CAMERA Panasonic PVR

PAGE 5 OF ____

DATE TIME	TAPE #	TEST #	DESCRIPTION	COUNT START	COUNT STOP
4-16-10	4	32	Disc Skimmer Midel 7131	38:15	40:00
4-16-10	4	33	↓	40:00	43:01
4-16-10	4	34	↓	43:01	46:30

PHOTO/VIDEO LOG

W.O. # 409 LSU Dielectric

CAMERA Ø Nikon

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DATE TIME	TAPE #	TEST #	DESCRIPTION	COUNT START	COUNT STOP
9/16/10		32	Disc Skimmer Midel 7131	1224	1222
9/16/10		33	↓ ↓ ↓ ↓	1222	1219
9-16-10		34	↓ ↓ ↓ ↓	1219	1217

Test	Device	Spd	RE	ORR	ORR/rpm	Test Oil	Oil Temp	Notes
		(rpm)	(%)	(gpm)	(gal/rev)		(°F)	
14	Disc	63.2	97.6	1.2	0.02	Diesel	61	
15	Disc	63.2	100.0	1.0	0.02	Diesel	62	
16	Disc	62.3	97.1	0.9	0.02	Diesel	62	
				1.0				Average
4	Disc	0.0	#DIV/0!	#VALUE!	#VALUE!	Hydro-cal	53	Abort test - discharge hose separated
5	Disc	60.6	97.6	8.2	0.13	Hydro-cal	52	
6	Disc	61.2	99.3	8.7	0.14	Hydro-cal	52	
7	Disc	61.2	89.8	8.1	0.13	Hydro-cal	52	
				8.3				Average
26	Disc	61.9	98.2	7.6	0.12	Midel 7131	50	
27	Disc	49.8	98.6	4.7	0.09	Midel 7131	48	Disc speed too slow - discharge pump was ingesting air
28	Disc	61.2	100.0	6.3	0.10	Midel 7131	48	Offload pump speed too slow, overflowing sump
32	Disc	60.6	96.9	6.6	0.11	Midel 7131	47	
33	Disc	61.2	97.9	6.4	0.10	Midel 7131	46	
34	Disc	61.2	98.0	6.1	0.10	Midel 7131	47	
				6.4				Average of tests 32-34
				6.3				Average of all six tests

Test	Device	Spd (rpm)	RE (%)	ORR (gpm)	ORR/rpm (gal/rev)	Test Oil	Oil Temp (°F)	Notes
17	Drum	30.2	100.0	0.8	0.03	Diesel	60	
18	Drum	30.2	98.0	0.7	0.02	Diesel	59	
19	Drum	30.0	98.0	0.7	0.02	Diesel	56	
				0.7				Average
1	Drum	30.8	99.3	10.0	0.32	Hydro-cal	54	
2	Drum	31.7	99.3	10.4	0.33	Hydro-cal	53	
3	Drum	33.0	97.0	10.1	0.31	Hydro-cal	52	
				10.2				Average
29	Drum	30.2	100.0	5.0	0.16	Midel 7131	47	
30	Drum	30.2	98.6	5.1	0.17	Midel 7131	47	
31	Drum	30.2	100.0	5.0	0.16	Midel 7131	48	
				5.0				Average

Test	Device	Spd	RE		ORR	ORR/rpm	Test Oil	Oil Temp	Notes
		(rpm)	(%)		(gpm)	(gal/rev)		(°F)	
11	Rope Mop	1.3	100.0		0.5	0.37	Diesel	49	
12	Rope Mop	1.3	100.0		0.5	0.36	Diesel	49	
13	Rope Mop	1.3	100.0		0.5	0.39	Diesel	50	
					0.5				Average
8	Rope Mop	1.3	96.3		2.6	1.94	Hydro-cal	49	
9	Rope Mop	1.3	99.0		2.6	1.99	Hydro-cal	46	
10	Rope Mop	1.3	99.8		2.5	1.90	Hydro-cal	47	
					2.6				Average
20	Rope Mop	1.3	100.0		1.7	1.30	Midel 7131	52	
21	Rope Mop	1.3	97.6		1.7	1.30	Midel 7131	51	
22	Rope Mop	1.3	100.0		1.7	1.31	Midel 7131	52	
					1.7				Average