Rapid Field Test to Evaluate Slick Dispersibility

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Background

- Dispersants use is an effective way to respond to large offshore oil spills
- Dispersants have a limited “window of opportunity” for effective use, hence expediting regulatory approval for field application is a critical task during initial response
- Dispersibility of the slick is one of the questions that needs to be answered (and provided evidence for) as quickly as possible
- Oil slick dispersibility could be evaluated by:
  - Modeling
  - Pilot spray from a plane or a boat
  - Small sample test on a response boat

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Existing Field Test Kits

- Field Dispersant Effectiveness Test (FDET) – EPA – USA (1987)
- Field Test (FET) – Norway (1999)
- National Plan Oil Spill Dispersant Effectiveness Field Test Kit (Nat-DET) – Australia (2012)
- 1-L Baffled Flask Field Test (BFFT) - BSEE – USA (2016)
- OSRL Dispersant Effectiveness Test Kit (2016)

OSRL

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Existing Field Test Kits

Some field tests kits (FDET [1987], FET [1999], OSRL [2016]) have simplified methods of preparing solutions, mixing and interpreting results; however, these basic processes:

- incorporate manual mixing that may result in variability among users; and
- may result in inconsistent interpretation of results.

Others (Nat-DET [2012] and BFFT [2017]) provide more scientific rigor; however, these methods:

- are not suitable for use by non-scientists;
- require more fragile and sophisticated test equipment; and
- require personnel training on a regular basis.

Nat-DET

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Project Goal

Develop a reliable rapid dispersant field test kit by incorporating an automated mixing system to standardize the mixing energy and ensure repeatability of the results.

- This kit is intended for use by OSRO personnel (first on-scene), with no scientific training beyond the "single page", pictorial-based instructions included in the kit.
- Collective components are packed in a Pelican case that is easily stored on the vessel and easily carried by one person.
- Sufficient volumes of oil and dispersant are easily dispensed by a lay person (e.g., using disposable pipettes – not auto-pipettors or gas-tight syringes).
- Rapid testing is accomplished in minutes not hours.
- Qualitative results are transmitted to experts for immediate review and interpretation.
- Components should not require regular maintenance or calibration, other than annual equipment power check and replacement of dispersant sample every few years.

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Key Points

- <u>This kit IS:</u>
  - meant to support real-time, incident-specific operational decisions; and
  - intended to provide an indication that the surface oil is dispersible prior to mobilization of dispersant assets.
- <u>This kit is NOT:</u>
  - an efficacy test;
  - intended to replace existing practices, such as dispersant test application; and
  - a substitute for scientific research that is likely initiated once science teams are mobilized.

Absence of the test results from the kit should not delay dispersants operations

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Project Advisory Committee

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- NOAA
- EPA
- BSEE
- TGLO
- Exxon
- BP
- Chevron
- Oxy
- MSRC
- CGA

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Concepts Tested

VWR.com

Amazon.com

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HannaInst.com

FisherSci.com

BabyBrezza.com

FisherSci.com

BraunHousehold.com

FisherSci.com

ColeParmer.com

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Final Test Kit Design

Elements of Protocol

- Mixing Unit – Southwest Science Digital Orbital Shaker* with flask holders
- Bottle Shape – Dimpled Erlenmeyer Flask (DF)
- Speed – 200 RPM
- Mixing Time – 2 mins
- Settling Time – 1 min

***SBT300 Digital Orbital Shaker**

- Holds flask clamps up to 2 liters and tube racks up to 50 ml
- Speed Range: 50 to 300 rpm in 10 rpm steps
- Time setting: up to 99 hrs in 1 min steps or continuous
- Operates in cold rooms down to 4C and incubators to 50C
- Orbit diameter: 19 mm (3/4in)
- Max Load Capacity: 5 lbs
- Size: 11"w x 10"d x 5"h
- Weight: 12 lbs
- Electrical: 115VAC, 1.5A

Orbital Shaker configured for 2 Dimpled flasks

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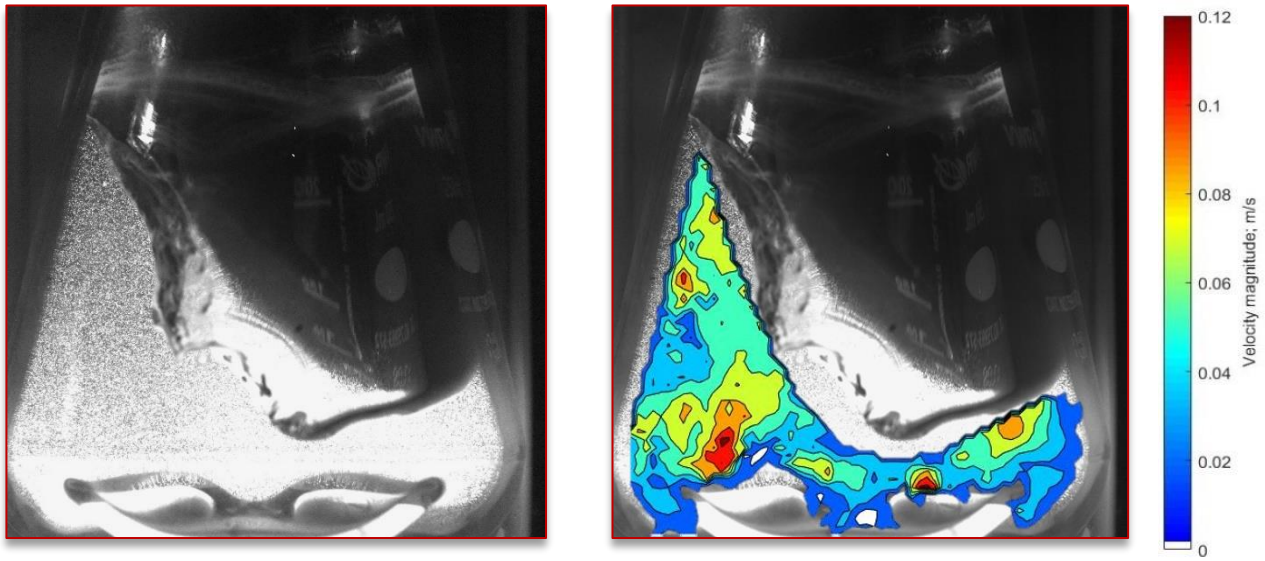
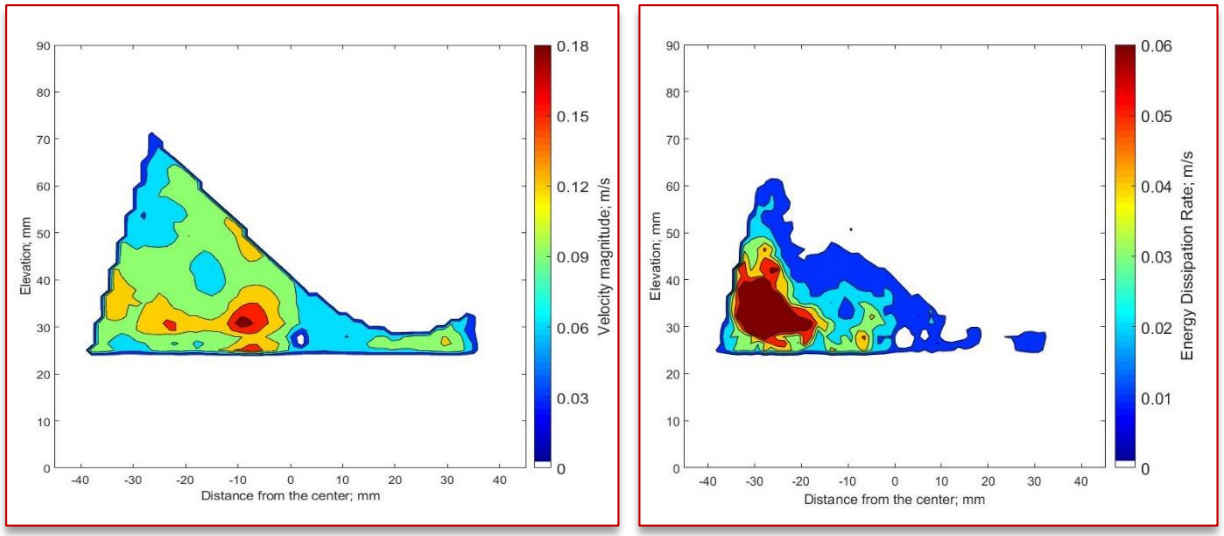
Mixing Characterization

- Analyzed by the Boufadel group (NJIT)
- Scientific turbulence characterization
- Evaluated speeds of 150 RPM, 200 RPM, and 250 RPM
- 200 RPM speed was selected
- Lower energy dissipation rate than in a baffled flask test
- Comparable to surface ocean turbulence level under moderate waves (1 to 2 feet)



NJIT



NJIT

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Mixing Protocol Testing

CRUDE OIL	~ API Gravity
Canadian Sour	14
Rock	15
----Rock (1-day Weathered)	*unknown*
Zuata 300 Blend	20.8
----Zuata 300 (3-day Emulsion)	*unknown*
Maya	22
Coulomb-4, MC474	29
APC GC-680	30
BP Thunderhorse	32
Appomattox, MC437	37
---Appomattox (3-day Emulsion)	*unknown*
---Appomattox (7-day Emulsion)	*unknown*
LLS ST James	38
Agbami	48
DISPERSANT	
1) EC9500A	N/A
2) Accell DWD	N/A

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Experiment Number	Date	Title
1	Early July	Preliminary Experiments
2	7/27/20	Comparing Mixing Units
3	7/28/20	Comparing Bottle Shapes
4	7/28/20	Square Bottle Test
5	7/29/20	Shipboard Evaluation (Oxford Benchmate)
6	7/30/20	Oil Sample Collection
7	7/30/20	Baffled Flask Test
8	7/31/20	Norwegian FET Evaluation
9	9/9/20	Collapsible Bucket Evaluation
10	9/9/20	Shipboard Evaluation (SW Science Shaker)
11	9/9/20	Varying RPM Evaluation (SW Science Shaker)
12	9/10/20	Rock Oil Test (4 ml)
13	9/10/20	Rock (Fresh) Oil Validity Test (2 ml)
14	9/10/20	Thunderhorse (Fresh) Oil Validity Test (2 ml)
15	9/11/20	Z300 (3-Day Emulsion) Validity Test (2 ml)
16	9/11/20	Rock (1-Day Weathered) Test (2 ml)
17	9/11/20	Z300 (Fresh) Oil Validity Test (2 ml)
18	9/24/20	Shipboard field trial of Southwest Science Shaker
19	9/24/20	Appomattox (Fresh) Oil Validity Test at Sea (2 ml)
20	9/26/20	Appomattox (3-Day Emulsion) Validity Test (2 ml)
21	9/30/20	APC-680 (Fresh) Oil Validity Test (2 ml)
22	9/30/20	LLS St. James (Fresh) Oil Validity Test (2 ml)
23	9/30/20	Maya (Fresh) Oil Validity Test (2 ml)
24	9/30/20	Coulomb (Fresh) Oil Validity Test (2 ml)
25	9/30/20	Agbami (Fresh) Oil Validity Test (2 ml)
26	9/30/20	Canadian Sour (Fresh) Oil Validity Test (2 ml)
27	9/30/20	Appomattox (7-Day Emulsion) Validity Test (2 ml)

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Total Oil Validity Tests - 14 (10 fresh, 1 weathered and 3 emulsified)

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Protocol Testing

GOM Crude Oil (API ~37 for fresh oil)

Fresh oil

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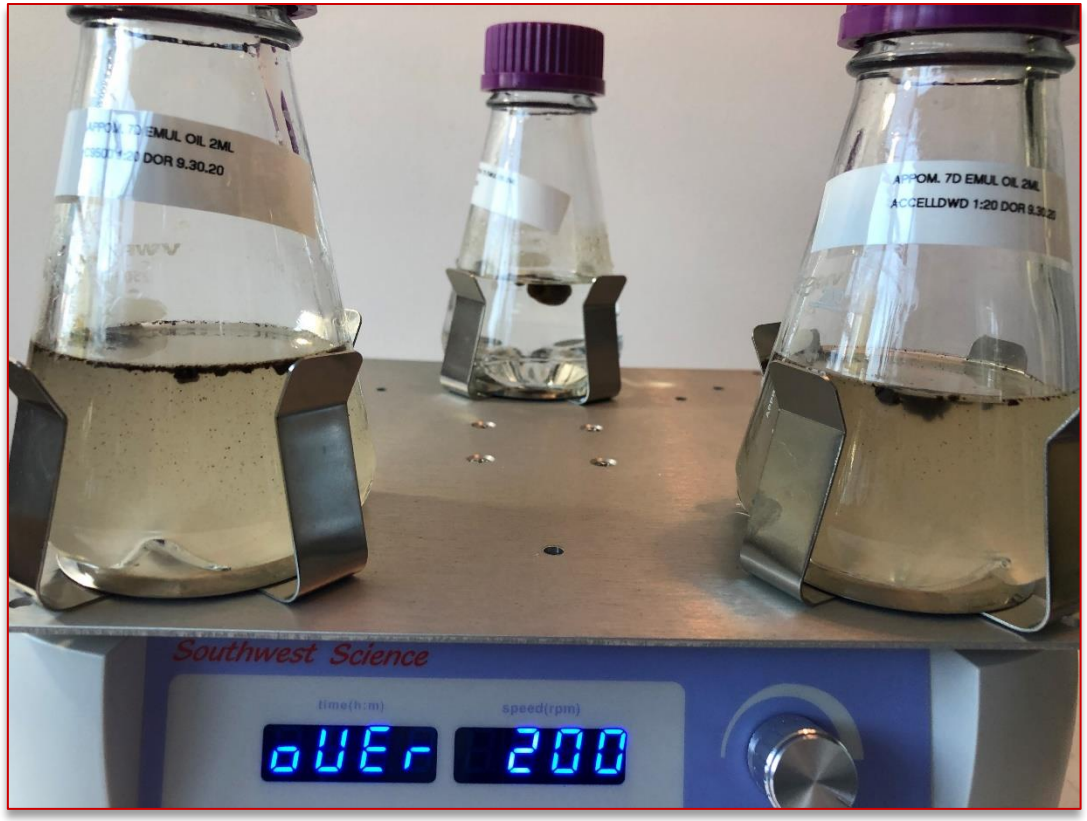
7-d Emulsion



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Protocol Testing

Visual Results for Other Oils at T= 1 min Settling Time

APC-680

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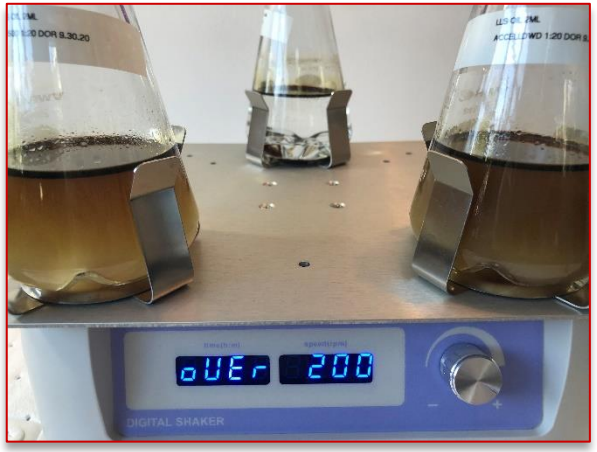
LLS St James



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Canadian Sour

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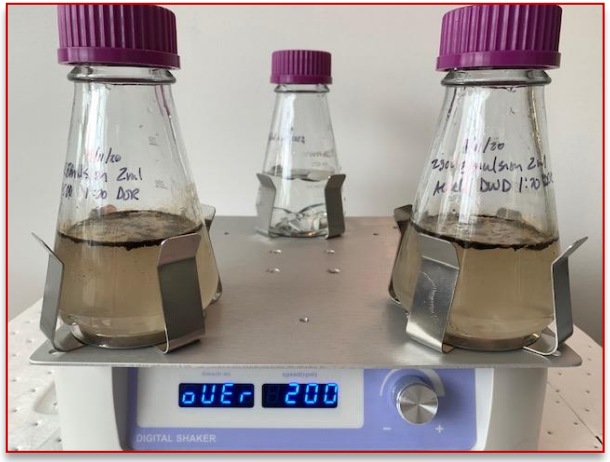
Z-300 Emulsion (3-day)



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Kit Inventory

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- Pelican 1650 Protector Case
- Interior: 28.6" × 17.5" × 10.7"
- 4 strong polyurethane wheels with stainless steel bearings
- Watertight, crushproof, and dustproof
- 2 level Pick N Pluck™ with convoluted lid foam
- Optional TrekPak Case Divider System
- Open cell core with solid wall design - strong, light weight
- Retractable extension handle
- Fold down handles
- Total weight including case and components ~50 lbs

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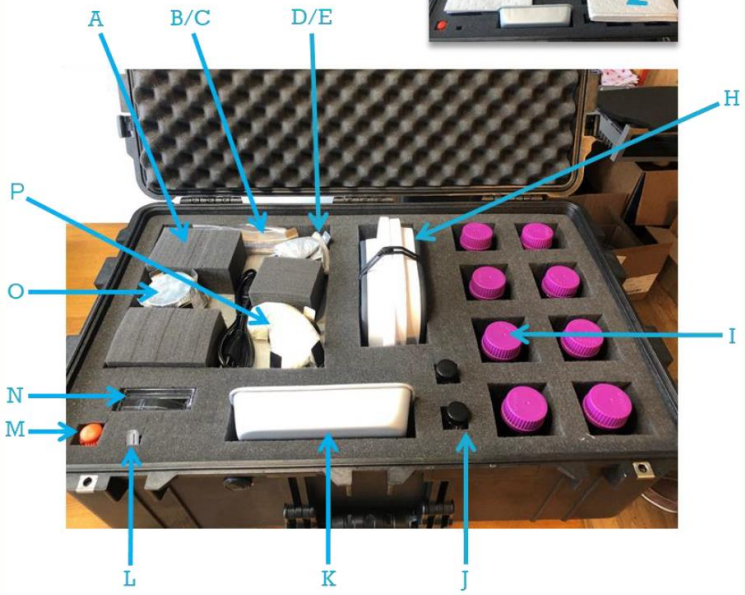
Kit Inventory

KIT CONTENTS AND REORDER LIST

Contains supplies to conduct up to 4 tests.

A) Orbital shaker (19 mm orbital) (1)
B) Plunger syringes (1-mL & 3-mL) (4 of each size)
C) Plastic pipettes (3-mL) (4)
D) Wooden spatulas (4)
E) Bamboo skewer (2)
F) Case and foam insert (1)
G) Oil adsorbent pads (12)
H) Collapsible bucket w/ polypropylene line (2)
I) Erlenmeyer dimpled flasks with lids (250-mL) (8)
J) Dispersant product vials (20-mL) in resealable bags
K) Aluminum pan (1)
L) Thermometer (1)
M) Screwdriver (1)
N) Hydrometer (1)
O) Aluminum weigh boats (12)
P) Other (gloves [non-latex]/waste bag/markers/log sheet/tape)



Version 1 (November 2020)

		Item Name and Model Number	Website	Price (plus tax /ship) 11/2020
A		1) Digital orbital shaker; 2) Platform; 3) 250-mL flask clamps (Southwest Science 1) #SBT300; 2) #SBT300-UNV; 3) F-CLAMP-250)	http://www.southwestscience.com/SBT300_Digital_Shaker.html; http://www.southwestscience.com/SBT300_Accessories.html;	1) $629 2) $63 3) $21 ea
B		Plunger syringe, graduated (1-mL and 3-mL) (Model: Frienda-Syringes)	https://www.amazon.com/Frienda-Measurement-Scientific-Measuring-Refilling/dp/B07L3NSPD8 https://www.amazon.com/Frienda-Measurement-Scientific-Measuring-Refilling/dp/B07P25XH8Z/ref=sr_1_5?dchild=1&keywords=syringe+3+mL&qid=1602703182&s=industrial&sr=1-5	$8.99 (Pack of 20) (Both sizes)
C		Plastic pipette, graduated (3-mL) (Model: Moveland #PP_5FGH)	https://www.amazon.com/moveland-Transfer-Graduated-Pipettes-Essential/dp/B085C13BCL/ref=sr_1_4?dchild=1&keywords=5mL+disposable+graduated+pipette&qid=1602699918&sr=8-4	$4.99 (Pack of 50)
D		Wooden spatulas 3.5" (Perfect Stix #PS300BA-100)	https://www.amazon.com/gp/product/B009EE1PPM/ref=ppx_yo_dt_b_asin_title_o07_s00?ie=UTF8&psc=1	$12.59 (Pack of 100)
E		Bamboo skewers (6") (Model: Hopelf #6)	https://www.amazon.com/Appetiser-Cocktail-Chocolate-Fountain-Barbecue/dp/B07MY7W5Lj/ref=sr_1_4?dchild=1&keywords=wooden+skewers&qid=1602725671&s=home-garden&sr=1-4	$4.00 (Pack of 100)
F		Case with foam insert Model: Pelican #6150	https://www.pelican.com/us/en/product/cases/protector/1650	$299
G		Oil adsorbent pads Model: Pig #MAT415	https://www.newpig.com/pig-oil-only-absorbent-mat-pad/p/MAT415	$47 (Pack of 50)
H		Collapsible bucket (5 L/1.3 Ga) (Sammart #B07WKBBR7P)	https://www.amazon.com/SAMMART-gallons-Collapsible-Rectangular-rectangular/dp/B07WKBBR7P?th=1	$12.96
I		Erlenmeyer dimpled flask (250-mL) (VWR #75993-572 [with lids])	https://us.vwr.com/store/catalog/product.jsp?product_id=22207136	$140.85 (Case of 10 flasks)
J		Dispersant product vials (20-mL) Type: To be provided by OSRO	Dispersant samples have a shelf-life. OSROs should replace these samples periodically (e.g., every few years).	--
K		Aluminum pan (Wilton #2105-8191)	https://www.amazon.com/Wilton-Performance-Aluminum-Square-Brownie/dp/B0000VMHVO/ref=sr_1_1?dchild=1&keywords=wilton+square+8%22+cake+pan&qid=1602773811&s=home-garden&sr=1-1	$8.99
L		Thermometer and case (SP Scienceware #B60570-1500)	https://www.amazon.com/gp/product/B00N1W7TXU/ref=ppx_yo_dt_b_asin_title_o05_s00?ie=UTF8&psc=1	$17.36
M		Screwdriver (Southwest Science)	Included with shaker	--
N		Hydrometer (Instant Ocean #TK-504)	https://www.amazon.com/gp/product/B005WZW2SG/ref=ppx_yo_dt_b_asin_title_o00_s00?ie=UTF8&psc=1	$12.95
O		Aluminum weigh boats (Heathrow Scientific #HS14521C)	https://www.amazon.com/gp/product/B01B9Y0JPG/ref=ppx_yo_dt_b_asin_title_o01_s00?ie=UTF8&psc=1	$18.36 (Pack of 100)
P		Other consumables (waste bags, disposable gloves [latex free], markers, tape) (Any brands)	Any available (~13-gallon bag/large gloves, tape)	--

Version 1 (November 2020)

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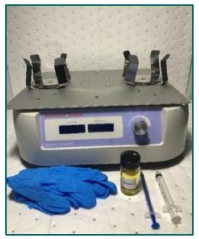
Instructions

Dispersibility Assessment Kit - Instructions

PREPARING EQUIPMENT AND SUPPLIES



Step 1: Place shaker directly on benchtop with bottom suction cups securely attached, surround with adsorbent mats, plug into power supply, and turn on switch in back. In addition, attach an adsorbent pad behind shaker to provide a white backdrop for photos/videos*.
**Remember to use company-issued devices (e.g., cell phones/tablets) for any visual documentation that may become legal evidence.*

Step 2: For shaker set up, depress front button one time and then turn dial to 200 RPM.

Step 3: Press same button again to set mixing time at 2 minutes.

Step 4: Press and hold button two seconds to start unit to ensure proper setup. (Note: it takes several seconds to reach desired RPM setting.)

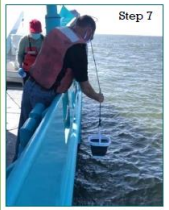
Step 5: Remove the following items and place on adsorbent pad next to shaker for later use:

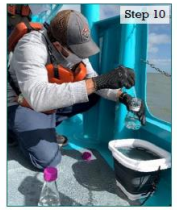
- ☐ 1 1-mL PLUNGER SYRINGE
- ☐ 1 DISPERSANT VIAL
- ☐ 1 SET OF GLOVES

COLLECTING SEAWATER

Step 6: Remove following items from kit and take to ship's deck using 8" pan to transport:

- ☐ 1 COLLAPSIBLE BUCKET
- ☐ THERMOMETER
- ☐ 1 3-mL PIPETTE
- ☐ HYDROMETER
- ☐ 2 FLASKS ("OIL ONLY" AND "OIL AND DISPERSANT")





Step 7: Collect clean seawater in collapsible bucket. Record lat/long on log sheet and then coordinate vessel repositioning to encounter oil slick.

Step 8: Use thermometer to take temperature of water in bucket and record on log sheet.

Step 9: Use hydrometer to measure salinity by submerging into bucket to fill with clean seawater and record on log sheet.

Step 10: Fill two flasks by dipping into bucket of clean seawater and filling to roughly 150 mL, using pipette to precisely adjust to 150 mL line. Replace caps on flasks. Do not dispose of clean seawater in the event a secondary test is requested. Leave clean seawater bucket on deck and carry everything else to shaker unit (while transiting to slick location).

COLLECTING OIL SAMPLES

Step 11: Remove following items from kit and take to ship's deck using 8" pan to transport:

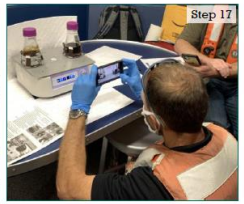
- ☐ 1 COLLAPSIBLE BUCKET
- ☐ 1 BAMBOO SKEWER
- ☐ 1 WOODEN SPATULA
- ☐ 2 SETS OF GLOVES
- ☐ 2 ADSORBENT PADS
- ☐ 1 3-mL SYRINGE
- ☐ 1 WASTE DISPOSAL BAG
- ☐ 2 ALUMINUM WEIGH BOATS
- ☐ 2 FLASKS (FILLED WITH 150 mL OF SEAWATER)

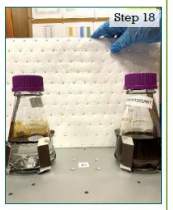
Step 12: Once positioned in oil slick, lower bucket to collect oil sample (use gloves). Record lat/long.

Step 13: Using aluminum weigh boat, skim oil from water's surface. If it is necessary to remove water from weigh boat (a), use a bamboo skewer to puncture side to drain excess water (b/c). Transfer oil into clean weigh boat using wooden spatula, if necessary (d/e).

Step 14: Into each flask, measure 2 mL of oil with the 3-mL syringe and dispense oil slowly onto water's surface. Do not touch water with syringe. Dispose of oiled gloves and replace with clean gloves, if necessary. Attach lids and carry flasks steadily to shaker unit. Leave oily seawater bucket on deck. If it is necessary to bring the small sample of oil into vessel's interior, use the 8" aluminum pan as secondary containment during transport.

CONDUCTING TEST





Step 15: Carefully place flasks into flask holders on shaker unit (labels facing forward). Gently handle flasks to prevent oil from stranding on sides.

Step 16: Remove lid of "Oil and Dispersant" flask. Measure 0.1 mL of dispersant in the 1-mL syringe and dispense droplets slowly onto different locations on oil. Do not touch floating oil with syringe. Re-attach lids to dispersant bottle and flask.

Step 17: Start video recording before starting shaker. Press and hold button (for two seconds - until shaker starts moving). The shaker will automatically stop after two minutes.

Step 18: Once shaker stops, start timer for 1 minute. After 1 minute, arrange flasks with labels facing forward and take a photo of the two flasks shown side by side with white background.

REPORTING RESULTS

Step 19: Save and send photo/video to requester at Unified Command (UC).

Step 20: Record information on log sheet, then take photo of log sheet and send to UC.

CLEANING UP

Step 21: Remove flasks from mixer and empty contents into oil waste container and then discard bottles.

Step 22: Use adsorbent pads to clean 8" aluminum pan.

Step 23: Secure dispersant vial lid with included tape, place in resealable bag and return to case.

Step 24: Return shaker to case as well as any other unused kit components and restock kit after returning to shore.

Secondary Testing of Undispersed Oil *(upon request)*

This optional testing should only be conducted if requested. It is intended as secondary analysis if there is not clear indication of oil dispersion.

- Fill aluminum pan with ~1" of seawater saved from Step 10.
- Use wooden spatula to collect oil sample from previously mixed "Oil and Dispersant" flask.
- Drop oil sample in center of water and observe if oil disperses over a time period, as directed by UC.
- Take photo/video of oil behavior in pan.

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Project Status

- Kit design was supported by the Advisory Committee.
- It was tested at sea several times including on Clean Gulf Associates vessel (OSRV Breton Island) in GOM in October 2020.
- CGA and MSRC staff received training, practiced with kit, sent test results to the shore and provided valuable recommendations.
- Training materials are available: Dispersibility Assessment Kit Training Video Dec 2020 - YouTube
- Peer-reviewed paper was published in Marine Pollution Bulletin
- The kits were given to MSRC (TX) and CGA (LA) for the use in the GOM and to OSRL (FL) for international responses.
- Anyone can make their own kit using instructions and component specifications.

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Questions and Answers

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