SORBENT TEST PROGRAM
1999 - 2000

INTERIM REPORT
EMERGENCIES ENGINEERING TECHNOLOGIES OFFICE

SAIC Canada
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SUMMARY

A sorbent testing program has been under development by Environment Canada and other funding partners over the past few years. This program has involved the development of standardized performance tests in both Canada and the United States. A database of test information derived from the new protocols is currently being developed which will permit the distribution of performance results to a broad audience via the internet, with a mechanism being developed for distribution via printed reports.

INTRODUCTION

The demand for some sort of standardized sorbent performance data had a dramatic increase following the incident involving the Exxon Valdez. Environment Canada had previously published reports every few years incorporating performance test data of sorbent products. A mechanism for generating and distributing test data in a timely fashion simply did not exist. Changes to the testing protocol which was used in the reports also hindered direct comparisons between the reports. Environment Canada decided to start the development of a program which would officially develop a new test standard, and ultimately lead to the creation of an ongoing testing program.

BACKGROUND

Environment Canada has developed over the past eight years, with support from agencies such as the Canadian Coast Guard, the U.S. Minerals Management Service, the U.S. Coast Guard, and the Marine Spill Response Corporation, an ongoing testing program for the evaluation of oil spill sorbents. Much of this testing has taken place in support of the development of new testing protocols. In 1994 a Canadian General Standards Board (CGSB) Committee on Sorbent Materials adopted a protocol which originated from Environment Canada. The intention at that time was to create a Certification and Listing program which would be run by the CGSB using this protocol to determine sorbent performance. Unfortunately after the initial adoption of the testing protocol, the CGSB declined to proceed in developing the Listing program.

Continued research by Environment Canada uncovered some problems with the CGSB protocol and modifications were investigated over the next two years. Ultimately a new protocol known as the Environment Canada Sorbent Test Protocol '97 was developed.

During this time, a third protocol, ASTM F726-81 (1993) was also in use. Differences with the Environment Canada protocol rendering direct comparisons of testing results invalid. It was generally felt that the Environment Canada protocol more closely mimicked the use of sorbents during actual spills, although some users who were not familiar with Environment Canada's work stated that they preferred to continue using the ASTM method which was simply more popular. It was proposed at that time to attempt to incorporate features of the Environment Canada protocol into the ASTM protocol. This would enable direct comparisons to be made, and effectively implement a North American standard.

In October of 1998 the proposed ASTM F726-99 protocol was balloted. Comments were received from committee members, with no negative votes. These comments were addressed at the February 1999 meeting of the F20 group responsible for the

F726-99 protocol, and the protocol was officially accepted as a new standard at that time.

REQUIREMENTS

OBJECTIVES

The primary objective of this project was to develop a program whereby the data collected during sorbent performance testing could be readily disseminated in a timely fashion. To that end, it was decided that a database of sorbent performance accessible via the Internet would be the most efficient method. A secondary means of publishing written reports is being considered.

PROCEDURE

A database structure was designed incorporating the structure of the data sheets which are normally used for testing. Software was developed which would extract key fields from a MS Excel® spreadsheet and compile the information within an executable file which would run from a web server. This would enable the data to be easily converted, while providing security in that the information could not be modified without recompiling the executable. A system was designed which would permit open access to a limited part of the data (the generic performance data) while maintaining a secure area which would contain additional technical information. This secure area would be accessible by registered personnel from Environment Canada, Canadian Coast Guard, U.S. Minerals Management Service, U.S. Coast Guard and possibly other government organizations.

RESULTS

A standard format has been developed to show the performance of individual sorbent products. Users will be able to view test summary descriptions and testing details. Summary information would include summary testing data as follows:

Company information
General sorbent material type
Dynamic Degradation Test: PASS / FAIL
Oil Adsorption - short test: pick up ratio in three oil types
Oil Adsorption - long test: pick-up ratio in three oil types
Calculations of pick-up ratios based upon measured or stated storage density.

Appendix A details a sample hard copy report format usually submitted to the manufacturer. Much of the information is simply not needed for the database, and a subset is extracted so that comparisons can be made. Appendix B lists the protocol which was discussed at the February 1999 ASTM meeting and subsequently passed with some minor editing changes. Appendix C lists the summary sorbent data as currently drafted in the database.

CONCLUSIONS and RECOMMENDATIONS

A new standard protocol, designated ASTM F726-99, has been adopted by the Environment Canada Sorbent laboratory. This protocol tests the performance of sorbents by measuring the quantity of test liquid a given quantity of sorbent material will pick up. The protocol tests sorbents in a range of oil viscosities using two time intervals. A database of this performance data is being structured and will be made available which will permit end users and other interested parties to view test data encompassing performance testing and other sorbent characteristics.

The database will be set up so that each product is displayed as a unique "page". Additional work is needed to enable automatic comparisons between different sorbents, and to generate graphs of comparative results. This will be implemented in the next phase of the database work. The text of the database is currently being translated into French and the entire site will be made available as soon as the translation is complete.

APPENDIX A - Standard Report Format

Introduction

SAIC Canada's Environmental Technologies Program is under contract to provide ongoing support and services to Environment Canada. As part of this support, a Sorbent Testing Program has been developed which offers manufacturers and distributors the ability to have their products tested, and the results made available in a database which is accessible to end users. In conjunction with its research partners, SAIC Canada plays an active role in the development of standards for evaluating response equipment as well as conducting product testing.

Objective

The purpose of these tests was to evaluate the sorbent's performance as per the Environment Canada Sorbent Performance Test Program, using ASTM Standard Method of Testing Sorbent Performance of Adsorbents (F726-99). This protocol is based, in part, upon test methods listed in the Canadian General Standards Board - Method for Testing Sorbents (CAN/CGSB-183.2-4), and internal standards initially developed in part by the Emergencies Engineering Technologies Office (formerly the Emergencies Engineering Division) of Environment Canada.

Procedures

Materials and Equipment

Sorbent Description

The following brief description of the sorbent is based on information supplied by the manufacturer and from the quantitative and qualitative observations obtained during testing. Such information is provided since it may be useful when interpreting or comparing results.

The ACME sorbent supplied for testing is described as a cellular synthentic particulate. It consists of particles which are white in colour, and has a measured bulk density of 0.113 g/cm^3.

Test Liquids

The following test liquids were used:

Test Liquid	Density (g/cm^3)	Viscosity (cP)	Temperature (°C)
Diesel	0.913	3	21.9
Medium Oil	0.930	210	21.7
Heavy Oil	0.987	2300	21.3

Equipment

The following apparatus was used to measure physical and chemical properties of the sorbent and/or test liquids.

Density	Anton-Paar DMA 35 hand-held digital densitometer. The unit contains a borosilicate U-shaped oscillating tube and a system for electronic excitation, frequency counting and display. An injected sample volume is kept constant and is vibrated. The density is calculated based on a measurement of the sample oscillation period and temperature. Replicate measurements are conducted and the average density is reported.
Viscosity	Brookfield DVII+ viscometer powered by a precision motor and equipped with a beryllium copper spring to measure torque. The degree to which the spring is wound is proportional to the viscosity of the fluid. Several of the following spindles are used per measurement when possible: LVT spindles (#1, #2, #3, #4),. Ultra Low viscosity Adapter (ULA) and spindle, Small Sample Adapter (SSA) and spindles SC4-18, SC4-31. Models are stated to be accurate to within 1% of their full scale range when employed in the specified manner. Readings should be reproducible to within 0.2% of full scale subject to environmental conditions such as variation in fluid temperature. Calibrations are conducted with Brookfield Standard Fluids.
Mass	Sample mass is measured using a Mettler PM 4000 analytical balance. The scale resolution is 0.01g and the reported reproducibility is 0.01g.
Test Cells	Pyrex 190 mm (diameter) x 100 mm (depth) crystallizing dishes are the typical test cells used although other vessels can be used in order to accommodate special materials.
Weighing Pans	Non-stick coated pans of 20 cm diameter.
Mesh Basket	Mesh baskets (mesh size approximately 1.1 mm diameter) are used to contain and drain Type II (particulate) samples.
Shaker Table	An Eberbach Corporation shaker table, modified to hold three 4L jars is used to agitate samples. The table is set at a frequency of 150 cycles per minute with an amplitude of 3 cm.

Test Protocol

The following summary test protocol which is applicable to Type II (particulate) sorbents was utilized. Any modifications to the protocol methods which were implemented are identified in italics.

The Dynamic Degradation Test

This procedure is designed to determine the buoyancy, hydrophobic and oleophilic properties of a sorbent sample under dynamic conditions. A sorbent sample is placed in a sealed 4L jar which is half-filled with water. The jar is placed on its side and mounted on a shaker table, set at a frequency of 150 cycles per minute at an amplitude of 3 cm, for a duration of 15 minutes. The contents of the jar are allowed to settle for a period of 2 minutes, after which observations pertaining to the condition of the water and the sorbent sample are recorded. If greater than 10% of the sorbent is observed to sink or the water column is rendered contaminated with sorbent particles, then the sorbent is designated with a Failure and is not recommended for use on open water. The sorbent samples are removed from the jar and the water pick-up ratio is determined.

4 mL of oil is added to the surface of the test jars which have been half-filled with water. The wetted sorbent samples used in the beginning of this procedure are returned to the jar and the container is placed on its side and mounted on the shaker table for an additional 15 minutes. The contents of the jar are allowed to settle for a period of 2 minutes and observations pertaining to the existence of any oil sheen on the surface of the water is noted.

The Oil Adsorption - Short Test (15 minutes)

This procedure is designed to determine a sorbent's pick-up ratio when placed in a pure test liquid under stagnant conditions. The sorbent sample is initially weighed and the value recorded. A test cell is filled with a layer of test liquid to a depth of approximately 80 mm. The sorbent sample is placed in a fine mesh basket and lowered into the test cell. After 15 minutes, the sorbent is removed from the cell and allowed to drain for 30 seconds *(sorbents tested in Heavy Oil is allowed to drain for 2 minutes)*. The sorbent is then transferred to a weighing pan and the weight recorded. All tests are conducted in triplicate.

The Oil Adsorption - Long Test (24 hours)

This procedure is designed to determine a sorbent's pick-up ratio when placed in a pure test liquid under stagnant conditions. The sorbent sample is initially weighed and the value recorded. A test cell is filled with a layer of test liquid to a depth of approximately 80 mm. The sorbent sample is placed in a fine mesh basket and lowered into the test cell. After 24 hours, the sorbent is removed from the cell and allowed to drain for 30 seconds *(sorbents tested in Heavy Oil are drained for 2 minutes)*. The sorbent is then transferred to a weighing pan and the weight recorded. All tests are conducted in triplicate.

Results and Discussion

Test results are listed in Laboratory Data Sheets, appended to this report

The Dynamic Degradation Test

After shaking for 15 minutes and settling for 2 minutes, the sorbent material was observed to have dissociated to some degree in the water column. Fine particles were observed throughout the water column, and particles which were floating near the top of the jar had turned translucent from their original opaque white colour indicating water uptake. Measurements confirmed a water pick-up ratio in excess of 10 times its weight.

Due to these factors the sorbent was deemed to have failed this test and is therefore not recommended for use on open waterways.

The Oil Adsorption - Short Test

Following completion of the above test, new sorbent samples were exposed to a range of test oils. Based on 15 minute exposure and 0.5 or 2 minute drain periods, the sorbent was observed to have the following oil sorption ratios:

Oil Type	Oil Viscosity (cP)	Pick-up Ratio (g oil/g sorbent)
Diesel Fuel	3	5.8
Medium Oil	210	12.3
Heavy Oil	2300	9.7

The Short L-Test (15 minutes) is the designated test which indicates standard performance.

The Oil Adsorption - Long Test

Following completion of the above test, new sorbent samples were exposed to a range of test oils. Based on 24 hour exposure and 0.5 or 2 minute drain periods, the sorbent was observed to have the following oil sorption ratios:

Oil Type	Oil Viscosity (cP)	Pick-up Ratio (g oil/g sorbent)
Diesel Fuel	3	6.2
Medium Oil	210	12.9
Heavy Oil	2300	14.3

Conclusions

The ACME Corporation sorbent material was tested using ASTM F726-99 in order to evaluate its performance.

It failed the buoyancy test by having more than 10% of the product sink under dynamic (wave) conditions thus is not recommended for use in waterways.

The oil sorption capacities, expressed as weight ratios of liquid sorbed per unit weight of sorbent, varied between 5.8 and 12.3 for the standard 15 minute tests. The sorbent did not reach saturation within 15 minutes for the heavy crude oil, managing only 9.7 g/g pick-up compared to 14.3 g/g when tested for 24 hours.

APPENDIX B - ASTM Protocol

ASTM Designation: F 726 - 99 (PROPOSED)

Standard Method of Testing

Sorbent Performance of Adsorbents[1]

This standard is issued under the fixed designation F 726; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense. Consult the DoD Index of Specifications and Standards for the specific year of issue which has been adopted by the Department of Defense.

1. Scope

1.1 This method covers laboratory tests which describe the performance of adsorbents in removing nonemulsified oils and other floating, immiscible liquids from the surface of water.

2. Referenced Documents

2.1 ASTM Standards:

D 1596 Test Method for Shock Absorbing Characteristics of Package Cushioning Materials[2]

D 2859 Test Method for Flammability of Finished Textile Floor Covering Materials[3]

F 716 Test Method for Sorbent Performance of Absorbents[4]

F 1127 Standard Guide for Containment by Emergency Response Personnel of Hazardous Material Spills

Manual 10 (STP 825)

2.2 Federal Standard:

Fed. Std. No. 141a Paint, Varnish, Lacquer and Related Materials, Methods of Inspection, Sampling and Testing[5]

[1]This method of testing is under the jurisdiction of ASTM Committee F-20 on Hazardous Substances and Oil Spill Response and is the direct responsibility of Subcommittee F20.22 on Mitigation. Current edition approved ????, Published ??????

[2]*Annual Book of ASTM Standards*, Vol 15.09.

[3]*Annual Book of ASTM Standards*, Vol 07.01.

[4]*Annual Book of ASTM Standards*, Vol 11.04.

[5]*Annual Book of ASTM Standards*, Vol 07.01. Available from 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959, Tel: 610-832-9500, Fax: 610-832-9555, e-mail: service@astm.org, Website: www.astm.org

2.3 Military Specification:

MIL-I-631D Insulation, Electric, Synthetic Resin Composition, Nonrigid

3. Summary of Method

3.1 The adsorbent material is tested using established standard tests for factors relating to storage, while specially developed tests are used for covering other performance factors. Oil and water adsorption strength, buoyancy, and reusability tests are included among these latter tests.

4. Significance and Use

4.1 This method is to be used as a basis for comparison of adsorbents in a consistent manner.

4.2 These tests are not appropriate for absorbent materials which are covered in another standard (F 716).

5. Terminology and Definitions

5.1 General Terminology

5.1.1 sorbent- an insoluble material or mixture of materials used to recover liquids through the mechanisms of absorption or adsorption, or both.

5.1.2 universal sorbent - an insoluble material or mixture of materials that will sorb both hydrophobic and hydrophilic liquid spills.

5.2 Definitions

5.2.1 absorbent - a material that picks up and retains a liquid distributed throughout its molecular structure causing the solid to swell (50% or more). The absorbent is at least 70% insoluble in excess fluid.

5.2.2 adsorbent - an insoluble material that is coated by a liquid on its surface including pores and capillaries without the solid swelling more than 50% in excess liquid.

5.2.3 thickener - a material (usually of higher molecular weight) that is soluble in excess liquid. These materials go from dry to gummy (viscoelastic) to flowable and then soluble. The final viscosity depends only on the liquid to solid ratio.

5.2.4 gellant - a material such as a colloidal network or other aggregate network which pervades and holds a liquid in a highly viscous fragile structure. Many gels may rapidly liquify with added heat or ionic/polar addition. These materials are soluble/flowable in excess liquid.

5.2.5 cubage - defines cubic content, volume or displacement

5.2.6 adsorbent cubage factor "C" - this is the ratio of sorbent volume used to the liquid volume sorbed.

5.3 Descriptions of Terms Specific to This Standard:

This standard does not apply to belt, rope, or weir type skimming devices.

5.3.1 oil - a substantially water immiscible organic liquids which will float on water (density less than 1 g/cm^3), typically with surface tension less than 40 x 10-^{3} N/m.

5.3.2 Type I adsorbent (roll, film, sheet, pad, blanket, web) - a material with length and width much greater than thickness and which has both linear form and strength sufficient to be handled either saturated or unsaturated.

5.3.3 Type II adsorbent (loose) - an unconsolidated, particulate material without sufficient form and strength to be handled except with scoops and similar equipment.

5.3.4 Type III adsorbent (enclosed):

5.3.4.1 IIIa, pillows - adsorbent material contained by an outer fabric or netting which has permeability to oil, but with openings sufficiently small so as to substantially retain the sorbent material within the fabric or netting.

5.3.4.2 IIIb, adsorbent booms - adsorbent material contained by an outer fabric or netting which has permeability to or is permeable to oil but with openings sufficiently small so as to substantially retain the sorbent material within the fabric or netting. The lengthwise dimension substantially exceeds other dimensions and with strength members running parallel with length. Booms are also provided with connections for coupling adsorbent booms together.

5.3.5 Type IV-agglomeration unit - an assemblage of strands, open netting, or other physical forms giving an open structure which minimally impedes the intrusion into itself of high viscosity oils. Normally for use with viscous oils, typically above 10,000 cP viscosity. Said oils are then held in this structure permitting the composite oil/structure to be handled (pompoms).

5.3.6 reuse - the art of extracting adsorbed liquids from an adsorbent through rolls or other compression techniques permitting the adsorbent to be used once again - limitations on reuse may include the U.S. Clean Water Act or other legal restrictions.

6. Apparatus

6.1 Exterior Exposure Tester, sufficient to be used under Federal Test Standard 141a, Method 6152, or actual exposure as detailed in 8.2.

6.2 Test Cells - the dimensions of the test cells shall be large enough to enable the adsorbent sample to float freely within the test cell. For type I and type II sorbents, the recommended test cell is a Pyrex™ 19 cm (diameter) x 10 cm (depth) crystallizing dish with a watch glass or glass plate cover. For larger samples, a 53 cm x 56 cm plastic sink (laundry tub or equivalent) to accommodate the sample is recommended.

6.3 Mesh Baskets - The basket shall be of a sufficient size and strength to accommodate the sample size and weight (150 cm^3, or 4-10 g minimum) when saturated. The basket must not be so tall as to interfere with a protective lid for the test cell.

NOTE: The mesh should retain the sorbent, yet allow free oil to drain away from the sorbent.

6.4 Shaker Table - capable of variable frequency from 20 to 240 cycles/min and variable amplitude of 1 to 4 cm.

6.5 Top Loading Balance - for Type I and II adsorbent, fitted with a hook or other hanging mechanism, 400 + g maximum capacity with 0.1 g resolution, or equivalent.

6.6 Continuous Reading Hanging Scale - for Type III and IV adsorbent, fitted with a hook or other hanging mechanism, 50+ kg maximum capacity with 100 g resolution, or equivalent.

7. Conditioning

7.1 Condition all adsorbent test specimens at 23 ± 4°C and 70 ± 20 % relative humidity for not less than 24 h prior to testing. Condition specimens in a fully exposed state with no coverings or wrapping that would hinder the ambient equilibration process.

7.2 If temperature conditions other than normal room temperature are expected to be important, then conditioning and testing should be carried out at temperatures of interest in addition to those specified in 7.1.

8. Tests for Storage Properties

8.1 Storage density - The density of the sorbent sample is calculated by determining the weight of a known volume (standard sorbent package as delivered to the consumer) of the sorbent. If standard storage packages are not available, then the mass of at least 1 L of sorbent is determined to calculate the storage density.

8.2 Mildew - The susceptibility of an adsorbent to mildew under normal storage is defined under Mil Spec MIL-I-631D, Section 3.5.7. The objective of this test is to determine expected shelf life under conditions which could lead to mildew.

8.3 Flammability-The procedure for this test is described in Test Method D 2859-93a, the Methenamine Pill Test. This test relates to ignition from a spark, cigarette, or other point source such as might be encountered in normal shipping and storage. It should not be inferred that an adsorbent which passes this test will fail to burn if ignited in another

manner such as full building involvement, bonfire, etc., and it should likewise be understood that the test is limited to and pertains to only unsaturated adsorbent samples as normally supplied by the manufacturer.

8.3.1 *This standard should be used to measure and describe the properties of materials, products, or assemblies in response to heat and flame under controlled laboratory conditions and should not be used to describe or appraise the fire hazard or fire risk of materials, products, assemblies under actual fire conditions. However, results of this test may be used as elements of a fire risk assessment which takes into account all of the factors which are pertinent to an assessment of the fire hazard of a particular end use.*

8.3.2 Test Type I adsorbents as a single sheet or pad as supplied by the vendor.

8.3.3 Uniformly arrange Type II adsorbents in a layer of sufficient size to fit the test apparatus. The thickness should be 1.5 mm uncompressed, and arranged such that the bulk density is equal to that found in the packaged product as supplied by the manufacturer.

8.3.4 Any type adsorbent can be tested in the package in which it is supplied by placing the standard Methenamine test mask on a flat portion of the package surface, and placing the pill in the center of the mask on the package and igniting it. Results would be interpreted as in the normal test.

9. Tests for Performance Properties

These tests involve the use of oils with a range of viscosities and densities as indicated below:

Oil Type	*Viscosity Range*	*Density Range*	*Example*
Light	1 - 10 cP	0.820 - 0.870 g/cm^3	Diesel Fuel
Medium	200 - 400 cP	0.860 - 0.930 g/cm^3	Crude Oil
Heavy	1,500 - 2,500 cP	0.930 - 1.000 g/cm^3	Bunker C or residual fuel
Weathered	8,000 - 10,000 cP	0.930 - 1.000 g/cm^3	Emulsified Crude Oil

9.1 Dynamic Degradation Test - This procedure is designed to test for water take-up and to determine oleophilic properties of an adsorbent sample under dynamic conditions. This test is performed at 23 ± 4°°C.

9.1.1 Type I Adsorbent - Sample pieces of the adsorbent (4 pieces cut with a sharp edge (to minimize compaction) into squares of approximately 6cm x 6cm) are first weighed then placed in a 4L jar which is half-filled with water and sealed. The container is then placed on its side and mounted on a shaker table, or similar device, set at a frequency of 150 cycles per minute and an amplitude of 3 cm for a duration of 15 minutes. The contents of the jar are allowed to settle for a period of 2 minutes. Observations pertaining to the condition of the adsorbent and the condition of the water are recorded. Any adsorbent pieces which do not remain floating at the surface of the water are considered to

have failed this test. The contents of the jar are strained through a mesh basket to catch the adsorbent samples, which are then weighed after a 30 second drain period. The water pick-up ratio is calculated from the weight measurements (see section 9.4).

The jar is half-filled with fresh water and 3 mL of oil (medium crude, 300 cP oil or equivalent) is added. The adsorbent sample is returned to the jar which is then sealed. The jar is placed on its side and mounted on a shaker table, or similar device, set at a frequency of 150 cycles per minute and an amplitude of 3 cm for a duration of 15 minutes. The contents of the jar are allowed to settle for a period of 2 minutes, at which time observations are noted. Observations include but are not limited to: quantity of adsorbent submerged, physical appearance of adsorbent and water, and the persistence and color of residual test liquid sheen.

9.1.2 Type II Adsorbent - An adsorbent sample (approximately 4 - 10 g or a maximum of 150 cm^3) is first weighed then placed in a 4L jar which is half-filled with water and sealed. The container is then placed on its side and mounted on a shaker table, or similar device, set at a frequency of 150 cycles per minute and an amplitude of 3 cm for a duration of 15 minutes. The contents of the jar are allowed to settle for a period of 2 minutes. Observations pertaining to the condition of the adsorbent and the condition of the water are recorded. If 10% or more of the adsorbent material has sunk then the adsorbent is considered to have failed this test. The contents of the jar are strained through a mesh basket to catch the adsorbent samples, which are then weighed after a 30 second drain period. The water pick-up ratio is calculated from the weight measurements (see section 9.4).

The jar is half-filled with fresh water and 3 mL of oil (medium crude, 300 cP oil or equivalent) is added. The adsorbent sample is returned to the jar which is then sealed. The jar is placed on its side and mounted on a shaker table, or similar device, set at a frequency of 150 cycles per minute and an amplitude of 3 cm for a duration of 15 minutes. The contents of the jar are allowed to settle for a period of 2 minutes, at which time observations are noted. Observations include but are not limited to: quantity of adsorbent submerged, physical appearance of adsorbent and water, and the persistence and color of residual test liquid sheen.

9.1.3 Types IIIa, IIIb, IV Adsorbents - Both the outer fabric or netting and the filler material are tested independently for type III adsorbents. Samples are prepared according to the protocol listed in section 9.1.1 for the outer fabric or netting of Type III adsorbents and type IV adsorbents, and the protocol listed in section 9.1.2 is used for any particulate filler material used in type III adsorbents. If the adsorbent material fails to remain floating as described in 9.1.1 or 9.1.2, then the adsorbent is deemed to have failed the Dynamic Degradation Test.

9.2 Oil Adsorption - Short Test This test gives idealized laboratory data which can be used to compare one adsorbent's oil capacity with another and likewise give relative cost effectiveness. It should be recognized that under normal use conditions, an adsorbent will not be exposed to sufficient oil layer thicknesses to become completely or rapidly saturated. This test will, therefore, give maximum possible capacity data and idealized time to saturation. The objective of this test is to determine optimum adsorbent capacity without the competing presence of water. As such, this data relates only to oil layer thicknesses which approximate or exceed that of the adsorbent. All adsorption test procedures to be run with adsorbent samples conditioned as in Section 7 and using specified oils at 23 ± 4°C.

9.2.1 Type I Adsorbent - The test liquid layer should be of a minimum thickness of 2.5 cm if the thickness of the adsorbent is under 2.5 cm. If the adsorbent is thicker than 2.5 cm, then a liquid layer at least as thick as the adsorbent sample should be used.

The adsorbent sample to be tested shall be a minimum weight of 4 g. Cut the sample with a sharp edge (to minimize compaction) to minimum dimensions of 13 x 13 cm square. The adsorbent is then weighed and the value is recorded.

The test cell is filled with an initial layer of test liquid. The adsorbent is lowered into the cell. The adsorbent shall be allowed to float freely within the test cell. After 15 minutes ± 20 seconds remove the adsorbent in a vertical orientation along an edge with a clip and let drain for 30 ± 3 seconds (use a 2 minute ± 3 seconds drain time for heavy and weathered oil). Place a tared weighing pan under the adsorbent to catch any additional drips and immediately transfer the adsorbent to the pan. Determine and record the sample weight. All tests are triplicated with the mean of the three runs being used for calculations. The oil pick-up ratio on a weight basis is calculated, as is the volume of oil per adsorbent sample (see section 9.4). If the value of any run (g/g) deviates by more than 15% from the mean of the three runs, then the samples will be rejected and the test repeated with three new specimens.

9.2.2 Type II Adsorbent - The test liquid layer should be of a minimum thickness of 2.5 cm if the thickness of the adsorbent sample spread over the area of the test cell is under 2.5 cm. If the adsorbent is thicker than 2.5 cm, then a liquid layer at least as thick as the adsorbent sample should be used.

The adsorbent sample to be tested shall be a minimum weight of 4 g. The adsorbent sample is weighed and the value is recorded. The test cell is filled with an initial layer of test liquid. The adsorbent is placed in the basket which is then lowered into the test cell. The adsorbent shall be allowed to float freely within the test cell. After 15 minutes ± 20 seconds remove the adsorbent with the basket and let drain for 30 ± 3 seconds (use a 2 minute ± 3 seconds drain time for heavy and weathered oil). Place a tared weighing pan under the adsorbent to catch any additional drips and immediately transfer the adsorbent to the pan. Determine and record the sample weight. All tests are triplicated with the mean of the three runs being used for calculations. The oil pick-up ratio on a weight basis is calculated, as is the volume of oil per adsorbent sample (see section 9.4). If the value of any run (g/g) deviates by more than 15% from the mean of the three runs, then the samples will be rejected and the test repeated with three new specimens.

9.2.3 Type III and IV Adsorbents - The full size adsorbent is weighed and the value is recorded. The test cell is filled with an initial layer of test liquid to a depth at least equal to the thickness of the adsorbent. The adsorbent is lowered into the cell. The adsorbent shall be allowed to float freely within the test cell. After 15 minutes ± 20 seconds manually remove the adsorbent in a vertical orientation and let drain for 30 ± 3 seconds (use a 2 minute ± 3 seconds drain time for heavy and weathered oil). Place a tared weighing pan under the adsorbent sample to catch any additional drips and immediately transfer the adsorbent to the pan. Determine and record the sample weight. All tests are triplicated with the mean of the three runs being used for calculations. The oil pick-up ratio on a weight basis is calculated, as is the volume of oil per adsorbent sample (see section 9.4). If the value of any run (g/g) deviates by more than 15% from the mean of the three runs, then the samples will be rejected and the test repeated with three new specimens.

9.3 Oil Adsorption - Long Test This test gives idealized laboratory data which can be used to compare one adsorbent's oil capacity with another and likewise give relative cost effectiveness. It should be recognized that under normal use conditions, an adsorbent will not be exposed to sufficient oil layer thicknesses to become completely or rapidly saturated. This test will, therefore, give maximum possible capacity data and idealized time to saturation. The objective of this test is to determine optimum adsorbent capacity without the competing presence of water. As such, this data relates only to oil layer thicknesses which approximate or exceed that of the adsorbent. All adsorption test procedures to be run with adsorbent samples conditioned as in Section 7 and using specified oils at 23 ± 4°C.

9.3.1 Type I Adsorbent - The test liquid layer should be of a minimum thickness of 2.5 cm if the thickness of the adsorbent is under 2.5 cm. If the adsorbent is thicker than 2.5 cm, then a liquid layer at least as thick as the adsorbent sample should be used.

The adsorbent sample to be tested shall have a minimum weight of 4 g. Cut the sample with a sharp edge (to

minimize compaction) to minimum dimensions of 13 x 13 cm square. The adsorbent is then weighed and the value is recorded. The test cell is filled with an initial layer of test liquid. The adsorbent is lowered into the cell. The adsorbent shall be allowed to float freely within the test cell. After 24 hours ± 30 minutes remove the adsorbent in a vertical orientation along an edge with a clip and let drain for 30 ± 3 seconds (use a 2 minute ± 3 seconds drain time for heavy and weathered oil). Place a tared weighing pan under the adsorbent to catch any additional drips and immediately transfer the adsorbent to the pan. Determine and record the sample weight. All tests are triplicated with the mean of the three runs being used for calculations. The oil pick-up ratio on a weight basis is calculated, as is the volume of oil per adsorbent sample (see section 9.4). If the value of any run (g/g) deviates by more than 15% from the mean of the three runs, then the samples will be rejected and the test repeated with three new specimens.

9.3.2 Type II Adsorbent - The test liquid layer should be of a minimum thickness of 2.5 cm if the thickness of the adsorbent sample spread over the area of the test cell is under 2.5 cm. If the adsorbent is thicker than 2.5 cm, then a liquid layer at least as thick as the adsorbent sample should be used.

The adsorbent sample to be tested shall have a minimum weight of 4 g. The adsorbent sample is weighed and the value is recorded. The test cell is filled with an initial layer of test liquid. The adsorbent is placed in the basket which is then lowered into the test cell. The adsorbent shall be allowed to float freely within the test cell. After 24 hours ± 30 minutes remove the adsorbent with the basket and let drain for 30 ± 3 seconds (use a 2 minute ± 3 seconds drain time for heavy and weathered oil). Place a tared weighing pan under the adsorbent to catch any additional drips and immediately transfer the adsorbent to the pan. Determine and record the sample weight. All tests are triplicated with the mean of the three runs being used for calculations. The oil pick-up ratio on a weight basis is calculated, as is the volume of oil per standard adsorbent sample (see section 9.4). If the value of any run (g/g) deviates by more than 15% from the mean of the three runs, then the samples will be rejected and the test repeated with three new specimens.

9.3.3 Type III and IV Adsorbents - The full size adsorbent is weighed and the value is recorded. The test cell is filled with an initial layer of test liquid to a depth at least equal to the thickness of the Adsorbent. The adsorbent is lowered into the cell. The adsorbent shall be allowed to float freely within the test cell. After 24 hours ± 30 minutes manually remove the adsorbent in a vertical orientation and let drain for 30 ± 3 seconds (use a 2 minute ± 3 seconds drain time for heavy and weathered oil). Place a tared weighing pan under the adsorbent sample to catch any additional drips and immediately transfer the adsorbent to the pan. Determine and record the sample weight. All tests are triplicated with the mean of the three runs being used for calculations. The oil pick-up ratio on a weight basis is calculated, as is the volume of oil per standard adsorbent sample (see section 9.4). If the value of any run (g/g) deviates by more than 15% from the mean of the three runs, then the samples will be rejected and the test repeated with three new specimens.

9.4 Calculations:

9.4.1 Using the data obtained in 9.1, calculate water adsorbency as a ratio of water adsorbed to dry adsorbent weight as follows:

Water Adsorbency = S_W / S_O

where:

S_O	=	initial dry adsorbent weight.
S_{WT}	=	weight of adsorbent samples at end of water test, and
S_W	=	(S_{WT} - S_O) net water adsorbed

EXAMPLE: Initial sample weight S_O = 8.1 g
Weight after water test S_{WT} = 15.3 g
Water Adsorbency = S_W / S_O = (15.3-8.1) / 8.1 = 1.01

Therefore the Water Adsorbency ratio by weight for this adsorbent is 1.0 to 1 or 1.0 g/g

9.4.2 Calculate oil adsorbency as the ratio of oil adsorbed to dry adsorbent weight:

Oil adsorbency$_m$ = S_S/S_O

where:

S_O	=	initial dry adsorbent weight,
S_{ST}	=	weight of adsorbent samples at end of oil test, and
S_S	=	(S_{ST} - S_O) net oil adsorbed,

EXAMPLE: Initial sample weight S_O = 9.1 g
Weight after oil test S_{WT} = 35.3 g
Oil Adsorbency = S_S / S_O = (35.3-9.1) / 9.1 = 2.88

Therefore the Oil Adsorbency ratio by weight for this adsorbent is 2.9 to 1 or 2.9 g/g

9.4.3 Calculate oil adsorbency as the volumetric ratio of oil adsorbed to volume of dry adsorbent.

Oil adsorbency$_V$ = S_{SV}/S_{OV}

where:

S_{SV} = net oil adsorbed (S_S) / oil density

S_{OV} = initial dry adsorbent weight (S_O) / sorbent storage density

EXAMPLE: Net oil adsorbed (S_S from 9.4.2) = 35.3 - 9.1 = 26.2 g
Oil density (measured during testing) = 0.927 g/cm^3
Initial dry adsorbent weight (S_O) = 9.1g
Sorbent storage density (measured from sorbent package) = 0.7 g/cm^3
Oil adsorbency$_V$ = S_{SV}/S_{OV} = (26.2 / 0.927) / (9.1 / 0.7) = 2.17 cm^3/cm^3

Therefore the Oil Adsorbency ratio by volume for this adsorbent is 2.2 to 1 or 2.2 cm^3/cm^3

9.4.4 Calculate Cubage Factor "C" as the inverse volumetric ratio of oil adsorbed to volume of dry adsorbent.

Adsorbent Cubage Factor "C" = S_{OV}/S_{SV}

EXAMPLE: S_{SV}/S_{OV} (from 9.4.3) was found to be 2.17
S_{OV}/S_{SV} = 1 / S_{SV}/S_{OV} = 1 / 2.17 = 0.46

Therefore the Cubage Factor "C" for this adsorbent is 0.46

10. Reuse (Type I, Type IIIa Only)[6]

10.1 Significance and Use-This test determines the extent to which an adsorbent can be saturated, have the oil extracted, and then repeat this cycle. One point to be used in judging the suitability of an adsorbent for reuse is the number of cycles it can endure without becoming unusable due to tearing, crushing, or other general deterioration. Other factors are the rate of decrease in adsorption capacity and the percentage of oil that can be removed with reasonable effort and equipment. Compression reuse may be tested in two ways using bulk compression as might be found in a squeeze type mop wringer and roller type wringers, and reuse involving centrifugation is detailed. Reuse involving solvent washing is regarded as a special uncommon procedure, and as such is not covered here.

[6]The reuse of adsorbent material which contains residual hazardous liquids may contravene existing waterway or other regulations such as the U.S. Clean Water Act. The end user is responsible for ensuring that all pertinent regulations are being followed.

10.2 Compression Extraction - Use the light medium, and heavy oils indicated in section 9 of this standard. Oil removal is effected with an apparatus consisting of an open container with a porous flat open cover above it with 30 to 60 % open space of sufficient strength to withstand a force of 70 kPa on each square centimeter area of adsorbent. Samples are prepared as directed in section 9.2.

10.2.1 Procedure:

10.2.1.1 Weigh the dry adsorbent sample (S_o) to within ± 2 %, then saturate, drain, and reweigh as in 9.2. Subtract the dry adsorbent weight to obtain total oil adsorbed (O_S). Place the adsorbent sample on the porous cover, and place a stiff plate (wood, metal) of known weight above it. Symmetrically add sufficient weight to the top of the plate to give a total weight such that the total weight, when divided by the gross area of the adsorbent in contact with the plate, gives 0.7 kg/cm^2. Extract the adsorbent for 15 ± 2 s after which remove the weights and plate. Place the sample in a freshly tared weighing pan and reweigh to within ± 2 %. Again subtract the dry adsorbent weight to obtain the net oil remaining (O_N).

10.2.1.2 Repeat this procedure four more times giving data over at least five cycles. Record this data by cycles (for example, O_{S1}, O_{S2}, O_{S3}), for oil adsorbed each cycle.

10.2.2 Calculations:

10.2.2.1 The total amount of oil the adsorbent is able to hold after each saturation cycle is a measure of the degree of deterioration and shall be reported as the adsorbency ratio by weight and by volume, and as a percentage of the oil adsorbed in the first saturation.

10.2.2.2 Calculate the adsorbency ratio by weight for each cycle based on total oil adsorbed as follows:

$$\text{Oil Adsorbency}_{Mx} = O_{Sx}/S_{Ox}$$

Where

S_{Ox} = initial adsorbent weight at beginning of cycle "x"
O_{STx} = weight of adsorbent samples at end of cycle "x", and
O_{Sx} = (S_{Ox} - O_{STx}) net oil adsorbed per cycle

Report the adsorbency ratio by weight for each cycle.

10.2.2.3 Calculate the adsorbency as the volumetric ratio of oil adsorbed to volume of adsorbent material. as follows:

Oil Adsorbency$_{Vx}$ = O_{SVx}/S_{OVx}

Where

O_{SVx} = net oil adsorbed (O_{Sx}) / oil density
S_{OVx} = initial adsorbent weight at beginning of cycle "x" (S_{Ox}) / sorbent storage density

Report the volumetric adsorbency ratio for each cycle.

10.2.2.4 Calculate the performance degradation as follows:

For cycle two, the percentage of first cycle oil capacity is (O_{S2}/O_{S1}). This is repeated similarly for cycle three as (O_{S3}/O_{S1}), and the remainder of cycles to the end point. Report the data for each cycle.

10.2.2.5 Calculate the percentage of oil removed for any given cycle as follows:

% oil removed for run X = (O_{Sx} - O_{Nx})/O_{Sx}

Report the performance degradation as a percentage of initial capacity for each cycle,

10.3 Wringer Extraction - Samples are prepared as directed in section 9.2 except that the sample shall be cut to 16 by 18 cm in size. This procedure is suitable for light medium and heavy oils only. The roller to be used should have rollers of sufficient length to accommodate the unfolded sample and of diameter from 3 to 10 cm. Pressure is applied at the rate of 4 kg/cm of nip while the adsorbent travels through the extractor at a velocity between 5 and 10 cm/s.

10.3.1 Procedure - Weigh the dry sample, saturate, drain, and reweigh as in 9.2 and calculate total oil adsorbed (O_s). Run the saturated adsorbent through the nip at a velocity of from 5 to 10 cm/s. Repeat this cycle four times giving data over at least five cycles.

10.3.2 Calculations - Perform calculations in accordance with 10.2.2.

10.4 Centrifuge - Samples are prepared as directed in 10.2. This procedure is suitable for light, medium and heavy oils only. The centrifuge should have explosion proof enclosures for all electrical components including, but not limited to, the drive motor and electrical control panel(s) and must meet local electrical codes for the liquids used.

10.4.1 Procedure - Weigh the dry sample, saturate, drain, and reweigh as in 9.2 and calculate total oil adsorbed (O_s). Run the saturated adsorbent through the centrifuge following manufacturers directions. Repeat this cycle four times giving data over at least five cycles.

10.4.2 Calculations - Perform calculations in accordance with 10.2.2.

11. Keywords

11.1 adsorbent; absorbent; oil; sorbent; adsorbent performance, gellant, thickener

APPENDIX C - draft SORBENT WEB SITE

[redacted]

[redacted]

[redacted]

SPD
AAQD
ERMD
ESD
EETO
MAPD

[redacted]

The Emergencies Engineering Technology Office of ETC

EC 1999-2000 Sorbent Test Program

- **Sorbent Test Database**
  Data Search page for Environment Canada 1999-2000 Sorbent Test Program.

- **Testing Protocol Summary**
  Testing of oil spill sorbent products, by *David Cooper, P.Eng.*
  - 1.0 Introduction
  - 2.0 Objective
  - 3.0 Materials and Equipment
    - 3.1 Sorbent Description
    - 3.2 Test Liquids
    - 3.3 Equipment
  - 4.0 Test Protocol
    - 4.1 The Dynamic Degradation Pre-Test
    - 4.2 The Dynamic Degradation Test
    - 4.3 The Oil Adsorption - Short Test
    - 4.4 The Oil Adsorption - Long Test
  - 5.0 Sample Results

1.0 Introduction

Environment Canada's Emergencies Engineering Technologies Office, in conjuction with its research partners, plays an active role in developing standards for evaluating response equipment as well as conducting product testing.

2.0 Objective

The purpose of these tests are to evaluate the sorbents performance as per the ASTM F726-99 Standard Method of Testing - Sorbent Performance of Adsorbents.

This protocol is based, in part, upon test methods listed in the Canadian General Standards Board - Method for Testing Sorbents (CAN/CGSB-183.2-4), and internal standards initially developed in part by the Emergencies Engineering Technologies Office (formerly the Emergencies Engineering Division).

3.0 Materials and Equipent

The following section details the physical types of sorbents and the equipment used to perform the testing.

3.1 Sorbent Descriptions

Type I adsorbent (roll, film, sheet, pad, blanket, web):	
	material with length and width much greater than thickness and which has both linear form and strength sufficient to be handled either saturated or unsaturated.
Type II adsorbent (loose):	
	an unconsolidated, particulate material without sufficient form and strength to be handled except with scoops and similar equipment.
Type III adsorbent (enclosed):	
	IIIa, pillows - adsorbent material contained by an outer fabric or netting which has permeability to oil, but with openings sufficiently small so as to substantially retain the sorbent material within the fabric or netting.
	IIIb, adsorbent booms - adsorbent material contained by an outer fabric or netting which has permeability to or is permeable to oil but with openings sufficiently small so as to substantially retain the sorbent material within the fabric or netting. The lengthwise dimension substantially exceeds other dimensions and with strength members running parallel with length. Booms are also provided with connections for coupling adsorbent booms together.
	Type IV-agglomeration unit - an assemblage of strands, open netting, or other physical forms giving an open structure which minimally impedes the intrusion into itself of high viscosity oils. Normally for use with viscous oils, typically above 10,000 cP viscosity. Said oils are then held in this structure permitting the composite oil/structure to be handled (pompoms).

3.2 Test Liquids

The sorbent material is tested in a series of oil viscosities. Typically the first three test liquids from the following list are used:

Oil Type	*Viscosity Range*	*Density Range*	*Example*
Light	1 - 10 cP	0.820 - 0.870 g/cm^3	Diesel Fuel
Medium	200 - 400 cP	0.860 - 0.930 g/cm^3	Crude Oil
Heavy	1,500 - 2,500 cP	0.930 - 1.000 g/cm^3	Bunker C or residual fuel
Weathered	8,000 - 10,000 cP	0.930 - 1.000 g/cm^3	Emulsified Crude Oil

3.3 Equipment

The following apparatus is used to measure physical and chemical properties of the sorbent and/or test liquids.

Density:	Anton Paar DMA 35 hand-held digital densitometer. The unit contains a borosilicate U-shaped oscillating tube and a system for electronic excitation, frequency counting and display. An injected sample volume is kept constant and is vibrated. The density calculated is based on a measurement of the sample oscillation period and temperature. Replicate measurements are conducted and the average density is reported.
Viscosity:	Brookfield DVII viscometer powered by a precision motor and equiped with a beryllium copper spring to measure torque. The

	degree to which the spring is wound is proportional to the viscosity of the fluid. Several of the following spindles are used per measurement when possible: LVT spindles (#1,#2,#3,#4), Ultra Low viscosity Adapter (ULA) and spindle, Small Sample Adapter (SSA) and spindles SC4-18, SC4-31. Models are said to be accurate to within 1% of their full scale range when employed in the specified manner. Readings should be reproducible to within 0.2% of full scale subject to environmental conditions such as variations in fluid temperature. Calibrations are conducted with Brookfield Standard Fluids.
Mass:	Sample mass is measured using a Mettler PM4000 analytical balance. The scale resolution is 0.01 g and the reported reproducibility is 0.01g
Test Cells:	Pyrex 190 mm (diameter) x 100 mm (depth) crystallizing dishes are the typical test cells used although other vessels can be used in order to accomodate special materials.
Weighing Pans:	Non-stick coated pans of 20 cm diameter are used to weigh the samples.
Mesh Basket:	Mesh baskets (mesh size approximately of 1.18 mm diameter) are used to contain and drain Type II (loose particulate) samples.
Shaker Table:	An Eberbach Corporation shaker table, modified to hold three (3) 4L jars is used to agitate samples. The table is set at a frequency of 150 cycles per minute with an amplitude of 3 cm.

4.0 Test Protocol

The following is only a summary of the actual protocol used. For the complete protocol, please contact ASTM offices atwww.astm.org

4.1 The Dynamic Degradation Pre-Test

This procedure is designed to determine the buoyancy, hydrophobic and oleophilic properties of a sorbent sample under dynamic conditions. A sorbent sample is placed in a sealed 4L jar which is half filled with water. The jar is placed on its side and mounted on a shaker table, set at a frequency of 150 cycles per minute at an amplitude of 3 cm, for a duration of 15 minutes. The contents of the jar are allowed to settle for a period of 2 minutes, after which observations pertaining to the condition of the water and the sorbent sample are recorded. The sorbent is tested for water pick-up. Under full protocol testing, if greater than 10% of the sorbent is observed to sink, further testing is halted.

4.2 The Dynamic Degradation Test.

Four millilitres of oil (~300 cP) is added to the surface of the test jars which have been re-filled with water. The wetted sorbent samples used in the Dynamic Degradation Pre-Test are returned to the jar and the container is placed on its side and mounted on a shaker table for an additional 15 minutes. The contents of the jar are allowed to settle for a period of 2 minutes and observations noted.

4.3 The Oil Adsorption - Short Test

Fresh sorbent samples are weighed and placed in test cells containing excess test liquids for a duration of 15 minutes. The samples are removed and weighed again at a precise time interval (which is dependant on the viscosity of the test liquid) and a pick-up ratio is calculated. All runs are performed in triplicate, with a maximum permissible deviation of 15%. If this deviation is exceeded, all three runs are performed again.

4.4 The Oil Adsorption - Long Test

Fresh sorbent samples are weighed and placed in test cells containing excess test liquids for a duration of 24 hours. The samples are removed and weighed again at a precise time interval (which is dependant on the viscosity of the test liquid) and a pick-up ratio is calculated. All runs are performed in triplicate, with a maximum permissible deviation of 15%. If this deviation is exceeded, all three runs are performed again.

5.0 Sample Results:

Emergencies Engineering Technology Office of ETC

EC 1999-2000 Sorbent Test Program

TESTING INFORMATION

COMPANY:	*Company X*	**DENSITY:**	*0.61 g/cm³*
SORBENT:	*XYZ*	**DATE TESTED:**	*Jan 1, 1999*
PROJECT #:	*EC99-0000*	**TESTED BY:**	*BA*
TYPE (I,II,III,IV):	*II*	**CHECKED BY:**	*DC*
MATERIAL:	*shredded polypropylene*		

DYNAMIC: DEGRADATION PRE-TEST

	1	2	3
Temperature (°C)	21	21	21
Sample weight (g)	10.4	10.2	8.8
Initial water pickup ratio (g_{liquid} / $g_{sorbent}$)	1.2	1.2	1.3
Buoyancy test (Pass / Fail)	Pass	Pass	Pass

COMMENTS:
Following 2 minute settling time:
Approx. 5% of sorbent sinks or is in suspension.
Water remains clear. Sorbent submerged; sorbent still floating.

DYNAMIC: DEGRADATION TEST

	1	2	3
Temperature (°C)	21	21	21
Persistence of oil sheen on surface (Y/N) (g_{liquid} / $g_{sorbent}$)	No	No	No

COMMENTS:
No sheen on surface. No noticable change in water colour or clarity.

SHORT TEST (15 Minutes)

	Oil #1			Oil #2			Oil #3		
SAMPLE	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
Temperature (°C)	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0
Sample weight (g)	10.01	10.03	10.01	9.98	9.98	9.99	5.08	5.00	5.10
Initial Capacity (g_{liquid} / $g_{sorbent}$)	11.33	10.80	10.52	13.05	12.93	13.17	5.44	6.05	4.61
Average Liquid up-take (g_{liquid} / $g_{sorbent}$)	10.9			13.1			5.4		
Standard Deviation (g_{liquid} / $g_{sorbent}$)	0.41			0.12			0.72		

LONG TEST (24 Hours)

	Oil #1			Oil #2			Oil #3		
SAMPLE	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
Temperature (°C)	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0
Sample weight (g)	11.20	10.60	10.83	10.54	10.30	11.02	10.27	9.20	9.78
Initial Capacity (g_{liquid} / $g_{sorbent}$)	12.45	11.98	11.88	15.31	14.94	13.71	18.34	17.20	17.92
Average Liquid up-take (g_{liquid} / $g_{sorbent}$)	12.1			14.7			17.8		
Standard Deviation (g_{liquid} / $g_{sorbent}$)	0.30			0.84			0.58		

Oil Type	***Density (g/cm^3)***	***Viscosity (cP)***	***Temperature***
Diesel	0.838	3.4	21.9
	Comment: Sorbent becomes saturated and sinks in oil. Drained 30 seconds		
Medium	0.876	350	22.2
	Comment: Sorbent becomes saturated and sinks in oil. Drained 2 minutes		
Heavy	0.974	2300	21.7
	Comment: Sorbent did not reach saturation in Short test. Drained 2 minutes		

For additional information, contact:

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