**NAVAL FACILITIES ENGINEERING SERVICE CENTER**
**Port Hueneme, CA 93043**

**NFESC**
**TECHNICAL REPORT**
**TR-2101-ENV**

# EVALUATION OF BIO-BASED INDUSTRIAL PRODUCTS FOR NAVY AND DOD USE

## PHASE I
## KENAF ABSORBENT

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## 1.0 INTRODUCTION

Alternative Agricultural Research and Commercialization (AARC) Corporation is a wholly owned corporation of the U.S. Department of Agriculture (USDA). AARC is a venture capital firm that is authorized to make investments in companies to help commercialize bio-based industrial products (non-food, non-feed) from agricultural, forestry materials, and animal byproducts. As these bio-based products are made from agricultural materials, they tend to be environmentally friendly. In many instances, these products replace petroleum products and are comprised of recovered agricultural waste material.

Since the Federal government has an equity position in these companies, Section 729 of the 1996 Federal Agricultural Improvement and Reform Act (P.L. 104-127, Title VII, Subtitle A, Chapter 2, Section 1657c) prompted an amendment of the AARC Corporation authorization. The authorization now allows other Federal agencies to establish procurement set-asides and encourages preferences for property that has been commercialized with assistance provided under Subtitle G of Title XVI of the Food, Agriculture, Conservation and Trade Act of 1990. To this end, the Federal Acquisition Regulations are in the process of being amended to encourage these preferences. In addition, both the Secretary of Defense and the Secretary of Agriculture have signed letters expressing their support of a partnership between Department of Defense (DOD) and USDA to increase DOD use of these bio-based products.

Under the sponsorship of AARC Corporation, Naval Facilities Engineering Service Center (NFESC) evaluated the potential use of a number of these bio-based products within the Navy and DOD. Representatives from both NFESC and AARC selected eleven bio-based products to undergo a two-phase evaluation process. This document provides the results from the first phase of the evaluation process.

## 2.0 EVALUATION METHODOLOGY

The evaluation methodology consists of a two-phase approach. Details of the methodology are outlined in the following two subsections.

### 2.1 Phase I: Preliminary Product Evaluation

Each vendor's manufacturing site was visited to collect product data, discuss product usage, and to obtain information regarding the performance claims, savings, and environmental benefits. Existing third-party certifications and test results were also reviewed and current users of the product were contacted and interviewed. In addition, scientific and engineering literature was researched to establish the physical, chemical, or biological mechanisms employed by the product in achieving its claimed performance. Potential opportunities for using the product within the Navy were identified and a preliminary life cycle cost (LCC) analysis was performed using the Phase I product data. The evaluation process did not proceed to Phase II if the results of the Phase I product investigation clearly indicated that the product could not be cost-effectively employed within the Navy or that the product had no apparent cost-effective potential for Navy use. An implementation plan was developed for those products evaluated as having cost effective use within the Navy. Proceeding onward to Phase II product testing was recommended when the Phase I analysis suggested that the product had potential for cost-effective Navy use but lacked sufficient data to conclusively validate product performance and/or LCC.

### 2.2 Phase II: Product Testing

For those products proceeding onto phase II of the evaluation process, a specific step-by-step test protocol is developed for each recommended product with the objective of providing sufficient data to verify product utility within the Navy. The protocol will be designed to evaluate life cycle performance of the product. Upon approval of the protocol by AARC, the product will be tested by a certified testing facility under controlled conditions. In addition, the life cycle performance of the product will be evaluated and the environmental, safety, and health benefits and trade-offs associated with the product will be estimated. A LCC analysis of the product will be performed using the proven costing techniques from the NAVFAC Economic Analysis Handbook P-442.

An implementation plan will be developed for each of the recommended products targeted for the potential user community within the Navy and DOD. During the development of the implementation plan, the requirements and needs of the Navy ship, aviation, and shore facilities will be considered. The resources of the Joint Group on Acquisition Pollution Prevention (JG-APP) will also be utilized to promote Army and Air Force implementation of the product. Product visibility may also be achieved through various publications distributed throughout DoD and other government agencies.

## 3.0 PRODUCTS EVALUATED

Table 3.1 lists the eleven products evaluated in Phase I for potential application within the DoD. Two of the products were determined unfeasible for use within the DoD. The remaining nine products are each presented in a separate evaluation report.

(Table 3.1 Omitted Due To Restricted Vendor Information)

## 4.0 AFFIRMATIVE PROCUREMENT

Section 6002 of Resource Conservation Recovery Act (RCRA) directs government agencies to promote recycling by increasing their purchases of products containing recovered materials. RCRA section 6002(e) requires the Environmental Protection Agency (EPA) to designate items that are or can be produced with recovered materials and prepare guidelines to assist procuring agencies in complying with their affirmative procurement responsibilities set forth in paragraphs (c), (d), and (i) of section 6002. Once EPA has designated items, section 6002 requires that any procuring agency spending more than $10,000 a year of Federal funds on an item must purchase the highest percentage of recovered materials practicable. Procuring agencies are Federal, state, and local agencies, and their contractors, which use appropriated Federal funds.

Executive Order 12873 reinforced RCRA's Federal buy recycled program by directing EPA to adopt modified procedures for designating items and providing procurement recommendations. Under the order, EPA issued a regulation known as Comprehensive Procurement Guideline (CPG) which contains the item designations, and also prepared a guidance document known as a Recovered Materials Advisory Notice (RMAN). The RMAN contains EPA's recommendations to procuring agencies to assist them in purchasing the designated items and meeting their statutory obligations. The RMAN also provides general guidance for developing an affirmative procurement program. An affirmative procurement program is an procuring agency's strategy for maximizing its purchases of EPA-designated items, and must consist of the following:

- Recovered materials preference program
- An agency promotion program
- A program for requiring vendors to reasonably estimate, certify, and verify the recovered materials content of their products; and
- A program to monitor and annually review the effectiveness of the affirmative procurement program

On September 16, 1998 Executive Order 12873 was replaced by Executive Order 13101 which expanded the affirmative procurement program to include bio-based products on the EPA designated item list. A bio-based product list will be developed and published by USDA in the Federal Register no later than March 23, 1999. The list shall also be updated biannually after publication to include additional items. It is assumed that the bio-based product evaluated in this report will be included in the list.

In the spirit of section 6002 of the Resource Conservation and Recovery Act (RCRA) and Executive Order 13101, Federal procuring agencies and personnel should strongly consider implementing sustainable bio-based products when selecting items to meet the goals of the affirmative procurement program.

## 5.0 KENAF ABSORBENT

### 5.1 Product Description

Kenaf absorbent is manufactured from the dry stalk of a kenaf plant, an annual agricultural crop. Kenaf, a member of the hibiscus family (Hibiscus cannabinus L.), is related to cotton, hemp, and okra. The stalk of the kenaf plant is comprised of two fiber types. About one-third of the stalk's dry weight is bark fiber known as bast. The remaining fiber is the white inner core commonly referred to as "kenaf". Refined bast fibers, similar to softwood fibers, are used to make writing paper, cigarette paper, filtration paper, and, with the addition of polypropylene, a fiberglass-like product. The refined core fibers, similar to hardwood tree fibers, are used to make a range of paper products including composite panels, animal bedding, potting media, and oil absorbent materials.

KenGro Corporation of Charleston, Mississippi, one of the largest manufacturers of kenaf, reports an annual yield of about 2,000-2,500 tons from approximately 500 acres (4-5 tons per acre). Kenaf grows quickly, often reaching 12-14 feet in as little as about five months. Kenaf is generally planted in May and harvested in March after drying in the field during the winter months. The kenaf is collected into loose bales or "modules" and usually stored outside, open to the elements until processing.

The following is a brief description of KenGro's proprietary manufacturing process and absorbent applications. The harvested kenaf plant is first processed in a hammermill where the plant stalks are pulverized. A trommel screen mechanically separates the bast from the core allowing for independent processing. The core is then placed on a shaker table, blown into a separate building, and run through either a mill or hammermill further reducing the core particles. Screens filter the core particles into two main particle sizes. Particles less than 1/4" but greater than 1/8" in diameter are referred to as "Bin 2". Particles less than 1/8" in diameter are referred to as "Bin 3". After screening, the Bin 2 and Bin 3 particles are bagged on site in loose form in plastic or paper bags. KenGro sells these small, large, or mixed particles wholesale to different distributors under a number of labels (ECOSORB, Kenaf 2000) for a variety of applications. The kenaf absorbent products are non-reusable and are intended for oil spills on land, water, or hard surfaces such as floors. On request, the kenaf can be packaged into socks although this may reduce the absorbency of the product.

KenGro reports using a minimal amount of herbicide and pesticides on their kenaf crops. In addition, no chemicals or biological organisms are added to the kenaf during or after processing. However, there are indigenous microbes in the kenaf plant that feed on hydrocarbons that promote bioremediation. KenGro is also currently investigating the possibility of adding a white rot fungus to further enhance the bioremediation properties.

**Contact Information**:


| | |
|---|---|
| Point of Contact: | R.H. Burress, President |
| Address: | KenGro Corporation<br>6605 Hwy. 32 E.<br>P.O. Box 432<br>Charleston, MS 38921 |
| Phone: | (601) 647-2456 |
| Fax: | (601) 647-2468 |


## 5.2 Vendor Claims

In regards to their oil absorbent material, KenGro claims the following:

- Products are made from a completely renewable annual agricultural crop (no depletion of natural resources).
- Products are all natural and 100% biodegradable.
- Products are non-toxic to humans and have no adverse effect on plants or animals.
- Products may be used for spills on land, on water, or as a floor sweep.
- Products absorb up to six times their weight
- Products are best suited for light oils.
- Products have less than a 1% leaching capability.
- Products enhance bioremediation of petroleum hydrocarbons.
- Products are lightweight thus reducing landfill or incineration disposal costs.
- Incineration yields less than 2% ash and a high BTU rating of 7,500 BTU/lb.
- Products are not soluble in water.
- Products used on water spills aid filtration of any liquid contaminants in water.

Table 5.1 lists some of the physical properties of the kenaf Bin 2 and Bin 3 products as reported by KenGro.

**Table 5.1: Physical Properties of Kenaf**

| Physical Properties | Kenaf Bin 2 | Kenaf Bin 3 |
|---|---|---|
| Particle Size (inches) | < 1/4 and > 1/8 | < 1/8 |
| Density ($lb/ft^3$) | 6 | 7 |
| Absorbency | Up to 6 times its own weight | Up to 6 times its own weight |
| Leaching rate (%) | < 0.02% | < 0.02% |

A copy of the vendor's product information sheet is included in Appendix A.

## 5.3 Application Procedures

One distributor of kenaf recommends the following applications of kenaf absorbent:

For Bioremediation of Oil Spills On Land: Spread kenaf over spilled hydrocarbon to an average of 2 inches in thickness and till into soil 5-6 inches deep. Allow natural bioremediation to occur.

For Oil Spills On Water: Spread kenaf manually or mechanically upwind of spill. Use screened forks or vacuum to remove saturated particles.

For Oil Spills On Hard Surfaces: Spread kenaf on spill until all hydrocarbon is absorbed. Use broom to sweep up saturated material and place in a suitable container.

## 5.4 Verification of Product Claims

### 5.4.1 Third Party Testing and Results

The majority of third party testing on kenaf absorbent has been conducted by Mississippi Forest Products Laboratory of Mississippi State University and Millsaps Sorbent and Environmental Laboratory of Millsaps College in Mississippi.

#### 5.4.1.1 Millsaps Sorbent and Environmental Laboratory Sorbency

Millsaps Sorbent and Environmental Laboratory, located at Millsaps College in Jackson, Mississippi, conducted sorbency tests on various sorbents which included kenaf Bin 2 and Bin 3, peat moss, kitty litter, and polypropylene. Testing was conducted in accordance with American Society for Testing and Materials (ASTM) test method F 726, Section 9.1.2. This test measured the sorbency of a material as defined by dividing the total amount of oil absorbed by the weight of the dry sorbent sample. The test determines the optimum absorbent capacity without the competing presence of water. The ASTM protocol warns that “under normal use conditions, an absorbent will not be exposed to sufficient oil layer thicknesses to become completely or rapidly saturated. This test therefore provides an indication of the maximum possible absorbency capacity and the idealized time to saturation. Table 5.2 summarizes the results of the absorbency tests. A copy of the test report, dated December 30, 1992, is included in Appendix A.

**Table 5.2: Average Absorbency Ratios for Kenaf and Other Sorbents**

| Oil Type | Absorbency Ratio: Grams of Oil Absorbed Per Gram of Absorbent | | | | |
|---|---|---|---|---|---|
| | Kenaf Milled Core 2 (Bin 2) | Kenaf Milled Fines (Bin 3) | Peat Moss | Kitty Litter | Polypropylene[1] |
| T-201 Heavy Crude | 2.90 | 1.64 | 1.23 | 0.31 | 9.81-15.21 |
| #2 Diesel | 4.39 | 5.54 | 3.50 | 0.44 | 9.22-13.16 |
| T-102 Light Crude | 5.87 | 6.92 | 3.48 | 0.45 | 9.81-16.61 |

[1] Ranges based on results of the lowest and highest performing polypropylene materials.

Table 5.2 shows that, aside from the polypropylene absorbents, the kenaf absorbents out-performed both kitty litter and peat moss. Kenaf's absorbency ratio for light crude oil and #2 diesel were determined to be 6.92 and 5.54 respectively. These findings support the absorbency claims made by KenGro. It should be noted that kenaf fines (not to be confused with kenaf milled fines) were also tested. The data, not included in the above table, showed an absorbency of 11.98 grams T-102 light crude oil absorbed per gram of sorbent. KenGro states, however, that this absorbency value should not be used because, in their opinion, the "fines" are not a practical or usable form of kenaf. The report asserts that the kenaf fines proved to be in the same range of efficiency as polypropylene fabrics, which have become a standard in environmental applications. In addition, the report recommended that these fines be studied for use as an absorbent filler for socks, pillows, or booms.

#### 5.4.1.2 Department of Plant Pathology and Weed Science, Mississippi State University

Kenaf samples were collected from three moisture levels within storage modules and examined for the occurrence of bacteria and fungi at Mississippi State University (MSU). The report does not mention using a specific test method. The test protocol, however, is described. The test results showed that four distinct bacterial colonies were present in all moisture levels. Five fungal species, one each from Aspergillus, Penicillium, Rhizopus, Nigrospora, and Sodaria genera were also identified. Along with these five, seven additional fungi were yet to be identified. A copy of the undated report is included in Appendix A.

### 5.4.1.3 Mississippi Forest Products Laboratory of Mississippi State University

Mississippi Forest Products Laboratory (MFPL) of MSU tested the efficacy of kenaf as a petroleum sorbent in highly contaminated soil. The report does not mention using a specific test method, although the test protocol is described. Briefly, T-102 light oil was added and mixed into sandy soil to simulate contaminated soil. A soil sample was collected and analyzed for total petroleum hydrocarbon (TPH) content. Kenaf was then added and mixed in with the contaminated soil. After 10 hours of dwell time, kenaf fines were separated from soil by air fractionation. The soil and kenaf fines were then extracted and analyzed for TPH content. This preliminary study showed a 56% petroleum loss from the soil while kenaf showed a 66% petroleum gain. The 10% difference was attributed to kenaf absorbing organics other than the petroleum from the soil.

MFPL also conducted a Toxicity Characteristic Leaching Procedure (TCLP) test to determine the leaching characteristics of kenaf. Initially, the contaminated kenaf contained 750,000 ppm of total petroleum hydrocarbons (TPH). The TCLP test showed that only a drop in 160 ppm TPH had leached out of the kenaf. This test summary did not mention using any specific method, stating only that the kenaf was extracted for TCLP by "EPA" methods and analyzed for TPH content.

The third test conducted by MFPL evaluated the use of microorganisms for bioremoval of petroleum oil from contaminated kenaf . In a test with unspecified method, kenaf fines were contaminated with petroleum oil and placed in flasks. Sterile water was added plus either a bacteria culture (known hydrocarbon bioremoval agent) in nutrient broth or a nutrient broth without the bacterial culture added to the flasks. After being on a rotary shaker for 7 days, the kenaf fines were filtered from the liquid media and all samples were tested for microbiological counts and TPH analysis. Both treatments with and without the bacteria culture removed petroleum from kenaf fines at 49% and 55%, respectively. The TPH concentrations in the liquid media were minimal which meant that the effective bioremoval agent was intrinsic to the kenaf with little contribution from the bacteria culture.

The report concluded that the preliminary results from the above three tests indicate that kenaf could be used as an excellent sorbent of oil and also as a carrier of microorganisms for bioremediation of petroleum wastes. Indigenous microorganisms associated with kenaf fines were found to be effective biodegraders as the bacterial culture used in the laboratory study. A summary of the test report entitled "Bench Scale Study of Kenaf as a Potential Oil Sorbent and Carrier of Biodegradation Microorganisms, dated September 27, 1993, is included in Appendix A.

#### 5.4.1.4 Department of Forest Products, Mississippi State University

A study of a biopile treatment of creosote-contaminated soil at a closed wood-treating facility was the subject of a dissertation submitted to the faculty of MSU by K. L. Hurt. Soils contaminated with creosote were placed in biopiles and treated and monitored at regular intervals for 360 days. The four methods of treatment were: 1) venting, 2) venting with a 1% by volume addition of kenaf, 3) venting with a 1% by volume addition of kenaf and a fungi (Cladosporium), and 4) as controls (no additives or vent pipes). Soil samples were collected periodically and analyzed for TPH, polycyclic aromatic hydrocarbons (PAH), nutrients, microbes, and TCLP (of the soil). Methods used included Standard Method 5520-F and EPA methods 9060, 351.4, 365.3, and 3520 A. The dissertation concluded that the test results indicated that the final concentrations of total PAHs in the control treatment were not significantly different than other treatments. Apparently, the indigenous soil microorganisms, the initial excavation, and the mixing aerated the soil and caused the rapid degradation rates that occurred before day 90. The dissertation does point out that, at several points throughout the study, the kenaf biopile significantly enhanced biodegradation of PAHs. The concentrations of total PAHs decreased the most through day 45 for the control and kenaf treatments at approximately 62% and 55% respectively. No other worthwhile reduction occurred after day 45. In addition, the final concentrations of TPH were similar for all treatments. With appropriate mixing and aeration, these particular native microflora were capable of degrading the petroleum hydrocarbons in the contaminated soils. A copy of the dissertation, dated December 1996, is included in Appendix A.

#### 5.4.1.5 Mississippi Agricultural and Forestry Experiment Station, Mississippi State University

The Mississippi Agricultural and Forestry Experiment Station (MAFES), MSU prepared an “Official Opinion” statement based on a number of experiments conducted at their facility. Test methods used were not specified in the statement. Test results from a chemical analysis indicates the pH of the kenaf core is approximately 6.8 and the specific gravity is less than one. Being a naturally occurring cellulosic material, kenaf is considered non-toxic and will have no effect on any plant or animal on land or in water. Kenaf is also fully biodegradable with biodegradation time dependent upon pH, carbon-nitrogen ratio and frequency of rainfall or irrigation. Under ambient outdoor conditions with no supplemental nitrogen, biodegradation occurs in approximately 24 months. In soil bioremediation and biodegradation of petroleum hydrocarbon contaminated kenaf core tests, biodegradation is enhanced and can occur in less than nine months. Indigenous microorganisms in the kenaf core serve as an effective bioremediation agent. An undated copy of the Official Opinion statement is included in Appendix A.

MAFES, MSU also analyzed kenaf core samples for energy and dry matter content. The data received did not include the method of analysis. Test results showed that kenaf core, as received, had 7,556.8 BTUs per pound of kenaf. The dry matter, a mass measurement of a sample after the removal of any water, was found to be 90.74%. Although the ash content was not determined, it is assumed to be less than 9.26%. A copy of the test results, dated November 15, 1991, is included in Appendix A.

#### 5.4.1.6 Mississippi State Chemical Laboratory, Mississippi State University

Mississippi State Chemical Laboratory (MSCL) at MSU conducted analytical tests on kenaf core in October of 1991 and 1992. Samples were analyzed for presence of pesticide and insecticide residues. The test method used was not specified. The most recent analytical test results are shown in Table 5.3. Copies of the test results, dated October 1, 1992, October 14, 1992, and December 14, 1998 are included in Appendix A.

Table 5.3 lists organochlorine and organophosphate pesticides and insecticides. The organochlorine pesticides identified in Table 5.3 are listed as toxic organic compounds and regulated by the Clean Water Act. The test results indicate that the concentrations of organochlorine pesticides present in kenaf were below the maximum contaminant levels of 0.01 mg/L set forth by the EPA.

**Table 5.3: 1992 Test Results For Pesticide and Insecticide Residues**

| COMPOUND | Concentration (ppm) | Detection Limit (ppm) |
|---|---|---|
| Chlorpyrifos | 0.03 | 0.01 |
| Treflan | ND | 0.01 |
| Heptachlor* | ND | 0.01 |
| Heptachlor Epoxide* | ND | 0.01 |
| Aldrin* | ND | 0.01 |
| alpha-BHC* | ND | 0.01 |
| beta-BHC* | ND | 0.01 |
| delta-BHC* | ND | 0.01 |
| gamma-BHC (Lindane)* | ND | 0.01 |
| Chlordane* | ND | 0.01 |
| 4, 4-DDD* | ND | 0.01 |
| 4, 4-DDE* | ND | 0.01 |
| 4, 4-DDT* | ND | 0.01 |
| Dieldrin* | ND | 0.01 |
| Endosulfan I* | ND | 0.01 |
| Endosulfan II* | ND | 0.01 |
| Endosulfan sulfate* | ND | 0.01 |
| Endrin* | ND | 0.01 |
| Mirex | ND | 0.01 |
| Methoxychlor | ND | 0.01 |
| Hexachlorobenzene* | ND | 0.01 |
| Ronnel | ND | 0.01 |
| Trithion | ND | 0.01 |
| Diazinon | ND | 0.01 |
| Methyl Parathion | ND | 0.01 |
| Ethyl Parathion | ND | 0.01 |
| Malathion | ND | 0.01 |
| Toxaphene* | ND | 0.01 |

ND – Not detected at specified level
*Organochlorine pesticides

#### 5.4.1.7 Louisiana Agricultural Experimental Station, Louisiana State University Agricultural Center and Department of Clothing and Textiles, Virginia Polytechnic Institute and State University

Faculty members from Louisiana Agricultural Experimental Station, Louisiana State University Agricultural Center and Department of Clothing and Textiles, Virginia Polytechnic Institute and State University, Blacksburg, Virginia conducted an absorbent study. The results of the study were published in Environmental Science and Technology, Vol. 26, No. 4, 1992 in an article entitled *Using Natural Sorbents In Oil Spill Cleanup*. In the study the natural fibers tested included cotton, milkweed, and kenaf. In addition, polypropylene and a blend of milkweed and polypropylene were used for comparisons. Absorbents were tested in artificial seawater with light crude oil and then with Bunker C oil using test methods described in the Technical Manual of the American Association of Textile Chemists and Colorists 106-1981 and ASTM D 95-70. The report stated that the oil sorption values of kenaf fiber and core materials were generally lower than that of milkweed or cotton but were similar to polypropylene web for Bunker C oil. Also, further separation of the naturally occurring fiber bundles of kenaf to the single fibers should increase oil sorption comparably to polypropylene. The study included three additional absorbency tests on the natural fibers that excluded kenaf. The general conclusions drawn from the report were predominately based upon these additional test results. Therefore, interpretation of the comparative results, as presented, may be misleading since a complete absorbency profile of kenaf was not investigated as fully as the other natural fibers. A copy of the report, dated 1992, is included in Appendix A.

### 5.4.2 Review of Material Safety Data Sheet

A review of the Material Safety Data Sheet (MSDS), compiled by KenGro, provides information that appears to be consistent with third party test data. A copy of the MSDS, dated January 1, 1998, is included in Appendix A.

### 5.4.3 Verification Issues

The vendor claim that kenaf used on water spills aid filtration of any liquid contaminants in water could not be verified since supporting third party test data was not submitted.

## 5.5 Current Users

Distributors for KenGro products state that the oil and gas industries are the major users of kenaf as an oil absorbent. Although kenaf particles are used as a floor sweep, the product is mainly used on hydrocarbon spills on water and to bioremediate hydrocarbon spills on land.

## 5.6 Product Comparisons

(Section 5.6 Omitted Due To Restricted Vendor Information)

## 5.7 Preliminary Life Cycle Costs

(Section 5.7 Omitted Due To Restricted Vendor Information)

## 5.8 Specifications

The Federal government has specifications, known as commercial item descriptions (CID), for various absorbents. A contract may require an absorbent to meet the requirements of a CID, but use of CIDs is not mandatory for most procurements. Table 5.9 summarizes the requirements of CIDs for a floor sweep absorbent and a loose absorbent for hydrocarbon spills on water. It should be noted that most particulate and sweep type absorbents are not sold to the government under contract. Nor do most absorbents sold to the government meet the specified requirements listed in Table 5.8.

**Table 5.8: Summary of Federal Specification Requirements For Sweep and Particulate Type Absorbents**

| Item Description | Test | Particulate Requirement | Sweep Requirement |
|---|---|---|---|
| CID Number | N/A | A-A-1281A | A-A-1280B |
| Media | N/A | Oil Sorbent, Particulate | Oil Sorbent, Sweep |
| Absorption Ratio of #2 Fuel Oil (Gram of Oil/ 1 Gram of Absorbent) | ASTM F 726 | 12 | 11 |
| Water Absorbency Ratio (Gram of Water/ 1 Gram of Absorbent) | ASTM F 726 | N/A | 1 |
| Absorbent Buoyancy | ASTM F 726 | Must Float When Saturated | 98 % |
| Fire Resistance Rating | ASTM D 2859 | Resistant to Flammability | Resistant to Flammability |
| Ignition Temperature ($^0$C) | ASTM D 1929 | 150 | 150 |
| Sieve Analysis | Shake 2g in #100 US Std Sieve for 5 min | Minimum of 88% Retention | N/A |
| Toxicity / Reactivity | N/A | Nontoxic, Nonpolluting, Nonreactive With Oil | Nontoxic, Nonpolluting, Nonreactive With Oil |

### 5.9 Potential Navy / DoD Users

All Joint Service activities with operations that involve petroleum, oil, and hydrocarbon products are potential users of kenaf absorbent.

### 5.10 Federal Supply Listings

KenGro does not have National Stock Numbers (NSN) for their absorbents, and they do not currently sell through the Defense Logistics Agency (DLA) or the General Services Agency (GSA).

### 5.11 Conclusions

The following conclusions can be made regarding kenaf absorbent:

- Made from a sustainable renewable resource.
- Appears to be an all-natural, bio-based and biodegradable product.
- Appears to accelerate the bioremediation process of TPH and PAH when using land farming techniques.
- Appears to have the necessary nutrients required for bioremediation.
- Is incompatible with oxidizers or oxidizing materials. Users should avoid prolonged exposure to highly concentrated acids or bases.
- Is not suitable for use in breezy areas or during windy conditions.
- Test results indicate that concentrations of organochlorine insecticides and pesticides are within the regulatory limits dictated by the CWA.
- Although kenaf appears to have a low leaching rate, used absorbent will require evaluation for disposal on a case by case basis given the necessary data submitted by the generator to allow proper waste classification.
- Provides at least 7,000 BTUs per pound of absorbent when incinerated.
- Contains 90.74 % dry matter.
- Bioremediation protocol is not clearly defined by KenGro. Documented and recommended kenaf to soil ratios vary considerably.
- Kenaf appears to be cost effective to similar products used by the Navy.
- Wave action may reduce float time to a few hours.

### 5.12 Recommendations

Procuring agencies serving the Federal government should implement purchase preference for kenaf absorbent where feasible. This action is in the spirit of Executive Order 13101 and RCRA Section 6002, although kenaf absorbent is not presently considered an EPA designated item.

### 5.13 Implementation

Section 6.0 contains detailed implementation methods and additional procurement contacts applicable to kenaf absorbent. The following processes can assist the visibility of kenaf absorbent within the military:

- The Defense Technical Information Center (DTIC) will receive a final copy of this report. Joint Service users can search for specific information using a "key words or phrases" search engine.

- Kenaf absorbent will be logged into the Joint Service Pollution Prevention Technical Library. This library exists as a Web site and is accessed by the Joint Service for Pollution Prevention guidance.

- The findings of this evaluation will be submitted as publication articles for Navy-wide periodicals. For example, "Currents", a full-color quarterly magazine, is published by NFESC and offers a wide variety of feature articles. "Indoor Air Monitor", a monthly periodical in an electronic format, publishes articles related to Safety or OSHA issues.