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Oil Spill Preparedness Division
Emerging Pollution Response Technology Evaluation: Mechanical Recovery, Dielectric Fluids

Final Report

August 2024

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Alexander Balsley, Michael A. Wurl, Kristi McKinney

US Department of the Interior
Bureau of Safety and Environmental Enforcement
Oil Spill Preparedness Division

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Cover image by U.S. Coast Guard RDC. Kvichak vessel with X30 grooved disc skimmer collecting dielectric fluid after waiting for fluid to pool up in the intake area, at Ohmsett.

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The U.S. Coast Guard Research and Development Center (USCG RDC) partnered with the Bureau of Safety and Environmental Enforcement Oil Spill Preparedness Division (BSEE OSPD) to execute independent evaluations of existing oil skimmers with dielectric fluids. This report documents the background, planning, and testing of four oil skimmers at the National Oil Spill Response and Renewable Energy Test Facility (Ohmsett) with Midel 7131, a synthetic ester dielectric fluid, and HyVolt II NG Naphthenic, a petroleum/mineral oil commonly used as transformer oil. RDC and BSEE OSPD team also tested with Hydrocal 100, a refined oil, often used in testing as a crude oil substitute, with similar viscosity to the two dielectric fluids, as a control. Experiment planning with the project sponsor (CG-MER) and Oil Spill Removal Organization (OSRO) representatives determined that tests would include two skimmers in stationary skimming mode and two in advancing skimming mode. After reviewing 15 preliminary offshore wind energy facilities' Oil Spill Response Plans, the team opted to test with a "fuzzy" disc skimmer, a brush skimmer, and a boat with both filter belt skimmer and grooved disc skimmer.

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EXECUTIVE SUMMARY

The U.S. Coast Guard Research and Development Center (USCG RDC) partnered with the Bureau of Safety and Environmental Enforcement Oil Spill Preparedness Division (BSEE OSPD) to execute evaluations of four oil skimmers with two dielectric fluids and one refined oil as a control. These evaluations also supported BSEE OSPD's Testing of Oil Spill Technologies (TOST) initiative, which evaluates oil pollution mitigation technologies to provide performance data to stakeholders. The Coast Guard Office of Marine Environmental Response Policy (CG-MER) endorsed this evaluation effort so that Federal On-Scene Coordinators (FOSCs) and other pollution responders can be better prepared for an offshore wind energy installation spill.

In an effort to reduce carbon emissions, the renewable energy sector is experiencing a significant uptick in offshore wind energy facility construction near U.S. coastlines. Each facility's electrical service platform (ESP) and wind turbines contain a variety of dielectric fluids necessary for operations. The increasing number of ESPs and wind turbines in the maritime environment increases the possibility of a dielectric fluid spill. The team's aim was to develop knowledge about the skimmers' capabilities with dielectric fluids that spill or may likely spill into U.S. coastal waters.

RDC and BSEE OSPD reviewed 15 preliminary Oil Spill Response Plans (OSRPs) from offshore wind facilities and met with Oil Spill Removal Organization (OSRO) representatives to determine which oil skimmers should be tested. The team chose four oil skimmers: two were tested in stationary skimming mode in accordance with ASTM F2709-19, and two were tested in advancing skimming mode. Advancing skimmer tests followed a methodology developed by BSEE and members from the ASTM subcommittee F20. The four skimmers used were: a Crucial 13/24 "fuzzy" disc skimmer, a Lamor MultiMax 50 brush skimmer, and a Marco FilterBelt skimmer and Elastec X30 grooved disc skimmer attached to a Kvichak boat.

The team assessed each skimmer with three test fluids: Midel 7131, HyVolt II NG, and Hydrocal 100. Midel 7131 is a synthetic ester dielectric fluid and HyVolt II NG Naphthenic is a petroleum/mineral oil commonly used as transformer oil. These are two common fluids used in offshore wind energy facility operations. Hydrocal 100, used as a test control, is a refined oil produced with viscosity similar to the viscosities of the two dielectric fluids.

The project team collected data about each oil skimmer's oil recovery rate (ORR) and recovery efficiency (RE) with each test fluid. In advancing skimming mode, the team also attempted to record the skimmer's throughput efficiency (TE) but could not make conclusive statements about this performance metric. This report captures all findings and presents conclusions and recommendations to FOSCs as to how existing oil skimmers should be used for dielectric fluid spills. RDC and BSEE OSPD do not anticipate a need to develop a new class of skimmers specifically to recover dielectric fluids; skimmers capable of recovering low-viscosity oils can recover dielectric fluids as well. This report can also be used as a knowledge product for OSROs, Area Committees, Federal/state agencies, and other spill responders. It will also help oil skimmer manufacturers better understand technology limitations and encourage product improvement.

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LIST OF ACRONYMS, ABBREVIATIONS, AND SYMBOLS

ASTM	American Society for Testing and Materials
BSEE	Bureau of Safety and Environmental Enforcement
°C	Degree Celsius
CG-MER	Coast Guard Office of Marine Environmental Response Policy
ERSP	Estimated Recovery System Potential
ESP	Electrical service platform
FOSC	Federal On-Scene Coordinator
ft	Foot or feet
gal	Gallon(s)
gpm	Gallon(s) per minute
ICCOPR	Interagency Coordinating Committee on Oil Pollution Research
in	Inch(es)
kt	Knot(s)
LAM	Lamor MultiMax
mm	Millimeter(s)
mPa·s	Millipascal-second(s)
n.d.	No date
NRR	Nameplate recovery rate
Ohmsett	National Oil Spill Response Research & Renewable Energy Test Facility
RE	Recovery efficiency
ORR	Oil recovery rate
OSPD	Oil Spill Preparedness Division
OSRO	Oil Spill Removal Organization
OSRP	Oil Spill Response Plan
ppt	Parts per thousand
rpm	Revolution(s) per minute
sec	Second(s)
TE	Throughput efficiency
TOST	Testing of Oil Spill Technologies
USCG	United States Coast Guard

1 INTRODUCTION

In 2022, the U.S. Coast Guard Research and Development Center (USCG RDC) partnered with the Bureau of Safety and Environmental Enforcement Oil Spill Preparedness Division (BSEE OSPD) for a two-year effort to independently evaluate new and emerging oil spill-response technologies. RDC's objective was to understand the true capabilities of these technologies and provide reports to Federal On-Scene Coordinators (FOSCs) so they could respond to oil spills more effectively. Results, conclusions, and recommendations from the evaluations would also serve as feedback to manufacturers for consideration in advancing their technologies. These evaluations also supported BSEE OSPD's Testing of Oil Spill Technologies (TOST) initiative, which aims to collect performance data about oil pollution mitigation technologies to facilitate decision making for oil spill preparedness and response operations.

For the first evaluation, the Coast Guard Office of Marine Environmental Response Policy (CG-MER) and other stakeholders concurred that new and emerging "Type I" adsorbents should be reviewed and tested. RDC and BSEE OSPD executed the evaluation at the National Oil Spill Response and Renewable Energy Test Facility (Ohmsett) in October 2022 that captured all findings and recommendations in a publicly available report (Balsley, Wurl, & McKinney, 2023). For the second evaluation, RDC and BSEE OSPD met with CG-MER to discuss the next mechanical-response technology of interest. BSEE OSPD and CG-MER indicated heightened interest in increasing preparedness for responding to dielectric fluid spills from offshore wind energy facilities or wind farms.

In 2022, an Executive Order called for a target capacity of 30 gigawatts of power generation from offshore wind energy facilities by 2030 in its push for transition to a more sustainable and environmentally friendly energy sector (The White House, 2022). Each modern wind turbine can generate approximately eight megawatts of electricity. To achieve the 30-gigawatt goal, the U.S. would need to install thousands of wind energy facilities along the U.S. coastlines. The number of planned offshore wind energy projects continues to grow and increases the possibility that an assortment of fluids and oils, including dielectric fluids, may spill and adversely impact the marine environment.

Dielectric fluids typically have low to medium viscosities, high thermal stability, and are non-reactive. These fluids are used in high voltage situations to provide lubrication, electrical insulation, cooling, and electrical arcing suppression. Dielectric fluids are used in high voltage situations (Aakre, Torbjørn, & Hestad, 2016) and tend to have higher flash points, high thermal conductivities, and higher stabilities (Stockton, et al., 2009) than typical crude oils.

A recent review of preliminary Oil Spill Response Plans (OSRPs) specified electrical service platforms (Offshore Sub-stations) with total oil capacities up to 257,000 gallons, including main power transformers, auxiliary/earthing transformers, reactors, diesel storage tanks, and diesel engines (Buschang, et al., 2024). If a significant containment failure occurred, a large amount of dielectric fluid could enter the environment. Offshore installations include oil skimmers in their ORSPs.

Generally, drum and disc skimmers are suitable for recovery of low and medium viscosity oils. Responders can also use weir skimmers but they typically recover large volumes of water, which can be problematic if storage is limited. Brush and filter belt skimmers are effective in recovering higher viscosity fluids (ASTM International, 2020). ASTM F726-17, "Standard Test Method for Sorbent Performance of Adsorbents for

Use on Crude Oil and Related Spills," includes Table 1 that shows ranges of dynamic viscosity and density associated with light, medium, heavy and weathered oils (ASTM International, 2017).

Table 1. Dynamic viscosity and density ranges for light, medium, heavy and weathered oil types from ASTM F726-17 (ASTM International, 2017).

Oil Type	Dynamic Viscosity Range (mPa·s)	Density Range (g/cm^3)
Light	1 to 10	0.820 to 0.870
Medium	200 to 400	0.860 to 0.970
Heavy	1,500 to 2,500	0.930 to 1.000
Weathered	8,000 to 10,000	0.930 to 1.000

Before this experiment, there was no data proving that existing oil skimmers can effectively recover dielectric fluids or if they are suitable choices as mechanical response options for FOSCs during dielectric fluid spills. Since dielectric fluids have low to medium viscosities and are made up of different compositions than crude or refined oil, USCG and BSEE were interested in learning how effective existing oil skimmers would be in recovering fresh dielectric fluids.

To address this knowledge gap, RDC and BSEE OSPD developed a systemic evaluation of four skimmers recovering two types of dielectric fluids in seawater. Evaluation results will give FOSCs and other spill responders an advantage in determining the most effective response options for dielectric fluids spills.

2 PURPOSE, EXPERIMENTAL SETUP, AND EVALUATION METHODS

The RDC and BSEE OSPD team executed a series of experiments at Ohmsett's main tank from 10-31 October 2023. Water in Ohmsett's main tank had a salinity value of approximately 30 parts per thousand (ppt) during the tests. The team divided the evaluation into two separate test procedures– one for stationary skimmers and the other for advancing skimmers. For stationary skimmers, the RDC and BSEE OSPD team used ASTM F2709-19, "Standard Test Method for Determining a Measured Nameplate Recovery Rate of Stationary Oil Skimmer Systems," (ASTM International, 2019) as guidance to determine the skimmers' oil recovery rates (ORR) and recovery efficiencies (RE). The team did not strictly adhere to the procedures in the standard, as the goal was not to determine each skimmer's nameplate recovery rate (NRR) with dielectric fluids. BSEE and members from the ASTM subcommittee F20 on Hazardous Substances and Oil Spill Response are currently developing a test method to determine the NRR for advancing skimmers; the team also used this methodology as guidance to evaluate the advancing skimmers. The two test approaches allowed the team to collect the skimmers' REs, ORRs, and throughput efficiencies (TEs). Section 2.3 discusses both evaluation methods in further detail.

In discussions with BSEE OSPD and Oil Spill Removal Organization (OSRO) representatives prior to the evaluation, the team learned that Midel 7131, a synthetic ester dielectric fluid, and HyVolt II NG Naphthenic, a petroleum/mineral oil commonly used as transformer oil, were two of the most common types of fluids proposed for use in the developing offshore wind facilities. The RDC and BSEE OSPD team also elected to test the skimmers with Hydrocal 100, a refined oil with viscosity similar to that of the other two dielectric fluids. Each test fluid's safety data sheet is provided as 8APPENDIX A.

Hydrocal 100 served as control and was a good point of comparison in the skimmers' performance with the other two dielectric fluids. Due to limited supply of Hydrocal 100 and dielectric fluids, the team needed to reuse fluids for the advancing skimmers that had been used previously for the stationary skimmer tests. They were designated as "used" fluids. Table 2 summarizes the viscosities as measured by the project team for each test fluid, new and used, at 20 ℃. The team collected several samples of each test fluid, fresh and used, over multiple days and averaged the viscosity values (see 8APPENDIX B).

Table 2. Average viscosities (at 20 ℃) of dielectric fluids and control oil (fresh and used) as measured by the project team.

Test Fluid	Dynamic Viscosity (mPa·s), Fresh	Dynamic Viscosity (mPa·s), Used
HyVolt II NG (dielectric fluid)	18.6	20.0
Hydrocal 100 (refined oil)	64.0	65.1
Midel 7131 (dielectric fluid)	72.8	55.1

Although Table 1 does not indicate temperature associated with viscosity values, viscosity values in Table 2 show that test fluids, both fresh and used, lie between viscosity values for light and medium oil albeit closer to light oil.

The project team dyed all three fluids to enhance their visibility for test purposes (Figure 1).

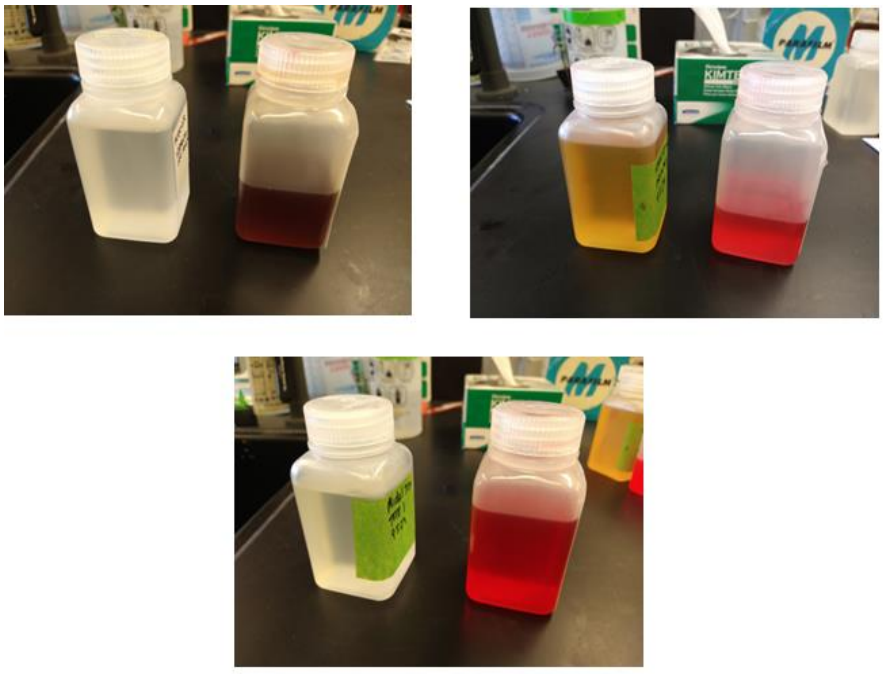

Figure 1. All test fluids had dye added to enhance visibility, with left container showing no dye added and the right with dye. Top left: Hydrocal 100. Top right: HyVolt II NG. Bottom: Midel 7131.

2.1 Purpose of Skimmer Evaluation with Dielectric Fluids

The primary purpose of this effort was to provide performance data about how a skimmer might perform with dielectric fluids in calm conditions for FOSCs and spill responders. RDC and BSEE OSPD designed the experiments to determine the following characteristics of each skimmer with the three test fluids described above:

- Oil recovery rate (ORR)[1]: The volume of oil/test fluid recovered by the skimmer per unit of time (gallons per minute, gpm).

$$ORR = \frac{Volume\ of\ oil\ recovered}{Time}$$

- Recovery efficiency (RE): The ratio, expressed as a percentage, of the volume of oil/test fluid recovered to the total volume of fluids recovered by the skimmer.

$$RE = \frac{Volume\ of\ oil\ recovered}{Total\ volume\ of\ fluids}\ x\ 100\%$$

- Throughput efficiency (TE): The ratio, expressed as a percentage, of the volume of oil/test fluid recovered to the volume of oil encountered. *Note: TE applies to advancing skimmers only*.

$$TE = \frac{Volume\ of\ recovered\ oil}{Volume\ of\ encountered\ oil}\ x\ 100\%$$

ORR, RE, and TE values are performance benchmarks for skimming systems and can be used as points of comparison between skimmers. The ASTM standard F2709-19 for testing stationary skimmers includes measuring ORR and RE performance metrics, which allows for consistent, repeatable evaluations of a skimmer's performance when recovering a thick slick of oil. Spill responders understand and rely on ORR and RE values when considering skimmers for oil spill incidents. The advancing skimmer evaluation methodology exposes a skimmer to a volumetric rate of oil that is based on its tow speed and swath width, and provides ORR, RE, and TE data. For advancing skimmers, TE is another performance metric of interest.

All skimmers require well-trained operators that can adjust settings according to the oil type and environmental conditions to maximize the skimmer's performance. Ideally, responders would operate skimmers at settings to maximize the ORR. However, depending on factors such as oil viscosity and slick thickness, increasing pump rate or skimmer rotational speed may increase water intake, which would decrease the skimmer's recovery efficiency (i.e., decreasing the RE value). In most spill scenarios, because of limited storage for recovered oil, operators seek to maximize oil volume and minimize water volume. While decreasing the rotational speed may improve RE, it may also decrease ORR, which would increase the time required to complete the collection operation. To achieve a balance between RE and ORR maximization, operators rely on their skills from training and previous experience with skimmers.

[1] Although the project team tested with dielectric fluids, it opted to retain the label "Oil" Recovery Rate (ORR) for the purpose of consistency and familiarity.

2.2 Skimmer Selection Process

RDC, BSEE OSPD, and CG-MER reviewed draft OSRPs from the offshore wind facilities and met with OSRO representatives to discuss what skimmers were identified for potential use in these OSRPs. It is important to note, however, that many of the OSRPs reviewed were in preliminary stages, and many did not specify OSROs or equipment that might be used. The RDC and BSEE OSPD team chose four skimmer systems because they either were called out for use in OSRPs or were representative of the type of skimmer technology that might be employed. The four skimmers included three different skimmer types – two disc skimmers, a brush skimmer, and a filter belt (also called sorbent belt) skimmer. They included:

- Crucial Model C-Disc 13/24 coated disc skimmer, commonly referred to as a "fuzzy" disc skimmer;
- Lamor MultiMax 50 brush skimmer;[2]
- Marco FilterBelt skimmer (with Kvichak vessel); and
- Elastec X30 grooved disc skimmer (with Kvichak vessel).[3]

Disc skimmers (both "fuzzy" and grooved disc) are typically applicable to low and medium viscosity oils (ASTM International, 2020) and can have recovery efficiencies of 95% (El-Gayar, Khodary, Abdel-Aziz, & Khalil, 2021) when recovering medium crude oil (~381 mPa·s) in stationary conditions. However, it is important to understand that most skimmer evaluations are conducted in controlled, optimal environments where there is little or no wave action and in a thick layer of oil. In real world conditions with thinner oil layers and likely emulsified oil, responders can expect lower ORR and RE.

The BSEE-owned Crucial disc skimmer (Figure 2) uses oleophilic discs covered with small fibers for enhanced recovery. The fibers on the discs help to increase the surface area, allowing for improved oil recovery when compared to a standard disc skimmer. These "fuzzy-disc" skimmers are found in OSRO inventories in various configurations of disc diameter and number of discs. The project team was familiar with this skimmer and operated it without manufacturer assistance.

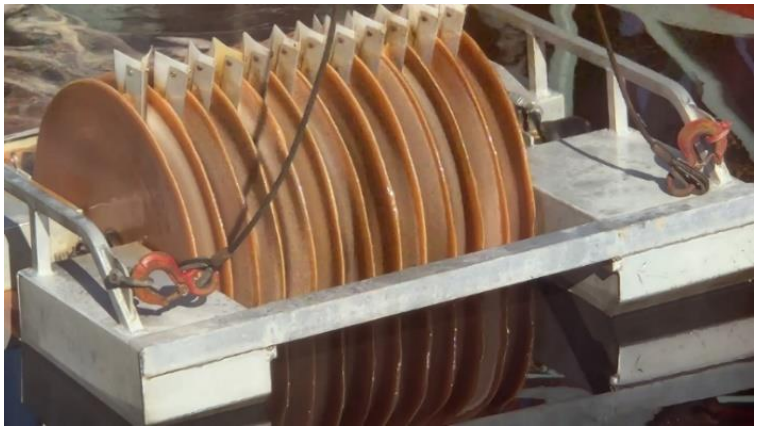

Figure 2. Crucial disc skimmer operating in Ohmsett's main tank with Hydrocal 100.

[2] BSEE owns both the Crucial disc skimmer and Lamor MultiMax 50 brush skimmer.
[3] The team identified Marco FilterBelt and Elastec X30 skimmers through market research. Elastec owns both skimmers and consented to Ohmsett test data about both products being published in a public report through a Statement of Work between RDC and Elastec.

The BSEE-owned Lamor MultiMax 50 (LAM 50) (Figure 3) is a free-floating oleophilic brush skimmer designed to recover oil in both fresh and salt water. The ability to operate in a broad range of environmental conditions has made the LAM 50 a popular option when responding to conventional oil spills. The LAM 50 has 3 rows of oleophilic brushes that can rotate in two directions depending on the fluid to be recovered.

Figure 3. Lamor MultiMax 50 brush skimmer on Ohmsett's deck.

Brush skimmers are typically applicable for recovery of medium and high viscosity oils (ASTM International, 2020). In a 2007 Bureau Veritas test conducted with the Lamor brush skimmer using intermediate fuel oil and bitumen (very heavy oil with a dynamic viscosity of 1,250,215 mPa·s at 15.2 ℃), results indicate good recovery efficiency with low free-water collection volume (Energy & Process Finland, 2008). Brush skimmers are typically less effective with low viscosity fluids compared to other skimmer types because this fluid type does not adhere to the brushes as well when lifted out of the water. Much of it drips back onto the water surface before it can be scraped off. However, this particular skimmer was selected for testing due to the presence of Lamor brush systems in OSRO inventories.

Lamor provided their standard short brushes used in most skimming operations and their "alternate" brushes, which are longer and denser (Figure 4). Lamor designed the alternate brushes specifically for recovering lower viscosity oils or fluids. Although this brush set was not included in the original test plan, the team elected to experiment with it in limited test runs to determine if its use affected ORR and RE. Lamor representatives were present on-site to assist with brush skimmer configuration and operation.

Figure 4. Two different Lamor brushes used for experiments. Left: Alternate (long/dense) brush. Right: Standard short brush typically used in most Lamor brush-skimming operations.

The team secured a Kvichak Marine Industries oil skimming vessel owned by Elastec for the advancing skimmer tests. It incorporates two interchangeable skimmer units including a Marco FilterBelt skimmer and an Elastec X30 grooved disc skimmer (Figure 5). During a spill response, the vessel advances through a slick with the fluid entering between guide booms and is recovered by the integrated skimmer. Kvichak oil skimming vessels equipped with the Marco FilterBelt skimmer are in inventories of multiple OSROs and were identified for use in at least one preliminary OSRP.

The use of Elastec's vessel provided an opportunity to test both the Marco FilterBelt skimmer and the Elastec-designed X30 grooved disc skimmer. Sorbent belt skimmers like the Marco FilterBelt are more applicable to the recovery of medium and high viscosity fluids (ASTM International, 2020); the project team anticipated that the grooved disc skimmer would perform well with the recovery of the low viscosity test fluids. Elastec personnel conducted the test runs under RDC and BSEE OSPD's oversight because of their lengthy experience with the vessel and operation of the two skimmers. The project team had limited experience working with the Marco FilterBelt skimmer, especially with installing and replacing filtering "pads" on the belt.

Figure 5. Elastec's Kvichak vessel in Ohmsett's main tank, rigged to the north bridge.

Elastec manufactures many types of interchangeable, attachable filtering "pads" that allow the Marco FilterBelt skimmer (Figure 6) to adapt to the different oil viscosities to improve skimmer's ORR and RE. Although there were several different types to choose from, RDC and BSEE OSPD agreed to purchase "sheen" filtering pads as Elastec recommended, which were designed to recover oil sheens and very light oils because all test fluids had low viscosity (Figure 7).

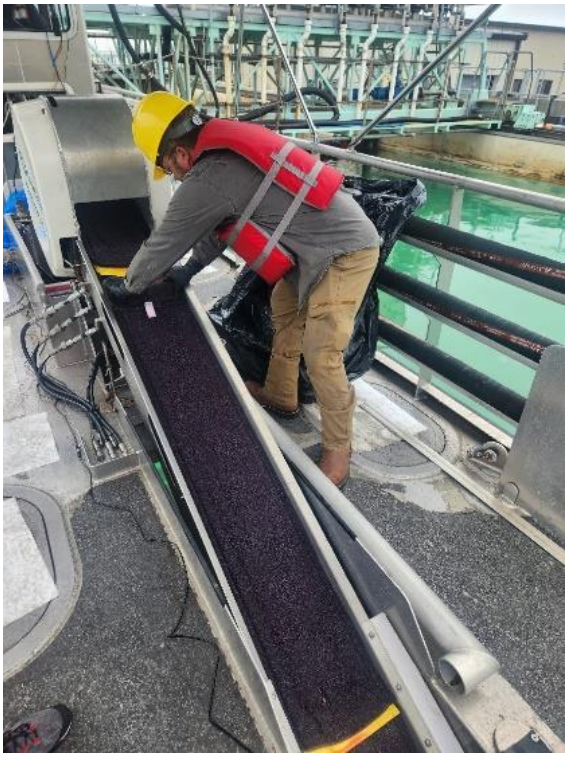

Figure 6. Elastec's Kvichak vessel equipped with Marco FilterBelt skimmer.

Figure 7. Up-close view of the Marco filter backing belt and sheen pad used for the tests (Elastec, n.d.b).

Elastec developed the grooved disc skimmer technology (Figure 8) for the Wendy Schmidt Oil Cleanup X CHALLENGE that Ohmsett hosted in 2011 (Beckwith, 2011). The X30 skimmer has small grooves on the sides of each disc, allowing for additional surface area to collect oil. These grooves allow the low-viscosity oils to develop additional cohesive force, resulting in the skimmer achieving an average RE of 90% with Hydrocal 300, which has an average viscosity of 199.7 mPa·s at 20 °C (Elastec, n.d.a).

Figure 8. Elastec's X30 grooved disc skimmer on Ohmsett's deck.

2.3 Evaluation Methods

2.3.1 Determining Oil Recovery Rate and Recovery Efficiency for Stationary Skimmers

The RDC and BSEE OSPD team used ASTM F2709-19 as guidance to determine the ORR and RE for each stationary skimmer, the Crucial disc skimmer and the Lamor MultiMax 50 brush skimmer. The team elected to follow the standard requiring the test area dimensions to be at least three times the length and width of the skimmer to be evaluated, so the skimmer can float freely and stay clear of tank walls. The project team tethered each skimmer to float in the center of the test area and attached the discharge hose to their recovery tanks on the north bridge (Figure 9).

Figure 9. Containment area for stationary skimmer tests.

The LAM 50 is the larger of the two skimmers at approximately 71 in x 56 in, so the test area needed to be at least 17.75 ft x 14 ft. However, Ohmsett increased the area to 18 ft x 16 ft to accommodate their sectional boom lengths. The project team then filled the test area from an oil tank on Ohmsett's main traversing bridge with the standard-suggested 3 in (75 mm) of test fluid (approximately 539 gallons). The team recorded test fluid and water temperatures with instruments inside and around the test area.

The stationary skimmer evaluation began with several "optimization" runs with the goal of achieving maximum oil recovery rate (ORR) while maintaining a recovery efficiency (RE) of at least 70%. This 70% value comes from the standard indicating that a stationary skimmer system shall have a minimum RE of 70% or the test run will not be valid for determining its nameplate recovery rate (NRR). It is important to note that since the purpose of the experiment was not to determine the skimmer's official NRR but to measure performance data with dielectric fluids, failing to meet the minimum RE of 70% did not "disqualify" a skimmer.

These runs provided an opportunity for the skimmer operator to become accustomed to the test fluid and determine which skimmer settings, such as rotational speed or discharge pump rate, should be used to achieve maximum ORR and RE.

During each optimization run, the project team discharged the recovered oil and water to one of the eight collection tanks on the north bridge. Once the skimmer recovered approximately one inch of the test fluid layer, the team ceased the skimming operation, recorded the total volume of fluids in the collection tank, and then allowed it to settle for a minimum of 30 minutes. After this time, the team decanted the free water and then recorded the volume of the remaining fluids. They then collected a sample of this fluid for lab analysis (using a centrifuge) to determine its remaining water content (Figure 10).

Figure 10. Using a centrifuge in Ohmsett's chemistry lab to determine a sample's water content.

With the water content known, the team could then determine the skimmer's RE from the optimization run. If above 70%, the team proceeded to execute three test runs with the same skimmer settings. If below, the team adjusted the skimmer's rotational speed or discharge pump rate and then repeated the optimization run. The team agreed to include the optimization run as the first of the three official test runs if and only if the results were determined to be acceptable and no changes were made to skimmer settings or test parameters. After each run, the team added new test fluid from the main bridge oil tank to the existing test fluid in the test area, returning to the standard 3-in thickness. The volume of the new test fluid replaced the volume of test fluid the skimmer recovered in the previous run.

After completing three official runs with one skimmer in a test fluid, the team switched out the skimmer and repeated the test procedure with the same test fluid. After the project team evaluated both skimmers with one test fluid, the team emptied the main bridge oil tank, refilled it with the next fluid and then repeated three runs with both skimmers. The team started with Hydrocal 100, moved on to HyVolt II NG, and then finished with Midel 7131. In total, the team executed 38 stationary test runs: 13 tests with the Crucial skimmer, 17 tests with the Lamor standard brushes, and eight tests with the Lamor alternate brushes (Coolbaugh, 2024).

2.3.2 Determining Oil Recovery Rate, Recovery Efficiency, and Throughput Efficiency for Advancing Skimmers

The project team tested the advancing skimmers using a test methodology recently developed by BSEE OSPD and members of the ASTM F20 committee. This test method is designed to assess an advancing skimmer's ORR, RE, and TE when encountering a minimum slick thickness of 0.1 inch (2.5 mm)[4]. To achieve the 0.1-inch slick thickness, oil is dispensed ahead of the skimmer at a rate based on the system's swath width and advancing speed (oil dispense rate). The test method is designed to provide performance metrics that can be used as inputs to the Estimated Recovery System Potential (ERSP) calculator[5] developed by BSEE and Genwest in 2012-2016 for offshore spills (Genwest Systems, Inc., 2012).

TE is a performance metric applied only to advancing skimmer systems and is designed to indicate the efficiency of a skimmer system in recovering all the oil it encounters as it advances through an oil slick. Due to the wide variety of advancing skimmer configurations, data collection methods to assess TE performance can be unique from skimmer to skimmer; it can be a challenging metric to assess accurately.

The two advancing skimmer systems tested were the Marco FilterBelt skimmer and the Elastec X30 grooved disc skimmer. Both skimmers were tested using the Kvichak vessel as a platform. The skimmers were fitted into the specialized slot on the bow of the Kvichak vessel. Using a crane, the team positioned Elastec's Kvichak vessel in the center of the main tank between the movable main and north bridges and tethered the vessel's stern to the north bridge with the bow facing southward. Test personnel were able to board the vessel via the north bridge. At the vessel's bow, the team attached the two 14-inch-high, 30-foot-long guide booms to the main bridge to create a 25-ft swath width and hung the test fluid distribution hose from the main bridge crane above the water surface and centered in front of the skimmer intake (Figure 11).

[4] The minimum slick thickness (0.1 in or 2.5 mm) for the advancing skimmer tests is significantly less than the minimum slick thickness required for stationary skimmer tests as per ASTM F2709-19 (3 in or 75 mm).
[5] Additional details on the ERSP calculator can be found at https://www.bsee.gov/what-we-do/oil-spill-preparedness/response-system-planning-calculators

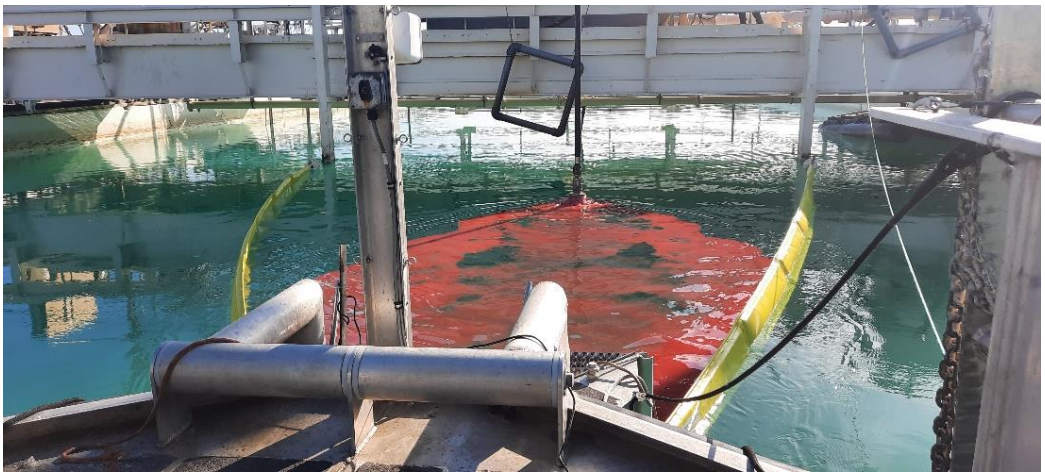

Figure 11. Dielectric fluid being released from a discharge pipe on the main bridge and floating towards the Kvichak vessel during an advancing skimmer system test.

The team began testing with optimization runs to determine the best skimmer settings to maximize the ORR, RE, and TE. For each optimization run, the bridges and attached vessel began at the northern end of the main tank. At test start, the main bridge pulled the full guide-boom and skimmer assembly along the length of the main tank (approximately 560 ft) towards the southern end at 0.75 kts. The project team released the test fluid from the main bridge oil tank at the determined oil dispense rate through the distribution hose. With assistance of the main bridge, the vessel and its skimmer intake area at the bow moved towards the floating test fluid. The team allowed the test fluid to accumulate for a short time at the skimmer's intake before commencing recovery operation (Figure 12).

Figure 12. Kvichak vessel with X30 grooved disc skimmer collecting dielectric fluid after waiting for fluid to pool up in the intake area.

Once steady-state conditions were achieved, the team began timed collection of recovered fluids. This fluid was directed to a collection tank. The fluid collected during the steady state timed collection was used to calculate oil recovery rate and recovery efficiency. After the timed collection ended, the system was allowed to continue skimming and recovered fluid was directed to a separate collection tank. If there was remaining oil after the bridges stopped at the south end of the tank, the skimmer was allowed to continue collection. This untimed collection was necessary to ensure that the skimmer had the opportunity to recover all the fluid it encountered to accurately assess TE.

After the skimmer recovered all remaining fluid, the team recorded the volume of total fluids in each collection tank. After a 30-minute minimum settling time, they decanted the water and measured the remaining fluid. The team then took a sample of the remaining fluid for lab analysis of the remaining water content. Again, the objective was to maximize both the ORR and RE values. If RE was found to be less than 70%, the team altered the following variables before the next optimization run:

- Test fluid dispense rate from distribution hose;
- Adding a deflector nozzle to the discharge hose to reduce the velocity of oil released to minimize oil escaping under the boom before reaching the skimmer;
- Skimmer's position relative to the water surface; and
- Skimmer rotational speed.

Similar to stationary skimmer tests, once the team identified the optimal skimmer settings that resulted in the highest RE possible (with a minimum of 70% being the goal), it accepted the previous optimization run as the first "official" run, and then executed two additional test runs. After one skimmer completed the three runs, Elastec personnel installed and calibrated the other skimmer; skimmers were exchanged while the Kvichak vessel was in the main tank. When both skimmers completed their runs with one test fluid, Ohmsett emptied the main bridge oil tank and refilled with the next fluid and repeated the entire procedure. The order of test fluids was Hydrocal 100, Midel 7131, and then HyVolt II NG. In total, the team executed 33 advancing runs with the Kvichak skimming vessel: 17 tests with the Marco FilterBelt skimmer and 16 tests with the X30 grooved disc skimmer (Coolbaugh, 2024).

3 RESULTS

3.1 Skimmer Performance with Hydrocal 100

Though not a dielectric fluid, Hydrocal 100 served as reference fluid or point of comparison to other dielectric fluids of similar viscosity. The project team evaluated all skimmers with fresh Hydrocal 100 except for the X30 grooved disc skimmer, which needed to be tested with reused Hydrocal 100. Table 3 captures all data from skimmer tests with Hydrocal 100.

Table 3. Skimmer performance data with Hydrocal 100.

Skimmer	Test Run	Total Oil Available for Recovery (gal)	Steady State Collection Time (sec)	Total Recovered Fluids (gal)	Total Recovered Oil (gal)	ORR (gpm)	RE (%)
Crucial	1	539	269	177.8	158.6	35.4	89.2
Crucial	2	539	289	180.7	169.8	35.2	93.9
Crucial	3	539	289	180.7	165.3	34.3	91.5
	Average					***35.0***	***91.5***
Lamor*	1	539	371	166.2	117.3	19.0	70.6
Lamor*	2	539	342	169.1	105.9	18.6	62.7
Lamor*	3	539	286	169.1	112.5	23.6	66.5
	Average					***20.4***	***66.6***
Marco	1	73	60	39.4	20.8	20.8	52.8
Marco	2	65	60	29.2	13.5	13.5	46.3
Marco	3	77	60	32.1	14.3	14.3	44.7
	Average					***16.2***	***48.0***
Elastec X30^	1	249	30	67.0	57.0	114.0	85.0
Elastec X30^	2	291	30	59.8	49.0	98.0	82.0
Elastec X30^	3	293	30	52.5	43.6	87.1	83.0
	Average					***99.7***	***83.3***

* Standard brush, 8 rotations per minute
^ Evaluated with reused test fluid

Samples of fresh and used Hydrocal 100 were almost indistinguishable with approximately 1.6% difference in dynamic viscosity and less than 1.0% difference in density. The average water content was 0.20% and 0.27% for fresh and used Hydrocal 100, respectively.

3.2 Skimmer Performance with HyVolt II NG

The project team evaluated all skimmers with fresh HyVolt II NG except for the X30 grooved disc skimmer, which was evaluated with *reused* HyVolt II NG. The project team exhausted its available supply of fresh HyVolt II NG before its tests with the X30 grooved disc skimmer and reused the fluid from previous tests. It was not a concern with reusing this test fluid because samples of fresh and used HyVolt II NG showed very little difference between them in terms of dynamic viscosity, density, and percent water content. The average dynamic viscosity was 18.6 and 20.0 mPa·s for fresh and used HyVolt II NG (see Table 2), respectively, a difference of less than 10%. Density was almost equal at 0.882 g/cm^3 and 0.886 g/cm^3 for fresh and used, which amounts to less than 1% difference. The water content for both was the same at 0.1%.

Table 4 shows all skimmer data with HyVolt II NG. Note that the project team encountered an error in capturing data for the first of three Crucial disc skimmer test runs with HyVolt II NG and recorded two test runs instead of the planned triplicate. Also note that TE data is not included in the results. The project team encountered several challenges that precluded accurate TE calculations. This included difficulties with segregating fluids recovered at the end of one test from the start of the next due to a small sump in the vessel itself, and some missing decant volume and fluid sampling data for the untimed fluid collection. These

challenges did not affect the steady state collection for ORR and RE calculations, but the project team did not have confidence in TE data accuracy. Note: For calculating TE, skimmer internal fluid storage needs to be cleared of oil between tests. In addition, the project team should develop a detailed fluid sampling plan prior to the tests to prevent missing data, which occurred.

Table 4. Skimmer performance data with HyVolt II NG.

Skimmer	Test Run	Total Oil Available for Recovery (gal)	Steady State Collection Time (sec)	Total Recovered Fluids (gal)	Total Recovered Oil (gal)	ORR (gpm)	RE (%)
Crucial	1	539	321	153.0	151.7	28.3	99.1
Crucial	2	539	320	153.0	152.3	28.6	99.5
	Average					***28.4***	***99.3***
Lamor*	1	539	917	250.7	117.2	7.7	46.8
Lamor*	2	539	806	250.7	133.0	9.9	53.0
Lamor*	3	539	917	250.7	143.0	9.4	57.0
	Average					***9.0***	***52.3***
Marco	1	80	60	56.8	28.2	28.2	49.7
Marco	2	90	60	43.7	21.4	21.4	49.0
Marco	3	82	60	53.9	24.3	24.3	45.1
	Average					***24.7***	***48.0***
Elastec X30^	1	256	30	42.3	38.1	76.2	90.1
Elastec X30^	2	229	30	48.1	44.3	88.6	92.1
Elastec X30^	3	227	30	46.6	42.0	84.0	90.1
	Average					***82.9***	***90.8***

* Standard brush, 8 rotations per minute
^ Evaluated with reused test fluid

At a hydraulic speed of 700 revolutions per minute (rpm) or a brush rotational speed of 8 rpm, the LAM 50 with standard brushes had an average RE of 52.3%. Although this fell short of the targeted 70% RE identified in the ASTM standard, this was the best RE achievable with the brush system.

After three runs with the standard brushes, Lamor representatives indicated that the brush skimmer might show improved performance with its alternate brushes, which are longer, denser and typically used for low-viscosity oil spills. Due to limited tank test time, the project team tested the alternate brushes with HyVolt II NG only twice at different speeds (700 rpm or brush rotational speed of 8 rpm and 1,200 rpm or brush rotational speed of 14 rpm) (Table 5). Note that steady-state collection times for the alternate brush tests were less than two minutes where the standard brush test times were 13-15 minutes.

Table 5. LAM 50 with alternate brushes performance data with HyVolt II NG.

Skimmer	Test Run	Total Oil Available for Recovery (gal)	Steady State Collection Time (sec)	Total Recovered Fluids (gal)	Total Recovered Oil (gal)	ORR (gpm)	RE (%)
Lamor**	1	539	114	43.7	28.7	15.1	65.7
Lamor****	1	539	116	72.9	40.6	21.0	55.7

** Alternate brush, 8 rotations per minute
**** Alternate brush, 14 rotations per minute

Compared to the brush skimmer results with standard brushes in Table 4, the skimmer with alternate brushes operating at the slower speed (hydraulic speed of 700 rpm or brush rotational speed of 8 rpm) showed improved performance with ORR and RE. In a single test run at 700 rpm, the alternate brush skimmer recovered 15.1 gallons of HyVolt II NG per minute at 65.7% RE. When the operator increased the hydraulic speed to 1,200 rpm or brush rotational speed of 14 rpm, the ORR further increased to 21.0 gpm, though at a reduced RE of 55.7%.

3.3 Skimmer Performance with Midel 7131

The project team tested all four skimmers with Midel 7131, the final test fluid of the experiment. The project team conducted several test runs with the LAM 50 alternate brushes at different hydraulic speeds to determine if the brush skimmer would show improved ORR and RE. These additional test runs necessitated the reuse of Midel 7131 for the advancing tests with both the Marco FilterBelt skimmer and the X30 grooved disc skimmer. Table 6 and *Standard brush, 8 rotations per minute

**Alternate brush, 8 rotations per minute
^ Evaluated with reused test fluid

Table 7 show all skimmer data with Midel 7131.

Table 6. Skimmer performance data with Midel 7131.

Skimmer	Test Run	Total Oil Available for Recovery (gal)	Steady State Collection Time (sec)	Total Recovered Fluids (gal)	Total Recovered Oil (gal)	ORR (gpm)	RE (%)
Crucial	1	539	278	163.2	125.7	27.1	77.0
Crucial	2	539	267	163.2	135.8	30.5	83.2
Crucial	3	539	283	166.2	135.1	28.6	81.3
	Average					***28.8***	***80.5***
Lamor*	1	539	660	249.2	205.8	18.7	82.6
Lamor*	2	539	456	204.1	161.9	21.3	79.4
Lamor*	3	539	375	205.5	161.8	25.9	78.8
	Average					***22.0***	***80.2***
Lamor**	1	539	649	243.4	195.8	18.1	80.4
Lamor**	2	539	507	227.4	156.6	18.5	68.9
Lamor**	3	539	432	227.4	159.0	22.1	69.9
	Average					***19.6***	***73.1***
Marco^	1	106	60	51.0	27.2	27.2	53.3
Marco^	2	109	60	40.8	23.3	23.3	57.2
Marco^	3	109	60	42.3	26.0	26.0	61.6
	Average					***25.5***	***57.4***
Elastec X30^	1	239	30	67.0	65.7	131.4	98.0
Elastec X30^	2	229	30	67.0	66.0	132.1	98.5
Elastec X30^	3	240	30	64.1	62.2	124.4	97.0
	Average					***129.3***	***97.8***

*Standard brush, 8 rotations per minute
**Alternate brush, 8 rotations per minute
^ Evaluated with reused test fluid

Table 7. LAM 50 performance data at higher hydraulic speed with Midel 7131.

Skimmer	Test Run	Total Oil Available for Recovery (gal)	Steady State Collection Time (sec)	Total Recovered Fluids (gal)	Total Recovered Oil (gal)	ORR (gpm)	RE (%)
Lamor***	1	539	261	308.99	183.77	42.2	59.5
Lamor***	2	539	227	323.57	187.93	49.7	58.1
	Average					***46.0***	***58.8***
Lamor****	1	539	289	247.78	131.16	27.2	52.9
Lamor****	2	539	354	308.99	171.93	29.1	55.6
Lamor****	3	539	344	320.65	176.67	30.8	55.1
	Average					***29.1***	***54.6***

*** Standard brush, 14 rotations per minute
**** Alternate brush, 14 rotations per minute

The project team conducted three test runs with the LAM 50's standard brushes at the hydraulic speed of 700 rpm or brush rotational speed of 8 rpm. After, the team accepted Lamor's suggestion to test with its alternate brushes to compare performance. Once conducted, the team agreed to add additional data points to better understand the difference in brush performance for Midel 7131. It executed test runs at higher hydraulic speed (1,200 rpm or brush rotational speed of 14 rpm) with both brush sets.

For the advancing skimmer system tests with the Marco FilterBelt and X30 grooved disc skimmers, the project team needed to reuse Midel 7131 due to the extensive testing with different brush sets for the LAM 50. Samples of fresh Midel 7131 had an average dynamic viscosity of 72.8 mPa·s and 55.1 mPa·s (see Table 2) for used Midel 7131, which was approximately 28% difference. However, the density values were almost equal with 0.968 g/cm^3 and 0.964 g/cm^3 for fresh and used Midel 7131, respectively. The water content for fresh Midel 7131 was 0.1% and 0.3% for used. When taking all fluid properties into consideration, the project team accepted that fresh and used Midel 7131 were comparable although the team acknowledges the difference in dynamic viscosity.

4 DISCUSSION AND ANALYSIS

4.1 Oil Recovery Rate and Recovery Efficiency for Stationary Skimmers

Figure 13 shows the average ORR for both the Crucial disc skimmer and the LAM 50 with the standard brushes at 700 rpm.

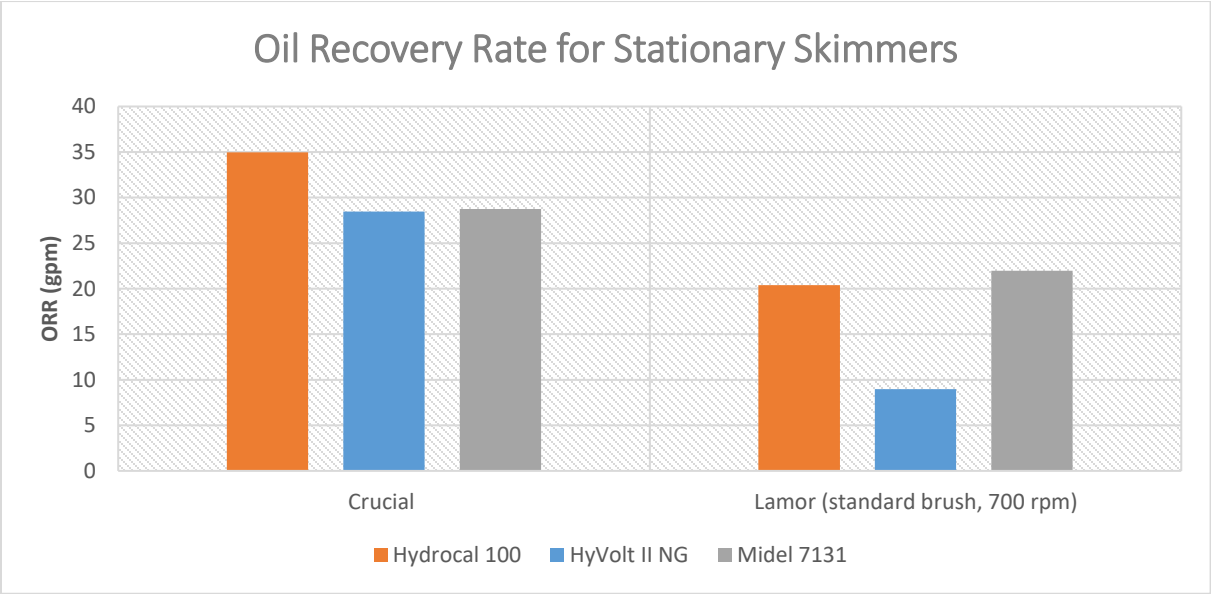

Figure 13. Oil recovery rate for stationary skimmers with all test fluids.

When testing the Crucial disc skimmer with HyVolt II NG, the team accepted two collection runs instead of three due to erroneous record keeping (see Table 4 for additional details about number of runs for each skimmer). The Crucial disc skimmer showed the highest ORR with Hydrocal 100 (control fluid) at 35.0 gpm but its recovery rate with both dielectric fluids was similar, 28.4 gpm with HyVolt II NG and 28.8 gpm with Midel 7131.

The primary "skimmer setting" with the LAM 50 was the standard brush set at 700 rpm and the team executed triplicates with all test fluids at this setting. The project team did not execute triplicates for different settings (e.g., brush type and hydraulic speed) with different test fluids since additional settings were not part of the original test plan. With the LAM 50 operating at 700 rpm with the standard brushes, its ORR and RE (Figure 14) appeared to be dependent on test fluid viscosity. As test fluid viscosity increased, so did its ORR and RE. Hydrocal 100's dynamic viscosity was in the middle of the three fluids and was also in the middle in terms of average ORR and RE. However, the ORRs for Hydrocal 100 and Midel 7131 were more similar to each other than the ORRs for Hydrocal 100 and HyVolt II NG. With HyVolt II NG, the LAM 50 had the lowest ORR at 9.0 gpm. The ORR was 20.4 and 22.0 gpm for Hydrocal 100 and Midel 7131, respectively. It appeared that the brushes had difficulty in picking up all three low-viscosity oil.

Figure 14 shows the average RE for both skimmers (LAM 50 with standard brushes at 700 rpm).

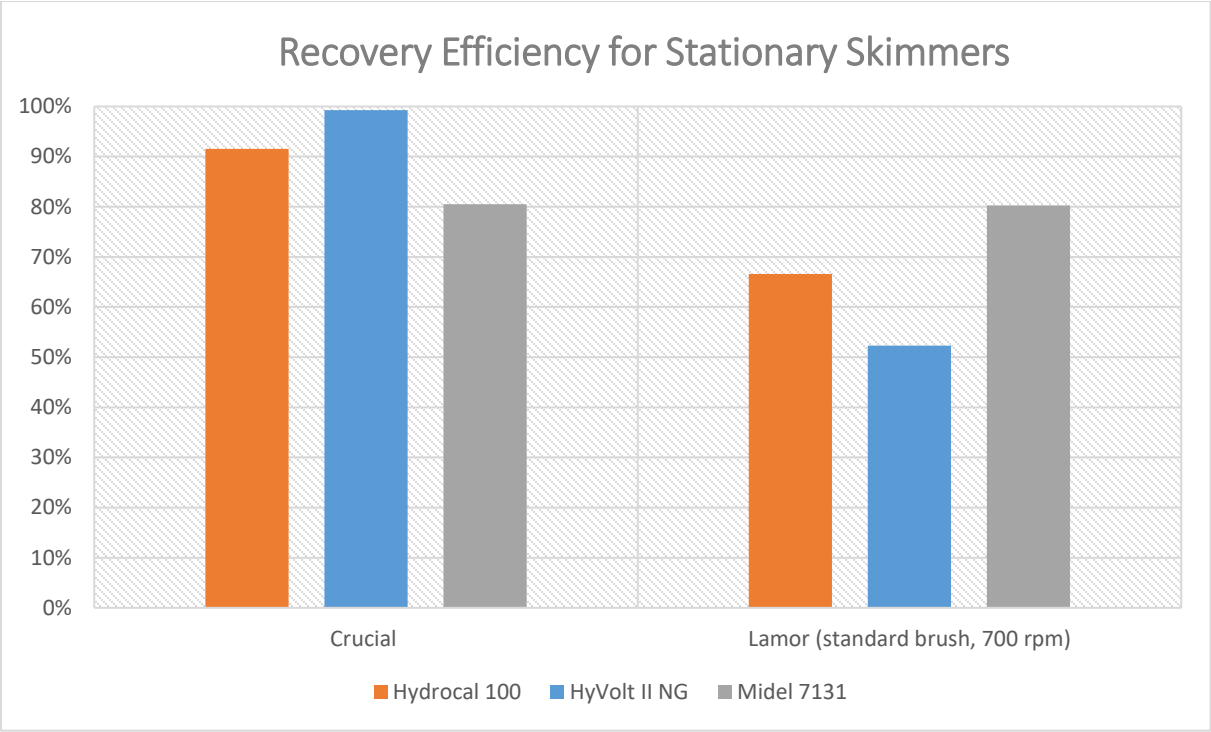

Figure 14. Recovery efficiency for stationary skimmers with all test fluids.

The disc skimmer shows decreased RE with higher test fluid viscosity. With the lowest-viscosity test fluid, HyVolt II NG, the disc skimmer showed the highest RE with an average of 99.3%. With the highest-viscosity test fluid, Midel 7131, the disc skimmer recorded the lowest RE at the average of 80.5%, a difference of approximately 19 percent. RE with Hydrocal 100 was in the middle with 91.5%. This finding may be attributed to the fact that lower-viscosity fluids have an easier time adhering to the oleophilic material ("fuzzy") coating (Yan, Yongchang Jiang, & Guihua, 2023). The lower-viscosity fluids can flow into and adhere to the small fibers within the disc skimmer coating. The low internal resistance allows the HyVolt II NG to easily spread over the fibrous skin and allow most of the water to fall back to the water's surface. When fluid viscosity increases, the test fluid and water begin to have trouble in separating at the interface, thus decreasing the skimmer's efficiency.

Recovery efficiency for the LAM 50 showed a steady increase across all three test fluids. With HyVolt II NG, its average RE was 52.3% but climbed to 66.6% with Hydrocal 100. With Midel 7131, its RE was 80.2%, an increase of 13.6 percentage points from Hydrocal 100. Test findings are consistent with current knowledge that brush skimmers are more efficient with higher-viscosity oils, and they are often used in real-world oil spills with medium to heavy crude oil. With lower-viscosity test fluids, the LAM 50 recovers greater amount of water. Section 4.1.1 describes test results with different brush skimmer settings in greater details.

4.1.1 Standard and Alternate Brushes for Lamor MultiMax 50 Brush Skimmer at 700 and 1,200 rpm

In addition to executing triplicates with all test fluids using the standard brushes operating at 700 rpm, the team also carried out triplicate testing with the alternate brushes at 700 and 1,200 rpm with Midel 7131. Since the brush skimmer showed a range of RE with both dielectric fluids, the team explored different skimmer settings using both the standard and alternate brushes for HyVolt II NG and Midel 7131 (Table 5 and *Standard brush, 8 rotations per minute
**Alternate brush, 8 rotations per minute
^ Evaluated with reused test fluid

Table 7).

The team did not test the alternate brushes with Hydrocal 100 due to limited tank time and it not being part of the original test plan. Figure 15 shows the average ORR for all test runs, including single runs, with both the standard and alternate brushes.

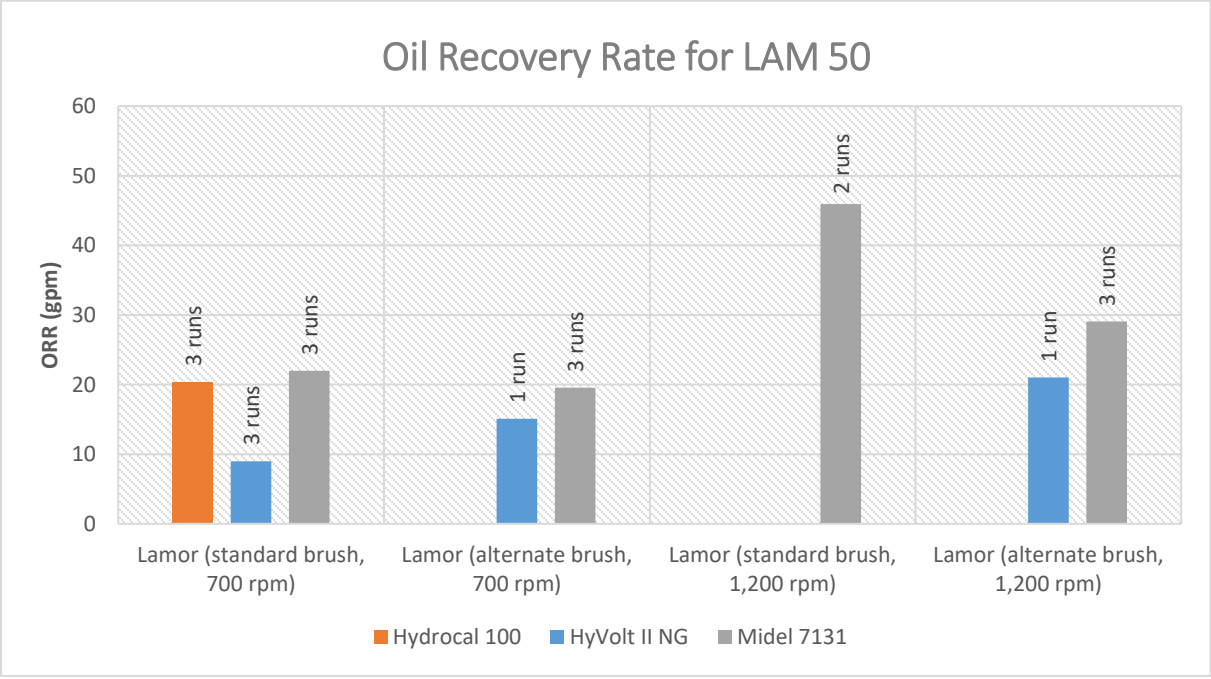

Figure 15. Oil recovery rate for LAM 50 at different settings.

The limited test data with the alternate brushes and different hydraulic speeds did not allow the project team to reach any firm conclusions. The best comparison that the team can make is the ORR and RE (Figure 16) values for both standard and alternate brushes with Midel 7131 at 700 rpm since it executed triplicates of each brush set. With the standard brushes, the ORR with Midel 7131 was 22.0 gpm but with the alternate brushes, the ORR dropped slightly to 19.6 gpm. The team conducted additional test runs with both brushes at a higher hydraulic speed of 1,200 rpm to determine if ORR may be significantly improved while maintaining the RE.

The team executed another triplicate with the alternate brushes using Midel 7131 at 1,200 rpm but could only do two runs using the standard brushes at the same speed. The ORR for both brush sets at the higher hydraulic speed was higher than that at 700 rpm (46.0 gpm to 22.0 gpm for standard and 29.1 gpm to 19.6 gpm for alternate). At 1,200 rpm, the alternate brushes showed much lower ORR than the standard brushes (29.1 gpm to 46.0 gpm).

The team executed single test runs with the alternate brushes with HyVolt II NG at 700 and 1,200 rpm. This limited data at 700 rpm show the alternate brushes had a greater ORR compared to the standard brushes (15.1 gpm to 9.0 gpm). The team did not test the standard brushes at 1,200 rpm with HyVolt II NG, so a comparison can only be made between the alternate brushes at 700 and 1,200 rpm. At 1,200 rpm with the alternate brushes with HyVolt II NG, the ORR was 21.0 gpm.

Figure 16 shows the average RE for all test runs with both the standard and alternate brushes.

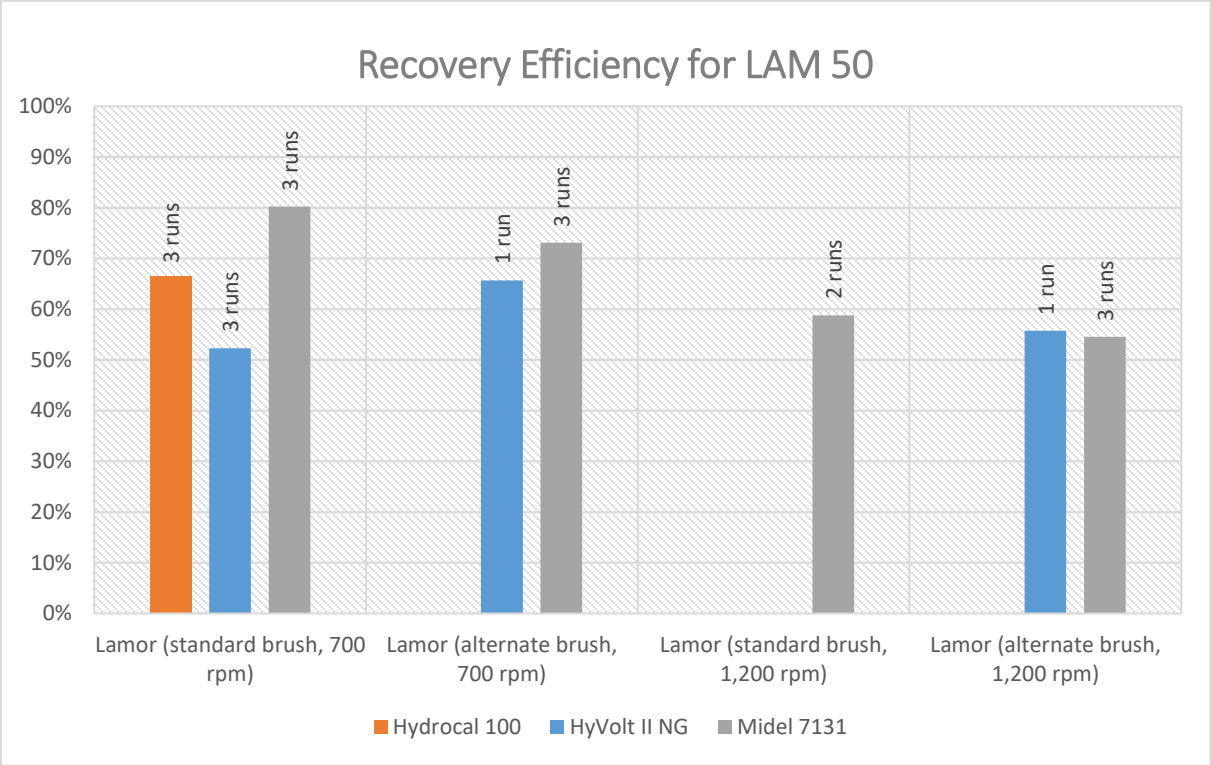

Figure 16. Recovery efficiency for LAM 50 at different settings.

As was the case with the ORR, there was a similar drop in RE for Midel 7131 between the standard and alternate brushes, with the standard having 80.2% and the alternate at 73.1%. When the team increased the hydraulic speed to 1,200, the RE for both brush sets was lower than that at 700 rpm (58.8% to 80.2% for standard and 54.6% to 73.1% for alternate). At 1,200 rpm, the alternate brushes had slightly less RE than the standard brushes (54.6% to 58.8%).

For alternate brushes with HyVolt II NG, data indicate there was greater RE at 700 rpm compared to the standard brushes (65.7% to 52.3%). At 1,200 rpm with the alternate brushes, the RE was 55.7%.

Both ORR and RE numbers for the alternate brushes are higher with Midel 7131 than HyVolt II NG except for the RE at 1,200 rpm. However, the team is unable to draw conclusions due to limited test runs with the alternate brushes with HyVolt II NG.

4.2 Oil Recovery Rate and Recovery Efficiency for Advancing Skimmers

Elastec representatives were present for all advancing-mode skimmer tests due to their extensive experience operating both the Marco FilterBelt skimmer and the Elastec X30 grooved disc skimmer on the Kvichak vessel. Since filter belt skimmers are not normally used for low-viscosity oil and this filter belt skimmer frequently experienced low RE (<70%), it required several optimization runs to ensure the highest ORR and RE possible.

Figure 17 shows the average ORR for both the Marco FilterBelt skimmer and the Elastec X30 grooved disc skimmer installed on Elastec's Kvichak vessel.

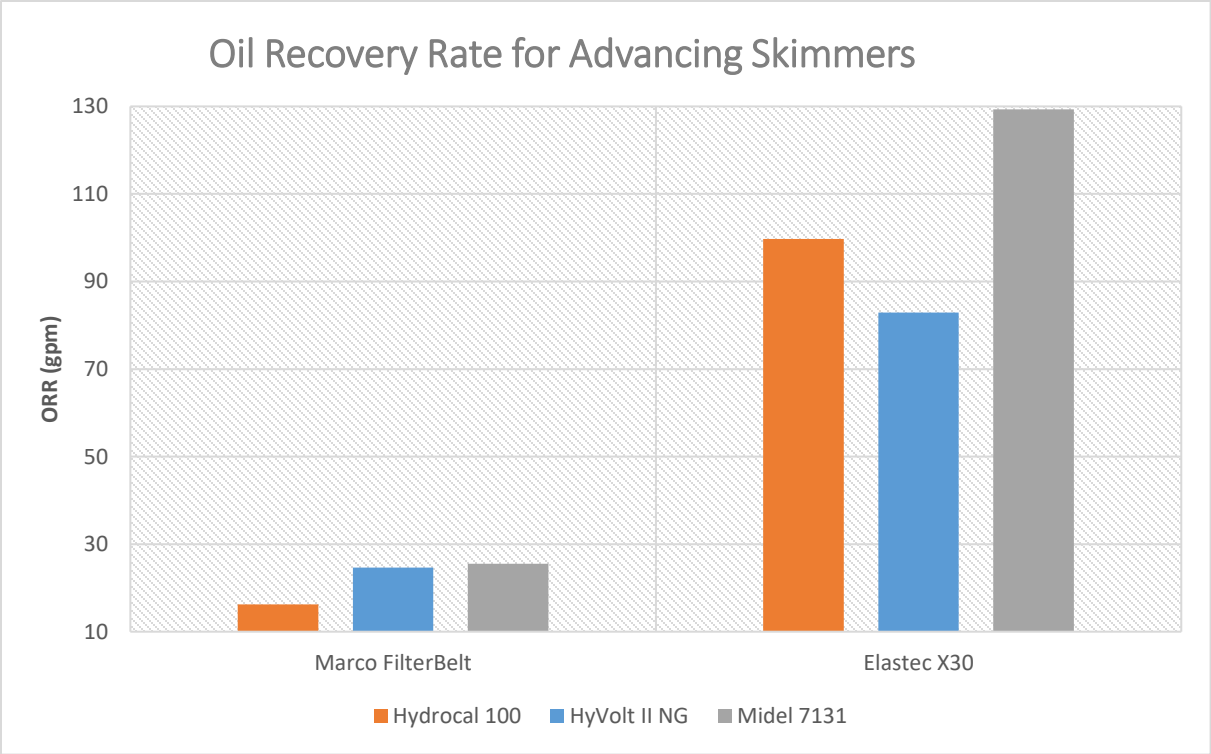

Figure 17. Oil recovery rate for advancing skimmers with all test fluids.

Of the three test fluids, the Marco FilterBelt skimmer had the lowest ORR with Hydrocal 100 at 16.2 gpm. However, its ORR was higher for HyVolt II NG and Midel 7131, with both numbers being similar to each other - 24.7 gpm for HyVolt II NG and 25.5 gpm for Midel 7131. Note that the team discharged used Midel 7131 for its test runs with the FilterBelt skimmer.

There was limited supply of each test fluid and the Elastec X30 grooved disc skimmer was the last skimmer tested; this necessitated the reuse of each test fluid for this skimmer. As shown in Table 2, the dynamic viscosity of each fresh and used test fluid was similar except for Midel 7131. The dynamic viscosity of used

Midel 7131 was approximately 24% lower. With this caveat, there appears to be a correlation for the X30 grooved disc skimmer between ORR and the three test fluids' viscosities. With HyVolt II NG, the ORR was 82.9 gpm for HyVolt II NG, increased to 99.7 gpm for Hydrocal 100, and then increased again to 129.3 gpm for used Midel 7131.

Figure 18 shows the average RE for both the Marco FilterBelt and Elastec X30 skimmers.

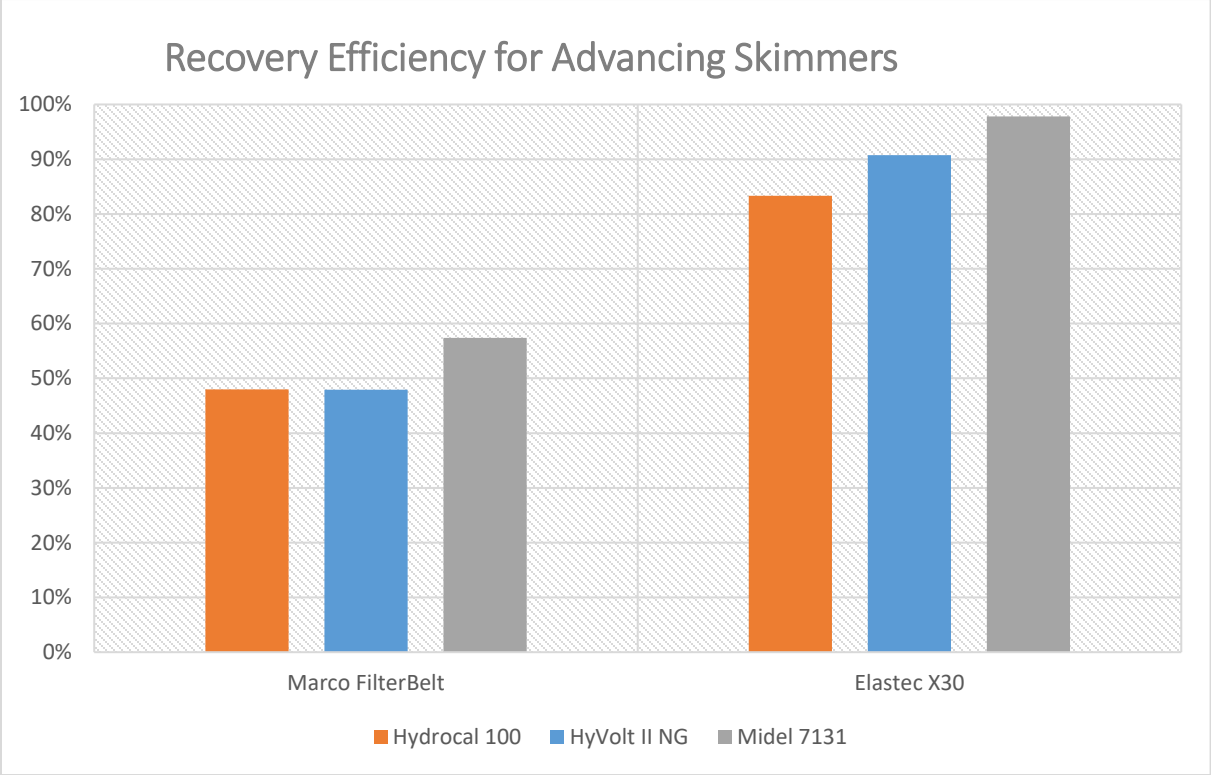

Figure 18. Recovery efficiency for advancing skimmers with all test fluids.

The Marco FilterBelt skimmer's RE for both HyVolt II NG and Hydrocal 100 was the same at 48.0% but improved to 57.4% for Midel 7131. The X30 grooved disc skimmer showed improved RE with the two dielectric fluids compared to Hydrocal 100, with used Midel 7131 showing the highest RE of the three test fluids. With HyVolt II NG, the skimmer recorded a RE of 90.8% but decreased to 83.3% for Hydrocal 100. However, the skimmer performed the best with used Midel 7131 with an average RE of 97.8%.

Elastec representatives needed to replace the sheen pads on the Marco FilterBelt skimmer three times during the experiments due to wear and tear (Figure 19).

Figure 19. Damaged sheen pads on the Marco FilterBelt skimmer due to wear and tear.

Elastec representatives faced the challenge of trying to increase the belt speed so that the skimmer's ORR would improve, but slow enough to avoid excessive pad shredding. There is no evidence that the dielectric fluids increased or decreased the amount of wear and tear the sheen pads experienced. The pads have a limited life span during recovery and are meant to be changed out.

5 CONCLUSIONS

The project team evaluated four oil skimmers on three test fluids – two dielectric fluids and one refined oil, which served as a control. In calm, test conditions, two disc skimmers designed to recover low-viscosity oils recovered dielectric fluids at a higher rate and more efficiently than a brush skimmer or a filter belt skimmer designed for higher-viscosity oils.

RDC and BSEE OSPD do not anticipate a need to develop a new class of skimmers specifically to recover dielectric fluids; skimmers capable of recovering low-viscosity oils can recover dielectric fluids as well. It is important to note that all test runs executed at Ohmsett were in calm water with fresh or once-used dielectric fluids. Like any other oil skimming operations, fluid weathering and sea state will affect recovery rates and efficiencies. This puts additional emphasis on the importance of operator training and experience when working with oil skimmers and low-viscosity fluids such as dielectric fluids.

5.1 Crucial "Fuzzy" Disc Skimmer

- The Crucial disc skimmer's recovery rate for both dielectric fluids was similar, but lower than for the light oil as a control.
- This skimmer showed very high RE of HyVolt II NG, and somewhat lower, but still acceptable efficiency for recovering the higher-viscosity Midel 7131. The oleophilic material on the disc skimmer may show preference for fluids of low viscosity.

5.2 Lamor MultiMax 50 Brush Skimmer

- The LAM 50 had difficulty picking up all three test fluids, with best recovery rate for the higher-viscosity Midel 7131.
- This skimmer's RE was also greatest with the higher-viscosity Midel 7131, and not so acceptable for the HyVolt II NG. This indicates the brush skimmer may be sensitive to the dielectric fluid's viscosity, and may be effective in spill scenarios with higher-viscosity dielectric fluids.
- Limited test runs with the Lamor alternate brushes and did not provide enough data to determine performance with the alternate brush set and other test fluids.

5.3 Marco FilterBelt Skimmer

- The Marco FilterBelt skimmer had a low recovery rate for the dielectrics, and even lower for the control oil.
- RE was below 70% for the two dielectrics and the control oil, but highest for higher-viscosity Midel 7131.

5.4 Elastec X30 Grooved Disc Skimmer

- The Elastec X30 grooved disc skimmer had highest recovery rate on Midel 7131, the higher-viscosity dielectric.
- This skimmer showed higher RE with the two dielectrics compared to the control oil.

6 RECOMMENDATIONS

RDC and BSEE OSPD recommend that oil spill responders use existing oil skimmers already proven to demonstrate good performance with low-viscosity oils (e.g., light refined or light crude oils) for dielectric fluid spills. Oil spill responders should plan to use oil skimmers that are designed for low viscosity fluids such as oleophilic disc and brush skimmers and avoid the use of oil skimmers that are known to work well with medium-to-high viscosity oils such as rope mop, filterbelt, and certain types of brush skimmers such as those with stiff bristles equipped for heavier or more-viscous oils.

RDC and BSEE OSPD recommend future research include testing existing oil skimmers with weathered dielectric fluids and in wave conditions. Throughput efficiency of advancing skimmers designed for low viscosity fluids should also be reevaluated. The project team could not obtain TE data due to the challenge of segregating fluids recovered at the end of one test from the start of the next and missing decant volume and fluid sampling data for the untimed fluid collection.

RDC and BSEE OSPD recommend that independent Government evaluations of new and emerging oil spill response technologies continue. Through BSEE OSPD's Testing of Oil Spill Technologies (TOST) initiative, RDC and the Interagency Coordinating Committee on Oil Pollution Research (ICCOPR) members may be able to support ongoing research. This would ensure that oil spill responders continue to have access to credible data about new and emerging technologies, and that response manufacturers can have the opportunity to improve their products based on those evaluations.

FOSCs and other pollution responders should use Section 7 of this report, “Guidance on Skimmer Selection for Recovering Dielectric Fluids for Planners and Responders”.

7 GUIDANCE ON SKIMMER SELECTION FOR RECOVERING DIELECTRIC FLUIDS FOR PLANNERS AND RESPONDERS

This FOSC guidance is based on research conducted at Ohmsett that evaluated skimmer oil recovery rate and recovery efficiency for three types of low-viscosity test fluids. The project team tested with two dielectric fluids, HyVolt II NG and Midel 7131. The third test fluid was Hydrocal 100, refined oil, that was used as control. Since the team had limited supply of each test fluid, they needed to be reused for parts of the evaluation. Table 8 shows the dynamic viscosity of fresh dielectric fluids as measured by the project team (Table 2) along with viscosity ranges of light, medium and heavy oils shown in Table 1 and mentioned in ASTM F726-17 (ASTM International, 2017) that spill responders are familiar with.

Table 8. Dynamic viscosities of dielectric fluids (in italics) and crude/refined oils.

Test Fluid	Dynamic Viscosity (mPa·s)
Light oil	1 to 10
HyVolt II NG	19
Hydrocal 100	64
Midel 7131	73
Medium oil	200 to 400
Heavy oil	1,500 to 2,500

Both types of dielectric fluids tested are among those proposed for use in the development of offshore wind facilities. For testing purposes, the team added dye to all test fluids to allow for easier visual observations during tests. If dielectric fluids are encountered during a real-world spill, they will be colorless/clear and difficult to discern from water.

When recovering fresh dielectric fluid in calm water conditions, the oil skimmer’s performance (oil recovery rate and recovery efficiency) may be dependent on the dielectric fluid’s dynamic viscosity. The project team hypothesizes that oil skimmers designed for refined/crude oil of low viscosity will likely exhibit comparable performance for dielectric fluids of similar viscosity.

Table 9 summarizes the oil recovery rate and recovery efficiency values for each skimmer tested with both dielectric fluids.

Table 9. Average oil recovery rate and recovery efficiency of skimmers with test fluids tested at Ohmsett.

Skimmer	Test Fluid	Oil Recovery Rate (average)	Recovery Efficiency (average)
Crucial "fuzzy" disc skimmer	HyVolt II NG	28.4 gpm	99.3%
	Midel 7131	28.8 gpm	80.5%
Lamor brush skimmer (standard/short brushes)	HyVolt II NG	9.0 gpm	52.3%
	Midel 7131	22.0 gpm	80.2%
Lamor brush skimmer (alternate/long and dense brushes)	Midel 7131	19.6 gpm	73.1%
Marco FilterBelt skimmer	HyVolt II NG	24.7 gpm	48.0%
	Midel 7131	25.5 gpm	57.4%
Elastec X30 grooved disc skimmer	HyVolt II NG	82.9 gpm	90.8%
	Midel 7131	129.3 gpm	97.8%

The results show that that disc skimmers, particularly the fuzzy coated and grooved disc technologies, showed good oil recovery rate and recovery efficiency and are recommended for use with dielectric fluid spills.

The filter belt skimmer designed for higher-viscosity oils, though fitted with sheen pads, did not perform as well with the low-viscosity fluids dielectric fluids in testing and is not recommended for use with dielectric fluid spills.

Though designed for medium-high viscosity oils, the brush skimmer's performance showed mixed effectiveness between the two dielectric fluids. With higher-viscosity dielectric fluids, the brush skimmer may be recommended for use. With lower-viscosity dielectric fluids, the brush skimmer is not recommended.

Oil skimmers' performance in real-world spill conditions are typically degraded when compared to that of laboratory conditions; skimmers specifically designed for low-viscosity oil should take precedence with low-viscosity dielectric fluid spills.

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APPENDIX A. TEST FLUIDS SAFETY DATA SHEETS

A.1 Hydrocal 100

SAFETY DATA SHEET

Hydrocal 100

CALUMET REFINING, LLC

Section 1. Identification

GHS product identifier : Hydrocal 100

Product code : 300103008000

Chemical name : Distillates (petroleum), hydrotreated heavy naphthenic

Other means of identification : Baseoil - unspecified; Distillates, petroleum, hydrotreated heavy naphthenic; Hydrotreated heavy naphthenic distillate, solvent extract, petroleum; Mineral oil, petroleum distillates, hydrotreated heavy naphthenic; Mineral oil, petroleum distillates, hydrotreated (severe) heavy naphthenic; Distillates (petroleum), hydro-treated heavy naphthenic; Hydrotreated heavy naphthenic distillate solvent extract (petroleum); OILS, MINERAL, HEAVY NAPHTHENIC, HYDROTREATED; OILS, NAPHTHENIC, HYDROGENATED; SEVERELY SOLVENT REFINED HEAVY PARAFFINIC DISTILLATES; HYDROTREATED LIGHT PETROLEUM DISTILLATE

Product type : Liquid.

Relevant identified uses of the substance or mixture and uses advised against

Identified uses
Petrochemical industry: Petroleum refining. Naphthenic Lubricant.

Uses advised against	Reason
None known.	

Supplier's details : Calumet Refining, LLC
2780 Waterfront Pkwy E. Drive Suite 200
Indianapolis, IN 46214
USA
Technical Services: 317-328-5660

Distributed By: R.E. Carroll, Inc.
1570 North Olden Avenue
Ewing, N.J. 08638-3204 USA
T: 609-695-8211/800-257-9365
Orders@RECarroll.com

24hr. CHEMTREC 1-800-424-9300 / International 1-703-527-3887 : 24 hr. CHEMTREC 1-800-424-9300 / International 1-703-527-3887

Section 2. Hazards identification

OSHA/HCS status : This material is considered hazardous by the OSHA Hazard Communication Standard (29 CFR 1910.1200).

Classification of the substance or mixture : ASPIRATION HAZARD - Category 1

GHS label elements

Hazard pictograms :

Signal word : Danger

Hazard statements : May be fatal if swallowed and enters airways.

Precautionary statements

Prevention : Not applicable.

Response : IF SWALLOWED: Immediately call a POISON CENTER or physician. Do NOT induce vomiting.

Storage : Store locked up.

Disposal : Dispose of contents and container in accordance with all local, regional, national and international regulations.

Date of issue/Date of revision : 03/02/2020 *Version* : 4 1/10

Section 2. Hazards identification

Hazards not otherwise classified : None known.

Section 3. Composition/information on ingredients

Substance/mixture : Substance

Chemical name : Distillates (petroleum), hydrotreated heavy naphthenic

Other means of identification : Baseoil - unspecified; Distillates, petroleum, hydrotreated heavy naphthenic; Hydrotreated heavy naphthenic distillate, solvent extract, petroleum; Mineral oil, petroleum distillates, hydrotreated heavy naphthenic; Mineral oil, petroleum distillates, hydrotreated (severe) heavy naphthenic; Distillates (petroleum), hydro-treated heavy naphthenic; Hydrotreated heavy naphthenic distillate solvent extract (petroleum); OILS, MINERAL, HEAVY NAPHTHENIC, HYDROTREATED; OILS, NAPHTHENIC, HYDROGENATED; SEVERELY SOLVENT REFINED HEAVY PARAFFINIC DISTILLATES; HYDROTREATED LIGHT PETROLEUM DISTILLATE

CAS number/other identifiers

CAS number : 64742-52-5

Ingredient name	%	CAS number
Distillates (petroleum), hydrotreated heavy naphthenic	100	64742-52-5

Any concentration shown as a range is to protect confidentiality or is due to batch variation.

There are no additional ingredients present which, within the current knowledge of the supplier and in the concentrations applicable, are classified as hazardous to health or the environment and hence require reporting in this section.

Occupational exposure limits, if available, are listed in Section 8.

Section 4. First aid measures

Description of necessary first aid measures

Eye contact : Immediately flush eyes with plenty of water, occasionally lifting the upper and lower eyelids. Check for and remove any contact lenses. Continue to rinse for at least 10 minutes. Get medical attention if irritation occurs.

Inhalation : Remove victim to fresh air and keep at rest in a position comfortable for breathing. If not breathing, if breathing is irregular or if respiratory arrest occurs, provide artificial respiration or oxygen by trained personnel. It may be dangerous to the person providing aid to give mouth-to-mouth resuscitation. Get medical attention if adverse health effects persist or are severe. If unconscious, place in recovery position and get medical attention immediately. Maintain an open airway. Loosen tight clothing such as a collar, tie, belt or waistband.

Skin contact : Flush contaminated skin with plenty of water. Remove contaminated clothing and shoes. Get medical attention if symptoms occur. Wash clothing before reuse. Clean shoes thoroughly before reuse.

Ingestion : Get medical attention immediately. Call a poison center or physician. Wash out mouth with water. Remove dentures if any. Remove victim to fresh air and keep at rest in a position comfortable for breathing. If material has been swallowed and the exposed person is conscious, give small quantities of water to drink. Stop if the exposed person feels sick as vomiting may be dangerous. Aspiration hazard if swallowed. Can enter lungs and cause damage. Do not induce vomiting. If vomiting occurs, the head should be kept low so that vomit does not enter the lungs. Never give anything by mouth to an unconscious person. If unconscious, place in recovery position and get medical attention immediately. Maintain an open airway. Loosen tight clothing such as a collar, tie, belt or waistband.

Most important symptoms/effects, acute and delayed

Potential acute health effects

Eye contact : No known significant effects or critical hazards.

Inhalation : No known significant effects or critical hazards.

Section 4. First aid measures

Skin contact : No known significant effects or critical hazards.

Ingestion : May be fatal if swallowed and enters airways.

Over-exposure signs/symptoms

Eye contact : No specific data.

Inhalation : No specific data.

Skin contact : No specific data.

Ingestion : Adverse symptoms may include the following:
nausea or vomiting

Indication of immediate medical attention and special treatment needed, if necessary

Notes to physician : Treat symptomatically. Contact poison treatment specialist immediately if large quantities have been ingested or inhaled.

Specific treatments : No specific treatment.

Protection of first-aiders : No action shall be taken involving any personal risk or without suitable training. It may be dangerous to the person providing aid to give mouth-to-mouth resuscitation.

See toxicological information (Section 11)

Section 5. Fire-fighting measures

Extinguishing media

Suitable extinguishing media : Use an extinguishing agent suitable for the surrounding fire.

Unsuitable extinguishing media : Do not use water jet.

Specific hazards arising from the chemical : In a fire or if heated, a pressure increase will occur and the container may burst.

Hazardous thermal decomposition products : Decomposition products may include the following materials:
carbon dioxide
carbon monoxide

Special protective actions for fire-fighters : Promptly isolate the scene by removing all persons from the vicinity of the incident if there is a fire. No action shall be taken involving any personal risk or without suitable training.

Special protective equipment for fire-fighters : Fire-fighters should wear appropriate protective equipment and self-contained breathing apparatus (SCBA) with a full face-piece operated in positive pressure mode.

Section 6. Accidental release measures

Personal precautions, protective equipment and emergency procedures

For non-emergency personnel : No action shall be taken involving any personal risk or without suitable training. Evacuate surrounding areas. Keep unnecessary and unprotected personnel from entering. Do not touch or walk through spilled material. Avoid breathing vapor or mist. Provide adequate ventilation. Wear appropriate respirator when ventilation is inadequate. Put on appropriate personal protective equipment.

For emergency responders : If specialized clothing is required to deal with the spillage, take note of any information in Section 8 on suitable and unsuitable materials. See also the information in "For non-emergency personnel".

Environmental precautions : Avoid dispersal of spilled material and runoff and contact with soil, waterways, drains and sewers. Inform the relevant authorities if the product has caused environmental pollution (sewers, waterways, soil or air).

Methods and materials for containment and cleaning up

Section 6. Accidental release measures

Small spill : Stop leak if without risk. Move containers from spill area. Dilute with water and mop up if water-soluble. Alternatively, or if water-insoluble, absorb with an inert dry material and place in an appropriate waste disposal container. Dispose of via a licensed waste disposal contractor.

Large spill : Stop leak if without risk. Move containers from spill area. Approach release from upwind. Prevent entry into sewers, water courses, basements or confined areas. Wash spillages into an effluent treatment plant or proceed as follows. Contain and collect spillage with non-combustible, absorbent material e.g. sand, earth, vermiculite or diatomaceous earth and place in container for disposal according to local regulations (see Section 13). Dispose of via a licensed waste disposal contractor. Contaminated absorbent material may pose the same hazard as the spilled product. Note: see Section 1 for emergency contact information and Section 13 for waste disposal.

Section 7. Handling and storage

Precautions for safe handling

Protective measures : Put on appropriate personal protective equipment (see Section 8). Do not swallow. Avoid contact with eyes, skin and clothing. Avoid breathing vapor or mist. Keep in the original container or an approved alternative made from a compatible material, kept tightly closed when not in use. Empty containers retain product residue and can be hazardous. Do not reuse container.

Advice on general occupational hygiene : Eating, drinking and smoking should be prohibited in areas where this material is handled, stored and processed. Workers should wash hands and face before eating, drinking and smoking. Remove contaminated clothing and protective equipment before entering eating areas. See also Section 8 for additional information on hygiene measures.

Conditions for safe storage, including any incompatibilities : Store in accordance with local regulations. Store in original container protected from direct sunlight in a dry, cool and well-ventilated area, away from incompatible materials (see Section 10) and food and drink. Store locked up. Keep container tightly closed and sealed until ready for use. Containers that have been opened must be carefully resealed and kept upright to prevent leakage. Do not store in unlabeled containers. Use appropriate containment to avoid environmental contamination. See Section 10 for incompatible materials before handling or use.

Section 8. Exposure controls/personal protection

Control parameters

Occupational exposure limits

Ingredient name	Exposure limits
Distillates (petroleum), hydrotreated heavy naphthenic	**ACGIH TLV (United States, 3/2019).** TWA: 5 mg/m³ 8 hours. Form: Inhalable fraction **OSHA PEL (United States, 5/2018).** TWA: 5 mg/m³ 8 hours. **NIOSH REL (United States, 10/2016).** TWA: 5 mg/m³ 10 hours. Form: Mist STEL: 10 mg/m³ 15 minutes. Form: Mist

Appropriate engineering controls : Good general ventilation should be sufficient to control worker exposure to airborne contaminants.

Environmental exposure controls : Emissions from ventilation or work process equipment should be checked to ensure they comply with the requirements of environmental protection legislation. In some cases, fume scrubbers, filters or engineering modifications to the process equipment will be necessary to reduce emissions to acceptable levels.

Individual protection measures

Section 8. Exposure controls/personal protection

Hygiene measures : Wash hands, forearms and face thoroughly after handling chemical products, before eating, smoking and using the lavatory and at the end of the working period. Appropriate techniques should be used to remove potentially contaminated clothing. Wash contaminated clothing before reusing. Ensure that eyewash stations and safety showers are close to the workstation location.

Eye/face protection : Safety eyewear complying with an approved standard should be used when a risk assessment indicates this is necessary to avoid exposure to liquid splashes, mists, gases or dusts. If contact is possible, the following protection should be worn, unless the assessment indicates a higher degree of protection: safety glasses with side-shields.

Skin protection

Hand protection : Chemical-resistant, impervious gloves complying with an approved standard should be worn at all times when handling chemical products if a risk assessment indicates this is necessary. Considering the parameters specified by the glove manufacturer, check during use that the gloves are still retaining their protective properties. It should be noted that the time to breakthrough for any glove material may be different for different glove manufacturers. In the case of mixtures, consisting of several substances, the protection time of the gloves cannot be accurately estimated.

Body protection : Personal protective equipment for the body should be selected based on the task being performed and the risks involved and should be approved by a specialist before handling this product.

Other skin protection : Appropriate footwear and any additional skin protection measures should be selected based on the task being performed and the risks involved and should be approved by a specialist before handling this product.

Respiratory protection : Based on the hazard and potential for exposure, select a respirator that meets the appropriate standard or certification. Respirators must be used according to a respiratory protection program to ensure proper fitting, training, and other important aspects of use.

Section 9. Physical and chemical properties

Appearance

Physical state : Liquid.

Color : Not available.

Odor : Not available.

Odor threshold : Not available.

pH : Not available.

Melting point : Not available.

Boiling point : Not available.

Flash point : Open cup: 165°C (329°F) [Cleveland.]

Evaporation rate : <0.0372 (butyl acetate = 1)

Flammability (solid, gas) : Not available.

Lower and upper explosive (flammable) limits : Not available.

Vapor pressure : 0.0021 kPa (0.016 mm Hg) [room temperature]

Vapor density : Not available.

Relative density : 0.9

Solubility : Insoluble in the following materials: cold water and hot water.

Solubility in water : Not available.

Partition coefficient: n-octanol/water : Not available.

Auto-ignition temperature : Not available.

Decomposition temperature : Not available.

Viscosity : Kinematic (40°C (104°F)): 0.187 to 0.2183 cm^2/s (18.7 to 21.83 cSt)

Flow time (ISO 2431) : Not available.

Section 9. Physical and chemical properties

Pour point : -43°C (-45.4°F)

Section 10. Stability and reactivity

Reactivity : No specific test data related to reactivity available for this product or its ingredients.

Chemical stability : The product is stable.

Possibility of hazardous reactions : Under normal conditions of storage and use, hazardous reactions will not occur.

Conditions to avoid : No specific data.

Incompatible materials : No specific data.

Hazardous decomposition products : Under normal conditions of storage and use, hazardous decomposition products should not be produced.

Section 11. Toxicological information

Information on toxicological effects

Acute toxicity

Product/ingredient name	Result	Species	Dose	Exposure
Distillates (petroleum), hydrotreated heavy naphthenic	LC50 Inhalation Dusts and mists	Rat	5.7 mg/l	4 hours
	LD50 Dermal	Rabbit	>2000 mg/kg	-
	LD50 Oral	Rat	>5000 mg/kg	-

Irritation/Corrosion

Not available.

Sensitization

Not available.

Mutagenicity

Not available.

Carcinogenicity

Not available.

Conclusion/Summary : The classification as a carcinogen need not apply as it can be shown that the substance contains less than 3 % DMSO extract as measured by IP 346.

Reproductive toxicity

Not available.

Teratogenicity

Not available.

Specific target organ toxicity (single exposure)

Not available.

Specific target organ toxicity (repeated exposure)

Not available.

Aspiration hazard

Name	Result
Distillates (petroleum), hydrotreated heavy naphthenic	ASPIRATION HAZARD - Category 1

Section 11. Toxicological information

Information on the likely routes of exposure : Routes of entry anticipated: Oral, Dermal, Inhalation.

Potential acute health effects

Eye contact : No known significant effects or critical hazards.

Inhalation : No known significant effects or critical hazards.

Skin contact : No known significant effects or critical hazards.

Ingestion : May be fatal if swallowed and enters airways.

Symptoms related to the physical, chemical and toxicological characteristics

Eye contact : No specific data.

Inhalation : No specific data.

Skin contact : No specific data.

Ingestion : Adverse symptoms may include the following:
nausea or vomiting

Delayed and immediate effects and also chronic effects from short and long term exposure

Short term exposure

Potential immediate effects : Not available.

Potential delayed effects : Not available.

Long term exposure

Potential immediate effects : Not available.

Potential delayed effects : Not available.

Potential chronic health effects

Not available.

General : No known significant effects or critical hazards.

Carcinogenicity : No known significant effects or critical hazards.

Mutagenicity : No known significant effects or critical hazards.

Teratogenicity : No known significant effects or critical hazards.

Developmental effects : No known significant effects or critical hazards.

Fertility effects : No known significant effects or critical hazards.

Numerical measures of toxicity

Acute toxicity estimates

Product/ingredient name	Oral (mg/kg)	Dermal (mg/kg)	Inhalation (gases) (ppm)	Inhalation (vapors) (mg/l)	Inhalation (dusts and mists) (mg/l)
Distillates (petroleum), hydrotreated heavy naphthenic Distillates (petroleum), hydrotreated heavy naphthenic	N/A N/A	2500 2500	N/A N/A	N/A N/A	N/A 5.7

Section 12. Ecological information

Toxicity

Product/ingredient name	Result	Species	Exposure
Distillates (petroleum), hydrotreated heavy naphthenic	Acute EC50 >100 mg/l Acute EC50 >100 mg/l Acute LC50 >100 mg/l	Algae Crustaceans Fish	72 hours 48 hours 96 hours

Persistence and degradability

Product/ingredient name	Aquatic half-life	Photolysis	Biodegradability
Distillates (petroleum), hydrotreated heavy naphthenic	-	-	Inherent

Bioaccumulative potential

Not available.

Mobility in soil

Soil/water partition coefficient (K_{OC}) : Not available.

Other adverse effects : No known significant effects or critical hazards.

Section 13. Disposal considerations

Disposal methods : The generation of waste should be avoided or minimized wherever possible. Disposal of this product, solutions and any by-products should at all times comply with the requirements of environmental protection and waste disposal legislation and any regional local authority requirements. Dispose of surplus and non-recyclable products via a licensed waste disposal contractor. Waste should not be disposed of untreated to the sewer unless fully compliant with the requirements of all authorities with jurisdiction. Waste packaging should be recycled. Incineration or landfill should only be considered when recycling is not feasible. This material and its container must be disposed of in a safe way. Care should be taken when handling emptied containers that have not been cleaned or rinsed out. Empty containers or liners may retain some product residues. Avoid dispersal of spilled material and runoff and contact with soil, waterways, drains and sewers.

Section 14. Transport information

	DOT Classification	TDG Classification	IMDG	IATA
UN number	Not regulated.	Not regulated.	Not regulated.	Not regulated.

Special precautions for user : **Transport within user's premises:** always transport in closed containers that are upright and secure. Ensure that persons transporting the product know what to do in the event of an accident or spillage.

Transport in bulk according to Annex II of MARPOL and the IBC Code : Not available.

Section 15. Regulatory information

U.S. Federal regulations : **TSCA 8(a) CDR Exempt/Partial exemption**: All components are listed or exempted.
Clean Water Act (CWA) 307: chrysene

Clean Air Act Section 112 (b) Hazardous Air Pollutants (HAPs) : Not listed

Clean Air Act Section 602 Class I Substances : Not listed

Clean Air Act Section 602 Class II Substances : Not listed

DEA List I Chemicals (Precursor Chemicals) : Not listed

DEA List II Chemicals (Essential Chemicals) : Not listed

SARA 302/304

Composition/information on ingredients

No products were found.

SARA 304 RQ : Not applicable.

SARA 311/312

Classification : ASPIRATION HAZARD - Category 1

Composition/information on ingredients

No products were found.

SARA 313

	Product name	CAS number	%
Form R - Reporting requirements	chrysene	218-01-9	0.00034

SARA 313 notifications must not be detached from the SDS and any copying and redistribution of the SDS shall include copying and redistribution of the notice attached to copies of the SDS subsequently redistributed.

State regulations

Massachusetts : The following components are listed: OIL MIST, MINERAL

New York : None of the components are listed.

New Jersey : The following components are listed: MINERAL OIL (HIGHLY REFINED); OIL MIST, MINERAL

Pennsylvania : None of the components are listed.

California Prop. 65

WARNING: This product can expose you to Chrysene, which is known to the State of California to cause cancer. For more information go to www.P65Warnings.ca.gov.
Information provided is based on industrial use and may not be relevant to consumer applications.

Ingredient name	Concentration (%)	No significant risk level	Maximum acceptable dosage level
chrysene	0.00034	Yes.	-

International lists

National inventory

Australia : All components are listed or exempted.

Canada : All components are listed or exempted.

China : All components are listed or exempted.

Europe : All components are listed or exempted.

Section 15. Regulatory information

Japan : **Japan inventory (ENCS)**: All components are listed or exempted.
Japan inventory (ISHL): Not determined.

New Zealand : All components are listed or exempted.

Philippines : All components are listed or exempted.

Republic of Korea : All components are listed or exempted.

Taiwan : All components are listed or exempted.

Thailand : Not determined.

Turkey : All components are listed or exempted.

United States : All components are listed or exempted.

Viet Nam : All components are listed or exempted.

Section 16. Other information

Procedure used to derive the classification

Classification	Justification
Asp. Tox. 1, H304	Expert judgment

History

Date of issue/Date of revision : 03/02/2020

Version : 4

Key to abbreviations : ATE = Acute Toxicity Estimate
BCF = Bioconcentration Factor
GHS = Globally Harmonized System of Classification and Labelling of Chemicals
IATA = International Air Transport Association
IBC = Intermediate Bulk Container
IMDG = International Maritime Dangerous Goods
LogPow = logarithm of the octanol/water partition coefficient
MARPOL = International Convention for the Prevention of Pollution From Ships, 1973 as modified by the Protocol of 1978. ("Marpol" = marine pollution)
N/A = Not available
SGG = Segregation Group
UN = United Nations

Indicates information that has changed from previously issued version.

Notice to reader

To the best of our knowledge, the information contained herein is accurate. However, neither the above-named supplier, nor any of its subsidiaries, assumes any liability whatsoever for the accuracy or completeness of the information contained herein.
Final determination of suitability of any material is the sole responsibility of the user. All materials may present unknown hazards and should be used with caution. Although certain hazards are described herein, we cannot guarantee that these are the only hazards that exist.

A.2 Midel 7131

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1. Identification of the Substance/Mixture and of the Company/Undertaking

1.1 Product Identifier
Material Name: MIDEL 7131.
EU REACH No.: 01-2120104110-86-0000.

1.2 Relevant identified uses of the substance or mixture and uses advised against
Product Use: Dielectric fluid.
Uses advised against: None.

1.3 Details of the supplier of the substance or mixture
Company: M&I Materials Ltd., Hibernia Way, Trafford Park, Manchester, M32 0ZD, UK.
Telephone: +44 (0)161 864 5411.
Emergency Telephone: +44 (0)161 864 5439.
Email: mideltech@mimaterials.com.

2. Hazards Identification

This product is not classified as hazardous and this document has been compiled for information purposes, in accordance regulation 1907/EC/2006, Annex II, as amended by Regulation (EU) No. 2015/830 and OSHA hazard communication guidelines.

2.1 Classification of the substance or mixture
Regulation (EC) No 1272/2008 (CLP): Not classified.

2.2 Label elements
Regulation (EC) No 1272/2008 (CLP): No symbol or signal word.

2.3 Other hazards
None.

3. Composition/Information on Ingredients

3 Substance
CAS No.: 68424-31-7.
Description: Fatty acids, C5-10 (linear and branched), mixed esters with pentaerythritol.
Composition:

Constituent	CAS Number	Contents
Fatty acid tetra esters	68424-31-7	>99.5%
Performance enhancing additives	Proprietary	<0.5%

All constituents are listed on the TSCA inventory. Additives used in this product are a trade secret, but do not lead to classification of the substance as hazardous.

4. First Aid Measures

4.1 Description of first aid measures
Inhalation: None envisaged due to the low vapour pressure of the substance.
Skin: Wash with soap and water. Obtain medical attention if irritation develops.
Eyes: Irrigate with copious amounts of water. Obtain medical attention if irritation develops.
Ingestion: Do not induce vomiting, obtain medical attention.

4.2 Most important symptoms and effects, both acute and delayed
No adverse effects expected.

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4.3 Indication of any immediate medical attention and special treatment needed
No special treatment required.

5. Fire Fighting Measures

5.1 Extinguishing media
Carbon dioxide, dry powder, ABF foam or water fog. Do not use water jets.

5.2 Special hazards arising from the substance or mixture
None.

5.3 Advice for fire fighters
Self-contained breathing apparatus may be required.

6. Accidental Release Measures

6.1 Personal precautions, protective equipment and emergency procedures
Spilt product constitutes a slip hazard. Avoid contact with skin and eyes.

6.2 Environmental precautions
Do not contaminate any lakes, streams, ponds, groundwater or soil. Avoid flushing into drains. In the event of a large spillage contain product as thoroughly as possible and dispose of in accordance with local regulations.

6.3 Methods and material for containment and cleaning up
Soak up spilt material with absorbent granules for disposal.

7. Handling and Storage

7.1 Precautions for safe handling
Avoid eye and prolonged skin contact.

7.2 Conditions for safe storage, including any incompatibilities
No special precautions required.

7.3 Specific end use(s)
Exposure to air should be minimised. Opened containers should be properly resealed.

8. Exposure Controls/ Personal Protection

8.1 Control parameters
No relevant control parameters.

8.2 Exposure controls
Eye washes should be available for emergency use.
Respiratory protection: Not required for normal use.
Skin protection: Wear coveralls.
Hand protection: Wash hands after use. For prolonged or repeated skin contact gloves are recommended.
Eye protection: If splashes are likely to occur wear safety glasses.

9. Physical and Chemical Properties

9.1 Information on basic physical and chemical properties
Appearance: Pale amber liquid.
Odour: Faintly sweet.
pH: Not applicable.
Freezing point: -56°C.
Initial boiling point and boiling range: >300°C.

Flash point: 260°C (closed cup).
Flammability (solid, gas): Non-flammable.
Upper/lower flammability or explosive limits: Data not available.
Vapour pressure: <0.001Pa at 20°C.
Vapour density: Not applicable.
Relative density: 0.97 at 20°C.
Water solubility: <1mg/l.
Solubility: Not applicable.
Partition coefficient: log Pow: >10
Auto-ignition temperature: No auto-ignition expected.
Decomposition temperature: Data not available.
Viscosity: 29mm^2/s at 40°C.
Explosive properties: Non-explosive.
Oxidising properties: Non-oxidising.

9.2 Other information
Not applicable.

10. Stability and Reactivity

10.1 Reactivity
Stable under normal conditions of use.

10.2 Chemical stability
Stable under normal conditions of use.

10.3 Possibility of hazardous reactions
Data not available.

10.4 Conditions to avoid
Temperatures >250°C.

10.5 Incompatible materials
Strong oxidising agents.

10.6 Hazardous decomposition products
None.

11. Toxicological Information

11.1 Information on toxicological effects
Likely routes of exposure: Skin and eyes are the most likely routes for exposure. Accidental ingestion may occur. Inhalation is not expected to be a relevant route of exposure.
Acute oral toxicity: Low toxicity: LD50 >2000mg/kg, OECD 401.
Acute dermal toxicity: Expected to be of low toxicity: LD50 >2000mg/kg, OECD 402.
Acute inhalation toxicity: Low volatility makes inhalation unlikely.
Skin corrosion/irritation: Not irritating, skin, OECD 404.
Eye corrosion/irritation: Not irritating, eye, OECD 405.
Respiratory or skin sensitisation: Not sensitising, skin, OECD 406.
Aspiration hazard: Not considered an aspiration hazard.
Carcinogenicity/mutagenicity: Not considered a mutagenic hazard or carcinogen. This product is not considered to be a carcinogen by IARC, ACGIH, NTP or OSHA.

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12. Ecological Information	When used and/or disposed of as indicated no adverse environmental effects are foreseen. Ecotoxicological effects based on knowledge of similar substances. **12.1 Toxicity** Salmo Gairdneri LC50 (96h), OECD 203: >1000mg/l. Daphnia Magna EI50 (48h), OECD 202: >1000mg/l. **12.2 Persistence and degradability** Readily biodegradable. **12.3 Bioaccumulative potential** No potential for bioaccumulation. **12.4 Mobility in soil** Product has low mobility in soil. **12.5 Results of PBT and vPvB assessment** The product does not meet criteria for toxicity which requires further assessment. It is not considered PBT or vPvB. **12.6 Other adverse effects** No other adverse effects envisaged.
13. Disposal Considerations	**13.1 Waste treatment methods** Product and packaging must be disposed of in accordance with local and national regulations. May be incinerated. Unused product may be returned for reclamation.
14. Transport Information	Not classified as hazardous under air (ICAO/IATA), sea (IMDG), road (ADR) or rail (RID) regulations. **14.1 UN number** Not relevant. **14.2 UN proper shipping name** Not relevant. **14.3 Transport hazard class** Not relevant. **14.4 Packing group** Not relevant. **14.5 Environmental hazards** Not relevant. **14.6 Special precautions for user** Not relevant.
15. Regulatory Information	**15.1 Safety, health and environmental regulations/legislation specific for the substance or mixture** Product is not subject to Authorisation under REACH.

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All constituent substances in this product are listed in the TSCA inventory.

15.2 Chemical safety assessment
A chemical safety assessment has been performed for this substance.

16. Other Information

Compiled according to regulation 1907/EC/2006, Annex II, as amended by Regulation (EU) No. 2015/830 and OSHA hazard communication guidelines.

16.1 Changes from last issue:
Sections 2 & 16: Update to regulations referenced.

The information provided in this Safety Data Sheet is correct to our best knowledge, information and belief at the date of its publication. It is intended to describe the product for the purposes of health, safety and environmental requirements only. It should not be construed as guaranteeing any specific property of the product.

A.3 HyVolt II NG

ERGON

SAFETY DATA SHEET

1. Identification

Product identifier	**HyVolt II NG**
Other means of identification	None.
Recommended use	Transformer Oil
Recommended restrictions	None known.
Manufacturer/Importer/Supplier/Distributor information	
Company:	Ergon, Inc.
Address:	P.O. Box 1639 Jackson, MS 39215
E-mail:	sds@ergon.com
Emergency Contacts	
Customer Service:	1-800-222-7122
Chemtrec:	1-800-424-9300 After Business Hours (North America Only) 1-703-527-3887 After Business Hours (International)

2. Hazard(s) identification

Physical hazards	Not classified.	
Health hazards	Aspiration hazard	Category 1
Environmental hazards	Not classified.	
OSHA defined hazards	Not classified.	

Label elements

Signal word	Danger
Hazard statement	May be fatal if swallowed and enters airways.
Precautionary statement	
Prevention	Do not breathe gas/mist/vapors/spray.
Response	IF SWALLOWED: Immediately call a POISON CENTER or doctor/physician. Do NOT induce vomiting.
Storage	Store locked up.
Disposal	Dispose of contents/container to an appropriate treatment and disposal facility in accordance with applicable laws and regulations, and product characteristics at time of disposal. See section 13 of this SDS for disposal instructions.
Hazard(s) not otherwise classified (HNOC)	None known.
Supplemental information	None.

3. Composition/information on ingredients

Mixtures

Chemical name	Common name and synonyms	CAS number	%
DISTILLATES (PETROLEUM), HYDROTREATED LIGHT NAPHTHENIC		64742-53-6	25 - 99
LUBRICATING OILS (PETROLEUM), C15-30, HYDROTREATED NEUTRAL OIL-BASED		72623-86-0	0 - 50

Chemical name	Common name and synonyms	CAS number	%
DISTILLATES (PETROLEUM), HYDROTREATED LIGHT PARAFFINIC		64742-55-8	0 - 45
DISTILLATES (PETROLEUM), SOLVENT-DEWAXED LIGHT PARAFFINIC		64742-56-9	0 - 10
SOLVENT NAPHTHA (PETROLEUM), HEAVY AROM.		64742-94-5	0 - 5
2,6-DI-TERT-BUTYL-P-CRESOL [BUTYLATED HYDROXYTOLUENE (BHT)]		128-37-0	< 0.3

4. First-aid measures

Inhalation Move to fresh air. Oxygen or artificial respiration if needed. IF exposed or concerned: Get medical advice/attention.

Skin contact Wash contact areas with soap and water. Remove contaminated clothing. Launder contaminated clothing before reuse. If skin irritation or an allergic skin reaction develops, get medical attention.

Eye contact Flush thoroughly with water. If irritation occurs, get medical assistance.

Ingestion Do NOT induce vomiting. If vomiting occurs naturally, have victim lean forward to reduce risk of aspiration. Call a poison control center immediately.

Most important symptoms/effects, acute and delayed Defatting of the skin.

Indication of immediate medical attention and special treatment needed Treat symptomatically.

General information Contact physician if discomfort continues.

5. Fire-fighting measures

Suitable extinguishing media Halon. Dry chemicals. Foam. Carbon dioxide (CO2). Water spray or fog. Do not use water jet as an extinguisher, as this will spread the fire.

Unsuitable extinguishing media Do not use a solid water stream as it may scatter and spread fire.

Specific hazards arising from the chemical No unusual fire or explosion hazards noted.

Special protective equipment and precautions for firefighters Wear full protective clothing, including helmet, self-contained positive pressure or pressure demand breathing apparatus, protective clothing and face mask.

Fire fighting equipment/instructions Cool containers exposed to flames with water until well after the fire is out. Firefighters must use standard protective equipment including flame retardant coat, helmet with face shield, gloves, rubber boots, and in enclosed spaces, SCBA. Use pressurized air mask if product is involved in a fire.

General fire hazards No unusual fire or explosion hazards noted. Flammability Class: Combustible IIIB

6. Accidental release measures

Personal precautions, protective equipment and emergency procedures Keep unnecessary personnel away. Local authorities should be advised if significant spillages cannot be contained. Wear appropriate protective equipment and clothing during clean-up. Do not touch damaged containers or spilled material unless wearing appropriate protective clothing. Ensure adequate ventilation.

Methods and materials for containment and cleaning up Large Spills: ELIMINATE all ignition sources (no smoking, flares, sparks or flames in immediate area). Stop the flow of material, if this is without risk. Dike the spilled material, where this is possible. Cover with plastic sheet to prevent spreading. Absorb in vermiculite, dry sand or earth or absorbent material then place into containers. Following product recovery, flush area with water.

Small Spills: Wipe up with absorbent material (e.g. cloth, fleece). Clean surface thoroughly to remove residual contamination.

Never return spills in original containers for re-use. For waste disposal, see section 13 of the SDS.

Environmental precautions Prevent further leakage or spillage if safe to do so. Prevent entry into waterways, sewer, basements or confined areas. Avoid discharge to the aquatic environment. Contact local authorities in case of spillage to drain/aquatic environment. Avoid discharge into drains, water courses or onto the ground. If this material is spilled into navigable waters and creates a visible sheen, it is reportable to the National Response Center.

7. Handling and storage

Precautions for safe handling DO NOT handle, store or open near an open flame, sources of heat or sources of ignition. Protect material from direct sunlight. Do not breathe dust/fume/gas/mist/vapors/spray. Wash hands after handling and before eating. Do not get this material in contact with eyes. Avoid contact with skin. Avoid prolonged exposure. All handling to take place in well-ventilated area. Shower after work. Remove and wash contaminated clothing promptly.

Conditions for safe storage, including any incompatibilities Store locked up. Keep away from heat, sparks and open flame. Store in a well-ventilated place. Use care in handling/storage.

8. Exposure controls/personal protection

Occupational exposure limits

US. OSHA Table Z-1 Limits for Air Contaminants (29 CFR 1910.1000)

Components	Type	Value	Form
DISTILLATES (PETROLEUM), HYDROTREATED LIGHT NAPHTHENIC (CAS 64742-53-6)	PEL	5 mg/m3	Mist.
DISTILLATES (PETROLEUM), HYDROTREATED LIGHT PARAFFINIC (CAS 64742-55-8)	PEL	5 mg/m3	Mist.
DISTILLATES (PETROLEUM), SOLVENT-DEWAXED LIGHT PARAFFINIC (CAS 64742-56-9)	PEL	5 mg/m3	Mist.

US. ACGIH Threshold Limit Values

Components	Type	Value	Form
2,6-DI-TERT-BUTYL-P-CRESOL [BUTYLATED HYDROXYTOLUENE (BHT)] (CAS 128-37-0)	TWA	2 mg/m3	Inhalable fraction and vapor.
DISTILLATES (PETROLEUM), HYDROTREATED LIGHT PARAFFINIC (CAS 64742-55-8)	TWA	5 mg/m3	Inhalable fraction.
LUBRICATING OILS (PETROLEUM), C15-30, HYDROTREATED NEUTRAL OIL-BASED (CAS 72623-86-0)	TWA	5 mg/m3	Inhalable fraction.
SOLVENT NAPHTHA (PETROLEUM), HEAVY AROM. (CAS 64742-94-5)	TWA	200 mg/m3	Non-aerosol.

US. NIOSH: Pocket Guide to Chemical Hazards

Material	Type	Value	Form
HyVolt II NG	STEL	10 mg/m3	Mist.
	TWA	5 mg/m3	Mist.

US. NIOSH: Pocket Guide to Chemical Hazards

Components	Type	Value	Form
2,6-DI-TERT-BUTYL-P-CRESOL [BUTYLATED HYDROXYTOLUENE (BHT)] (CAS 128-37-0)	TWA	10 mg/m3	
DISTILLATES (PETROLEUM), HYDROTREATED LIGHT NAPHTHENIC (CAS 64742-53-6)	Ceiling	1800 mg/m3	
	STEL	10 mg/m3	Mist.
DISTILLATES (PETROLEUM), HYDROTREATED LIGHT PARAFFINIC (CAS 64742-55-8)	STEL	10 mg/m3	Mist.
	TWA	5 mg/m3	Mist.
DISTILLATES (PETROLEUM), SOLVENT-DEWAXED LIGHT PARAFFINIC (CAS 64742-56-9)	STEL	10 mg/m3	Mist.
	TWA	5 mg/m3	Mist.
SOLVENT NAPHTHA (PETROLEUM), HEAVY AROM. (CAS 64742-94-5)	TWA	100 mg/m3	

Biological limit values No biological exposure limits noted for the ingredient(s).

Exposure guidelines

US ACGIH Threshold Limit Values: Skin designation

SOLVENT NAPHTHA (PETROLEUM), HEAVY AROM. (CAS 64742-94-5) Can be absorbed through the skin.

Appropriate engineering controls Adequate ventilation should be provided whenever the material is heated or mists are generated. Provide adequate ventilation, including appropriate local extraction, to ensure that the defined occupational exposure limit is not exceeded.

Individual protection measures, such as personal protective equipment

Eye/face protection Goggles/face shield are recommended.

Skin protection

Hand protection Chemical resistant gloves are recommended. If contact with forearms is likely wear gauntlet style gloves.

Other Chemical/oil resistant clothing is recommended. Launder contaminated clothing before reuse.

Respiratory protection Under normal conditions, respirator is not normally required. When workers are facing concentrations above the exposure limit they must use appropriate certified respirators.

Thermal hazards Not available.

General hygiene considerations Always observe good personal hygiene measures, such as washing after handling the material and before eating, drinking, and/or smoking. Routinely wash work clothing to remove contaminants. Discard contaminated footwear that cannot be cleaned.

9. Physical and chemical properties

Appearance Clear & bright

Physical state Liquid.

Form Liquid.

Color Water White to Pale

Odor Mild Petroleum Odor

Odor threshold Not available.

pH Not applicable

Melting point/freezing point	< -40 °F (< -40 °C) ASTM D 5950
Initial boiling point and boiling range	> 460 °F (> 237.78 °C) ASTM D 2887/ ISO 3294
Flash point	>= 293.0 °F (>= 145.0 °C) Cleveland Open Cup ASTM D 92/ ISO 2592
Evaporation rate	Not available.
Flammability (solid, gas)	Not available.
Upper/lower flammability or explosive limits	
Flammability limit - lower (%)	Not available.
Flammability limit - upper (%)	Not available.
Explosive limit - lower (%)	Not available.
Explosive limit - upper (%)	Not available.
Vapor pressure	Not available.
Vapor density	Not available.
Relative density	0.89 (59 °F (15 °C) ASTM D 4052/ ISO 12185)
Solubility(ies)	
Solubility (water)	Insoluble
Partition coefficient (n-octanol/water)	Not established.
Auto-ignition temperature	> 599 °F (> 315 °C) ASTM E 659
Decomposition temperature	Not available.
Viscosity	9.3 cSt (104 °F (40 °C) ASTM D 341)

10. Stability and reactivity

Reactivity	The product is stable and non-reactive under normal conditions of use, storage and transport
Chemical stability	Stable.
Possibility of hazardous reactions	Hazardous polymerization does not occur.
Conditions to avoid	Heat, flames and sparks. Avoid temperatures exceeding the flash point.
Incompatible materials	Strong oxidizing agents.
Hazardous decomposition products	Upon decomposition, this product emits carbon monoxide, carbon dioxide and/or low molecular weight hydrocarbons.

11. Toxicological information

Information on likely routes of exposure

Inhalation	May be fatal if swallowed and enters airways.
Skin contact	Frequent or prolonged contact may defat and dry the skin, leading to discomfort and dermatitis
Eye contact	May be irritating to eyes.
Ingestion	May cause gastrointestinal discomfort if swallowed. Do not induce vomiting. Vomiting may increase risk of product aspiration. May be fatal if swallowed and enters airways.
Symptoms related to the physical, chemical and toxicological characteristics	Defatting of the skin. Coughing. Shortness of breath. Discomfort in the chest.

Information on toxicological effects

Acute toxicity	Not applicable.
Skin corrosion/irritation	May cause defatting of the skin, but is neither an irritant nor a sensitizer.
Serious eye damage/eye irritation	Not classified. May cause minor irritation on eye contact.
Respiratory or skin sensitization	
Respiratory sensitization	Not classified.
Skin sensitization	Not classified. May cause defatting of the skin, but is neither an irritant nor a sensitizer.

Germ cell mutagenicity	No data available to indicate product or any components present at greater than 0.1% are mutagenic or genotoxic.
Carcinogenicity	This product is not considered to be a carcinogen by IARC, ACGIH, NTP, or OSHA. Note L - Meets EU requirement of less than 3% (w/w) DMSO extract for total polycyclic aromatic compound (PAC) using IP 346. Not classified.

IARC Monographs. Overall Evaluation of Carcinogenicity

Not listed.

OSHA Specifically Regulated Substances (29 CFR 1910.1001-1052)

Not regulated.

US. National Toxicology Program (NTP) Report on Carcinogens

Not listed.

Reproductive toxicity	Contains no ingredient listed as toxic to reproduction
Specific target organ toxicity - single exposure	Not classified.
Specific target organ toxicity - repeated exposure	Not classified.
Aspiration hazard	May be fatal if swallowed and enters airways.
Chronic effects	Prolonged inhalation may be harmful. Prolonged exposure may cause chronic effects
Further information	Risk of chemical pneumonia after aspiration.

12. Ecological information

Ecotoxicity Not expected to be harmful to aquatic organisms.

Product		Species	Test Results
HyVolt II NG			
Aquatic			
Crustacea	EC50	Daphnia	800 mg/l, 48 hours estimated
Components		**Species**	**Test Results**
2,6-DI-TERT-BUTYL-P-CRESOL [BUTYLATED HYDROXYTOLUENE (BHT)] (CAS 128-37-0)			
Aquatic			
Crustacea	EC50	Water flea (Daphnia pulex)	1.44 mg/l, 48 hours

Not available. * Estimates for product may be based on additional component data not shown.

Persistence and degradability	Not inherently biodegradable.
Bioaccumulative potential	Bioaccumulation is unlikely to be significant because of the low water solubility of this product.
Mobility in soil	Not available.
Other adverse effects	No other adverse environmental effects (e.g. ozone depletion, photochemical ozone creation potential, endocrine disruption, global warming potential) are expected from this component.

13. Disposal considerations

Disposal instructions	When this product as supplied is to be discarded as waste, it does not meet the definition of a RCRA waste under 40 CFR 261. Disposal recommendations are based on material as supplied. Disposal must be in accordance with current applicable laws and regulations, and material characteristics at time of disposal.
Hazardous waste code	Not applicable.
Waste from residues / unused products	Dispose of in accordance with local regulations. Avoid discharge into water courses or onto the ground.
Contaminated packaging	Empty containers should be taken to an approved waste handling site for recycling or disposal. Since emptied containers may retain product residue, follow label warnings even after container is emptied. Offer rinsed packaging material to local recycling facilities.

14. Transport information

DOT

Not regulated as dangerous goods.

IATA

Not regulated as dangerous goods.

IMDG

Not regulated as dangerous goods.

Transport in bulk according to Annex II of MARPOL 73/78 and the IBC Code Not available.

General information Not regulated as dangerous goods.

15. Regulatory information

US federal regulations This product is a "Hazardous Chemical" as defined by the OSHA Hazard Communication Standard 29 CFR 1910.1200.

All components are on the U.S. EPA TSCA Inventory List.

CERCLA/SARA Hazardous Substances - Not applicable.

HyVolt oils are certified to be PCB-free. HyVolt oils are processed from naturally occurring raw materials with no additives or recycled oils that might introduce PCB contamination.

TSCA Section 12(b) Export Notification (40 CFR 707, Subpt. D)

Not regulated.

CERCLA Hazardous Substance List (40 CFR 302.4)

Not listed.

SARA 304 Emergency release notification

Not regulated.

OSHA Specifically Regulated Substances (29 CFR 1910.1001-1052)

Not regulated.

Superfund Amendments and Reauthorization Act of 1986 (SARA)

SARA 302 Extremely hazardous substance

Not listed.

SARA 311/312 Hazardous chemical Yes

Classified hazard categories Aspiration hazard

SARA 313 (TRI reporting)

Not regulated.

Other federal regulations

Clean Air Act (CAA) Section 112 Hazardous Air Pollutants (HAPs) List

Not regulated.

Clean Air Act (CAA) Section 112(r) Accidental Release Prevention (40 CFR 68.130)

Not regulated.

Safe Drinking Water Act (SDWA) Not regulated.

US state regulations This product does not contain a chemical known to the State of California to cause cancer, birth defects or other reproductive harm. California Safe Drinking Water and Toxic Enforcement Act of 1986 (Proposition 65): This material is not known to contain any chemicals currently listed as carcinogens or reproductive toxins.

International Inventories

Country(s) or region	Inventory name	On inventory (yes/no)*
Australia	Australian Inventory of Chemical Substances (AICS)	Yes
Canada	Domestic Substances List (DSL)	Yes
Canada	Non-Domestic Substances List (NDSL)	No
China	Inventory of Existing Chemical Substances in China (IECSC)	Yes
Europe	European Inventory of Existing Commercial Chemical Substances (EINECS)	Yes
Europe	European List of Notified Chemical Substances (ELINCS)	No

Country(s) or region	Inventory name	On inventory (yes/no)*
Japan	Inventory of Existing and New Chemical Substances (ENCS)	Yes
Korea	Existing Chemicals List (ECL)	Yes
New Zealand	New Zealand Inventory	Yes
Philippines	Philippine Inventory of Chemicals and Chemical Substances (PICCS)	Yes
Taiwan	Taiwan Chemical Substance Inventory (TCSI)	Yes
United States & Puerto Rico	Toxic Substances Control Act (TSCA) Inventory	Yes

*A "Yes" indicates that all components of this product comply with the inventory requirements administered by the governing country(s)
A "No" indicates that one or more components of the product are not listed or exempt from listing on the inventory administered by the governing country(s).

16. Other information, including date of preparation or last revision

Issue date 05-06-2014

Revision date 03-09-2020

Version # 04

NFPA ratings
Health: 2
Flammability: 0
Instability: 0

References
ACGIH
EPA: AQUIRE database
NLM: Hazardous Substances Data Base
US. IARC Monographs on Occupational Exposures to Chemical Agents
IARC Monographs. Overall Evaluation of Carcinogenicity
National Toxicology Program (NTP) Report on Carcinogens
ACGIH Documentation of the Threshold Limit Values and Biological Exposure Indices
Chemical Abstracts Service Registry Handbook
CRC: Handbook of Chemistry and Physics
ILO Safety Cards
International Labour Organization
International Maritime Organization Marine Pollutants List
NFPA Hazardous Chemical Data Sheets
NIOSH Pocket Guide
Registry of Toxic Effects of Chemical Substances (RTECS)
US DOT Hazardous Materials Regulations

Disclaimer
The information provided in this Safety Data Sheet is correct to the best of our knowledge information and belief at the date of its publication. The information given is designed only as a guidance for safe handling, use, processing, storage, transportation, disposal and release and is not to be considered a warranty or quality specification. The information relates only to the specific material designated and may not be valid for such material used in combination with any other materials or in any process, unless specified in the text.

Revision information
Hazard(s) identification: Storage
Composition / Information on Ingredients: Disclosure Overrides
Physical & Chemical Properties: Multiple Properties
Toxicological information: Carcinogenicity

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APPENDIX B. AVERAGE DYNAMIC VISCOSITIES FOR TEST FLUIDS

Test Fluid	Sample	Dynamic Viscosity (mPa·s)
HyVolt II NG, Fresh	1	17.82
	2	18.71
	3	18.94
	4	18.94
	Average	**18.6**
HyVolt II NG, Used	1	19.64
	2	20.42
	Average	**20.0**
Hydrocal 100, Fresh	1	62.52
	2	65.55
	Average	**64.0**
Hydrocal 100, Used	1	65.90
	2	62.80
	3	66.60
	Average	**65.1**
Midel 7131, Fresh	1	71.76
	2	72.91
	3	73.31
	4	73.23
	Average	**72.8**
Midel 7131, Used	1	54.52
	2	58.32
	3	52.60
	Average	**55.1**

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Department of the Interior (DOI)
The Department of the Interior protects and manages the Nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors the Nation's trust responsibilities or special commitments to American Indians, Alaska Natives, and affiliated island communities.

Bureau of Safety and Environmental Enforcement (BSEE)
The mission of the Bureau of Safety and Environmental Enforcement works to promote safety, protect the environment, and conserve resources offshore through vigorous regulatory oversight and enforcement.

BSEE Oil Spill Preparedness Program
BSEE administers a robust Oil Spill Preparedness Program through its Oil Spill Preparedness Division (OSPD) to ensure owners and operators of offshore facilities are ready to mitigate and respond to substantial threats of actual oil spills that may result from their activities. The Program draws its mandate and purpose from the Federal Water Pollution Control Act of October 18, 1972, as amended, and the Oil Pollution Act of 1990 (October 18, 1991). It is framed by the regulations in 30 CFR Part 254 – *Oil Spill Response Requirements for Facilities Located Seaward of the Coastline*, and 40 CFR Part 300 – *National Oil and Hazardous Substances Pollution Contingency Plan*. Acknowledging these authorities and their associated responsibilities, BSEE established the program with three primary and interdependent roles:

- Preparedness Verification,
- Oil Spill Response Research, and
- Management of Ohmsett - the National Oil Spill Response Research and Renewable Energy Test Facility.

The research conducted for this Program aims to improve oil spill response and preparedness by advancing the state of the science and the technologies needed for these emergencies. The research supports the Bureau's needs while ensuring the highest level of scientific integrity by adhering to BSEE's peer review protocols. The proposal, selection, research, review, collaboration, production, and dissemination of OSPD's technical reports and studies follows the appropriate requirements and guidance such as the Federal Acquisition Regulation and the Department of Interior's policies on scientific and scholarly conduct.