Biofuel Feedstock
Inter-Island Transportation

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A Comparison of Hawaii’s Inter-Island Maritime Transportation of Solid Versus Liquid Biofuels Feedstocks

Hawaii Natural Energy Institute
Desktop Study
October 2012

Photographs, from left:
Open-top container, courtesy of Hawaii Stevedores, Inc.
Bulk sand delivery at Kalaeloa, courtesy of Honolulu Advertiser
ISO Tank Container, courtesy of Hawaii Intermodal Tank Transport
Petroleum products barge, courtesy of Sause Brothers Inc.
This report was funded by the U.S. Department of Energy and written by Ms. Joelle Simonpietri, Senior Energy Analyst at the Hawaii Natural Energy Institute.
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Purpose of This Study

An understanding of the options that are or could be available to transport biofuels feedstock between islands is needed to estimate the future development of a mature biofuels industry in Hawaii. Private sector practitioners have previously assumed that solid biomass is more difficult and costly than liquid feedstock to ship between islands. An understanding of the options and cost drivers are needed in order to make decisions about the nature of a potential future biofuels system, for example decisions on whether the refining infrastructure should be centralized on Oahu or distributed on neighbor islands. Continental U.S. truck/rail/river shipping economics are not representative of the maritime and relatively small-scale nature of inter-island transport in Hawaii. This desktop study is a first attempt to survey options and ascertain costs representative of inter-island shipping options in Hawaii.

Methodology

This report combines a desktop market survey with a case study. All cost data was gathered during the month of June 2012.

The desktop survey is a first-order comparison of “port A to port B” options to ship liquid versus solid biofuels feedstock between islands. Costs discussed in this report are just the incremental operational costs for the maritime transportation portion of the transportation system. Consultations were conducted with agricultural firms, regulated and unregulated shipping companies, petroleum production and distribution companies, and biofuels companies, and searches were performed on the academic literature, popular press, and internet.

The case study uses the annual harvest of the sole commercial sugar plantation in Hawaii as the basis for this scenario: 300,000 short tons per year of sugar cane bagasse is produced on Maui and made available for transportation to Oahu for use as a biofuels feedstock. 300,000 short tons represents 75% of the average annual harvest of 400,000 tons.

A short and not exhaustive list of some assumptions made are:

1) That the sugar plantation opts at some undetermined future date to make the bagasse available for biofuels rather than combust it to produce electricity for sale to the local electric utility;
2) The other 100,000 tons are assumed to be sufficient to combust and power the mill’s operations;
3) Any refining done on Oahu will be physically located in Kalaeloa/Campbell Industrial Park, in part due to appropriate zoning and available space and in part to take advantage of existing fuel production and distribution infrastructure.

Important factors that could not be included in the one-month scope of work of this study are the capital investment costs such as barge charters or purchases, new fuel or barge piers, new and unique loading and unloading or safety equipment; ground transportation costs, such as loading and operating trucks from plantation to port to refinery; the costs and considerations of storing bagasse or pyrolysis oil; the capital or operating cost to process bagasse to reduce the density or dry it to reduce the moisture content; or costs of the bagasse production or biofuels refining.

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1 Photograph courtesy of Mr. Lee Jakeway, Director of Energy Development, Hawaiian Commercial & Sugar Co.
Executive Summary

At full scale, shipment of liquid feedstock via fuel barge has the lowest transportation cost, fifteen cents per gallon of crude oil equivalent and an aggregate cost of $3.3 million per year. Shipment via International Standards Organization (ISO) tank containers (aka “isotainers”) is a close second at twenty cents per gallon crude oil equivalent, and an aggregate cost of $4 million per year. Transporting bagasse in bulk solid form via open-top containers is five times more costly, largely because bagasse is relatively “fluffy,” requiring many containers to be in circulation simultaneously. Transporting solid bagasse in bulk form via dedicated barge would probably compete well in cost relative to the other options, but a cost estimate could not be obtained for this study. In practice, actual projects would likely start with containerized bagasse or pyrolysis oil and then transition to the dedicated barge transport methods as the volume of activity increases. All four transportation options considered in this study will require investment in equipment, port capacity, trial and error of new practices, and some research and development.

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The volume of material shown in the table above differs from the 300,000 tons used as the scenario’s starting point for the following reasons:

1) To prevent spontaneous combustion\(^2\) at its natural moisture content of 50%\(^3\), the bagasse needs to be dried to not more than 40% water weight by volume prior to shipping\(^4\). Therefore the volume to be shipped is 250,000 short tons per year.

2) To convert to pyrolysis oil, the 300,000 tons of bagasse needs to be dried to not more than 10% water weight before it can enter the pyrolysis system\(^5\), or 166,666 short tons per year. An

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\(^4\) A standard for a desired moisture level of bagasse for transportation is not readily available. Preferred moisture percentages by weight to prevent self-combustion ranged from 25% to 40% in consultations with forestry products producers, pyrolysis oil producers, industry literature, and academic publications.
average of 78% of the bagasse weight is recovered in liquid form as pyrolysis oil after conversion, for a resulting shipment volume of 130,000 short tons per year.

Viewed in terms of Hawaii’s existing inter-island transportation infrastructure, transport of liquefied feedstock required a relatively low 5-6% increase in activity over current transportation capacity. Solid feedstock presented more of an impact, requiring that an entire new barge be placed into service in addition to the three serving Maui currently. As far as harbor capacity, the Hawaii State Department of Transportation\(^6\) has already studied options to increase liquid fuel transport capacity to accommodate biofuels potential. Solid feedstock transportation options have not been studied as rigorously.

Other significant constraints that could not be factored into the analyzed costs were the:

1) Cost to dry the bagasse to 10-40% moisture content by weight in order to either reduce spontaneous combustion risk or introduce it into the pyrolysis oil system. Of note, the average annual humidity in Kahului, Maui is 66\(^8\).

2) Cost and benefits of other methods to liquefy bagasse. Pyrolysis oil production is optimized for relatively dry feedstock like timber chips, which are normally 20-30% moisture in the field and dried at the lumber mill down to 4-8% moisture\(^9\). Bagasse at 50% moisture may be more suitable for “wet” process to convert to alcohol or oil, such as microbial digestion.

3) Highly acidic nature of pyrolysis oil at pH <2. This makes even shipment in existing fuel barges and feeder equipment that handle “black” products like heavy fuel oil and crude oil unlikely unless appropriate protective coatings can be determined and cost-effectively applied. Other liquid feedstock types not expressly considered in this case study could have a lower adoption hurdle. Alcohol (ethanol) is already routinely transported inter-island via fuel barge, and crude vegetable oil is relatively inert and non-corrosive\(^10\). See sample MSDS sheets in the Appendix.

4) Logistical layout on Oahu, which would require any bagasse containers or oil isolainers to be unloaded from the cargo barge at Honolulu port and then trucked over public roads to the industrial park at Kalaeloa. Kalaeloa Harbor currently handles bulk products (coal) and fuel loading/offloading, but would probably require the implementation of planned harbor upgrades before the full scale of 200,000 tons of bagasse per year could be accommodated.

\(^5\) Robert C. Brown of Iowa State University and Jennifer Holmgren, Vice President of Honeywell UOP LLC, "Fast Pyrolysis and Bio-Oil Upgrading" presentation circa 2010; http://www.ascension-publishing.com/BIZ/HD50.pdf


\(^7\) Photographs courtesy of Hawaii Stevedores, Inc., Honolulu Advertiser, and Hawaii Intermodal Tank Transport

\(^8\) Current Results http://www.currentresults.com/Weather/Hawaii/humidity-by-month.php

\(^9\) Interview with Ensyn LLC pyrolysis oil process engineers.

\(^10\) Interview with Airlines for America Association Fuels Quality Assurance Manager on ASTM sub-committee work on maritime transportation of aviation fuels and potential aviation biofuels feedstocks.
Narrative Assessment of Maritime Transportation Options

Four transportation options are considered in this assessment, two for bulk solid bagasse and two for pyrolysis oil converted from bagasse. Cost estimates could be made for three of the options considered: open-top container, isotainer, and fuel barge.

Cost estimates are discussed several ways: aggregate annual shipping costs to move the entire annual volume of product, cost per ton of materiel shipped, and cost per gallon of crude oil equivalent. The methods to arrive at aggregate and per-ton costs are option-specific and discussed in more detail below. To arrive at the estimated cost per gallon crude oil equivalent, an assumption was made that the bagasse would be pyrolyzed on either Maui before transportation or Oahu after transportation. Pyrolysis oil is 50% dissolved water weight, and the remaining mass theoretically acts very similarly to crude oil when processed through a hydrotreating system similar to that used for petroleum refining, yielding a “tunable” combination of light ends, naphtha, and light and heavy distillates (gasoline/jet fuel/diesel/heavy fuel oil). Because of the high variety in mass and energy density of the products derived from hydrotreating pyrolysis oil, a density of crude oil at 7.33 barrels per ton and 42 gallons per barrel was used to approximate a “gallon of crude oil equivalent.”

Solid Feedstock Transportation Options

The two options for inter-island transportation of solid bagasse considered for this report were open-top containers transported via cargo barge on regulated sailings, or piled in bulk form onto a dedicated bulk solids barge.

Current inter-island cargo transportation methods

The preponderance of materiel transported inter-island is transported in containers aboard flat-top or roll-on/roll-off barges. There are also bulk solid shipments of sand and lumber in dedicated bulk solids barges, and transportation of sugar in bulk solid form from Hawaii to the U.S. west coast for

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1 Aggregated from multiple presentations and interviews with UOP and Ensyn pyrolysis oil practitioners
3 Photo courtesy of Young Brothers, Inc. A specification sheet for this barge is in the appendix.
4 Photo courtesy of Mr Ray Davis, theaffirmationspot.com
5 Andrew Gomes, "Isle concrete suppliers forced to import sand," Honolulu Advertiser, 19 Aug 2007
6 2012 advertisement in trade publication, Sause brothers Inc.
refining and packaging aboard the *Moku Pahu*, a combined tug-barge with 37,000 tons of capacity in an enclosed hold specifically designed for open ocean transportation of small-particle size dry bulk material.\(^{17}\)

Open-top containers are traditionally top-loaded at origin and driven to the port, then lifted off the truck rails by crane and transferred to the container barge for shipping, then lifted off the barge by crane and stacked at the destination port until it is time to place them onto a truck for delivery to the destination facility. 20-foot containers are the norm, however 40-foot containers have been increasing in popularity. The harbors at both Maui and Honolulu have upgraded handling equipment that can handle the larger 40-foot units.\(^{18}\) The *Ho’omaka Hou* barge for example has a maximum capacity of 616 20-foot equivalent units (TEU). There are at least three regulated sailings of cargo barges like *Ho’omaka Hou* from Maui to Oahu per week. Additional details on a cargo barge and sample open-top container are included in the appendix.

**Option 1: Open-Top Container Shipment of Bagasse**

This desktop assessment concludes that shipping 250,000 short tons of bagasse per year from Kahului port on Maui to Honolulu harbor on Oahu via 40-foot open-top containers would cost $1283.00 per container and require 15,800 individual container shipments per year, for a total cost of $20.2 million dollars per year or $81.07 per ton.

The volume of containers could theoretically be reduced to 8,500 containers per year if the bagasse could be dried or pretreated to double its density from the current average of 186 kg per cubic meter\(^{20}\) in order to fill each container to its maximum payload weight of 58,480 lbs\(^{21}\). If not, the relatively “fluffy” density of the bagasse constrains the amount that can be fit in each container to 29.2 short tons, requiring the larger number of 15,800 container shipments per year. 40-foot open top containers can carry more bagasse per trip and are used in this case study.

Because of the diverse particle size of bagasse (0.5mm to 26mm in length)\(^{22}\) relative to sand or sugar (0.5 to 1 mm)\(^{23}\), further study is needed to see if existing sand/sugar cargo handling methods can accommodate bagasse. Open-top containers were suggested by an inter-island shipper as the best option for physical containment and shipment of bagasse in the near term.\(^{24}\)

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17 Combined from vessel information provided on MarineTraffic.com, findthedata.org, and marinearchitect.com

18 Hawaii Department of Transportation, Harbors Division

19 Open top container, image courtesy of Hecksher Inc from [www.hecksher.com](http://www.hecksher.com), June 2012.

20 Averaged from bagasse densities reported by Turn et al and Hobson & Mann, see citations in this paper.

21 Averaged from online specifications provided by several container supply companies. A specification sheet from one company is included in the appendix.

22 Range derived from multiple reports, one of which was "Sugarcane bagasse particles size used in enzymatic hydrolysis in the literature and obtained by a pneumatic classifying equipment“ report for Fundação de Amparo à Pesquisa do Estado de São Paulo, Brazil. Undated. See [http://bbest.org.br/abstracts/resumos/R0181-1.pdf](http://bbest.org.br/abstracts/resumos/R0181-1.pdf)

23 R.P Jennings, Hewlett’s South African Refineries Ltd, “Further improvements in Raw Sugar Quality” proceedings to the *South African Sugar Technologist’s Association*, April 1967

24 Telephone interview with Young Brothers Inc. commercial sales manager, June 2012.

Carrying capacity of containers are standardized by the International Standards Organization (ISO) and bounded on the upper end by gross vehicle weight limits for most U.S. public roads (as well as Hawaii), which is 88,000 lbs. The increased size of the 40-foot container increases the weight of the container itself, reducing the payload weight that it can carry over public roads.

Based upon open quotes available at Alibaba.com, 20-foot open-top containers cost $500 (used) to $6000 (new) to purchase, have a 26 cubic meter volumetric capacity, and can carry a maximum of 31 short tons payload per container. 40-foot containers also range in price from $500 to $6000 each to purchase, have a 66 cubic meter volumetric capacity and can carry a lower payload of 29.3 short tons per container.

The shipping cost per container is based on the regulated inter-island fare provided by one of Hawaii’s shipping companies, Young Brothers Inc., which quoted a $1175.00 shipping charge from Kahului Harbor on Maui to Honolulu Harbor on Oahu and a $107 empty container return fee. Those fees include a 2.5% fuel surcharge, are fixed on a per-container basis, and do not vary by weight.

Young Brothers Inc. currently operates one cargo barge which leaves Oahu for Maui three times a week. The normal barge load is about 400 containers and capacity is a maximum load of 616 twenty-foot equivalent containers per trip, so the bagasse shipments from this case study would represent an increase over normal shipping volume by 33% at proven density and 14% if the bagasse can be compressed to remove the density constraint. This volume is high enough that it would require a significant level of coordination with the port authority and shipping companies.

To estimate the incremental capital cost for the open top containers themselves, it was estimated that the containers could be “turned” in one week, i.e. loaded, shipped, unloaded, and returned within seven calendar days, leading to a requirement for 300 isotainers in service on any given week. Assuming 100% availability, a purchase price midway between the low and high points quoted above, a weighted average cost of capital of 8% per year, and an amortization period of five years, the incremental capital cost for the containers came to $1.00 per ton. Adding the incremental capital cost to the shipping cost netted a transportation cost of $81.07 per ton of bagasse and an aggregate annual shipping cost of $20 million.

Material Safety Considerations of Fresh Bagasse

Normal practice for shipping dry bulk between islands is for relatively inert materials like sand and lumber. Freshly milled bagasse at 50% moisture content risks spontaneous combustion if stored for more than 24 hours. While this risk may be mitigated somewhat by predictive modeling and management practices to encourage drying, normal practice in Hawaii is to process the bagasse within 24-48 hours at the sugar mill, by going from the cane press directly to the combustion chamber to power the mill and produce electricity for sale. Previous experiments in Hawaii have shown that storing

26 Interview with Young Brothers Inc. commercial sales manager, June 2012.
the bagasse in wet form for the 7-14 days needed for a reasonable inter-island shipping schedule may raise an unacceptable risk of combustion: A closed container loaded with a sample of fresh bagasse on Maui heated up to 120°F in less than 24 hours, and wood chips at 45% moisture content stored in open trailers heated the trailers to the touch after a 30-45 day storage experiment. Since bagasse is not frequently transported off-farm or transported through regular commercial shipping in the U.S. or Hawaii, a Material Safety Data Sheet (MSDS) for bagasse from an Australian firm is provided in the Appendix, along with a draft MSDS for Hawaii-harvested banagrass.

**Option 2: Dry Bulk Barge Shipping of Bagasse**

In a bulk solids barge scenario, the entire 250,000 ton supply of bagasse could be transported from Maui to Oahu approximately 6,100 to 13,100 short tons per trip, for a total of 19 to 41 trips per year. This estimate is based on several assumptions, some of which are that port handling equipment is expanded to load/unload bagasse in bulk form, the bagasse could be dried to not more than 40% moisture content to reduce the risk of spontaneous combustion, and a barge is purchased or chartered and made available exclusively for bagasse. This study also assumes that the barge specifications are the same as those of the container barge, and that the bagasse would be piled on top of the barge in the same manner as is done for grain shipments via barge along inland waterways in the continental U.S. The latter normal practices are the same as for coal or compost: trapezoidal piles 6-30 meters wide, up to 30 meters high, and as much as 300 meters long, with a base angle of 60 degrees and covered by tarpaulins. Assuming the bagasse can be piled on the barge in this way and that the 30 meter pile height is a constraint for safety/materials handling purposes, the light density of bagasse constrains the total amount that can be shipped (as was also the case for open-top container) to 6100 tons per barge trip. The higher cargo load of 13,100 tons per trip corresponds to a case where the bagasse can be piled higher (at least twice the normal pile height of 30 meters) in order to reach the payload maximum of the barge, which is 13,100 tons.

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30 Interview with Mr. Lee Jakeway, Hawaiian Commercial & Sugar Co. manager, June 2012.
Port Capacity Considerations for Bulk Solids Feedstock

On Oahu currently, the port of Honolulu handles all containerized shipments while Kalaeloa Harbor currently handles bulk products (such as coal) and the majority of petroleum fuel loading and offloading. Any bagasse containers or pyrolysis oil isotainers would have to be unloaded from the cargo barge at Honolulu port and then trucked over public roads to the industrial park at Kalaeloa for refining. This case study’s full scale of 200,000 tons of bagasse per year gives rise to a suggestion to put the bulk solids handling facilities in at Kalaeloa Harbor rather than Honolulu Harbor, so that this large quantity of materials would not need to be driven across Oahu.

Estimating costs for a chartered barge depends on multiple variables such as duration of agreement, access to port berths, cost to bring a new barge to Hawaii to place in service, operating costs for pilot and crew, and establishment of materiel handling equipment in ports at both ends of the transit to handle loading bagasse in bulk solids form. There is an open quote of $3 million dollars exclusive of transportation costs on Alibaba.com from a Singaporean supplier for a ballastable cargo barge very similar to the ones in use in Hawaii today.\(^3\) Full cost estimation for obtaining a new bulk solids barge, associated loading/unloading equipment, and port capacity expansion is out of the scope of this study.

Liquid Feedstock Transportation Options

Current inter-island petroleum distribution system

The current inter-island distribution method for petroleum products is via barge, formally named “oil products barges”\(^3\) and referred to as “barge” or “fuel barge” for the remainder of this section. Smaller shipments, such as gasoline supply to the island of Lanai, are via “ISO container tanks”\(^3\), known in industry and referred to in the rest of this study as “isotainers.”

\(^3\) United Nations Directories for Electronic Data Interchange for Administration, Commerce and Transport (UN/EDIFACT) website, [http://www.unece.org/trade/undid/d03a/tred/tred8179.htm](http://www.unece.org/trade/undid/d03a/tred/tred8179.htm).
\(^3\) International Organization for Standardization [http://www.iso.org](http://www.iso.org), see published standard for Series 1 Freight Containers
Fuel is either imported as crude oil and refined at one of the two refineries on Oahu, or imported as refined product. The majority of the petroleum product and all of the ethanol sold in the state comes to or via Oahu. Crude petroleum is offloaded at one of the two refinery moorings. Refined products imported to Hawaii are offloaded at the Kalaeloa Harbor fuel pier. The refined petroleum products are then distributed from the refineries/Kalaeloa tank farms via pipelines to terminals, either for use on Oahu or for transfer to barges for neighbor island deliveries. There are a handful of fuel barges operating in the state: one by Tesoro, two by Chevron, and a couple of others operated by charter for Hawaiian Electric Industries and petroleum marketers such as Aloha Petroleum.

Hawaii’s petroleum distributors have at least one single barge to carry “black products” like low-sulfur fuel oil (LSFO) and bunker fuel, and at least two separate “clean” barges to carry gasoline, ethanol, jet fuel, diesel, and naphtha. A sample clean products barge schedule has the barge leaving Oahu every Tuesday for Hilo on Hawaii Island and Kahului on Maui, for Molokai once every two months, and every other weekend for Port Allen on Kauai. The barge carries about 60,000 barrels of fuel, of which 10,000-15,000 barrels are jet fuel. 60,000 barrels is within the 40,000-80,000 barrel capacity given in the DOT’s Harbor study for a “large” fuel barge, and is used as the base case for the pyrolysis oil discussion below. Hawaiian Electric Industries Inc. also has a large 67,500 barrel barge dedicated to “black products,” the Noa, which calls at Maui to deliver product every other week.

The entire fuel distribution system is designed and operated to segregate jet fuel from other “clean” products like gasoline and diesel, and all clean products from black. Ethanol is transported via barge and tanker truck but using dedicated and segregated tanks and lines until the last possible moment, when it is blended into the gasoline flow stream via the tanker truck loading manifold as it is loaded for final delivery. Using one of the clean products barges as an example, two of the barge’s fourteen compartments are dedicated to jet fuel and the remainder are reserved for other products: generally two for gasoline, two for diesel, one for naphtha (used for electricity generation on neighbor islands), and one for ethanol. Compartment capacity varies due to the shape of the ship’s hull; the compartments hold approximately 2000-7000 barrels each. The offloading terminals at Kahului and Hilo have dedicated manifolds for jet fuel and black products each and mix and match the manifolds for the other clean products. The lines on the barge maintain segregation between jet, clean, and black products, but can be compromised by operator error or occasionally by design if there’s a strong need to use one of the dedicated jet compartments to transport another product type. Tanker trucks have

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38 Interview with Tesoro Honolulu terminal facility manager and operating staff, July 2011.
39 Interview with Hawaiian Electric Industries Inc Fuels Operations Manager, Sep 2012.
40 Interview and site visit with Chevron Honolulu terminal operators, July 2011.
41 Interview and site visit with Tesoro Honolulu terminal operators, July 2011
two to six internal compartments, with the most common configuration being four compartments. Tanker trucks generally follow the same protocol as barges when it comes to segregating or mixing the various products.

The barges generally leave Oahu full and come back empty except for “transmix” fuel, which is the result of using a clean fuel to flush tanks or separate slugs of fuel in pipelines. Transmix is offloaded from the barge and held in a tank at the Honolulu harbor terminal until it can be trucked back to the refinery for re-refining.


Options for liquid biofuel feedstock transport

For a liquid biofuel feedstock produced on the neighbor islands and shipped to Oahu for refining, it would be possible to start shipping initial volumes with isotainers via the cargo barges. At higher volume levels, it may be possible to transport liquid feedstock to Oahu in the otherwise empty compartments of the fuel barges returning to Oahu from the neighbor islands. Pyrolysis oil and vegetable oil feedstock could be transported via the “black products” compartments and alcohol feedstock via the ethanol compartments. The two options – Isotainer and barge – are discussed in more detail below, along with material compatibility and safety items to consider.

For this case study, the scenario is narrowed to just pyrolysis oil. It was assumed that the bagasse would be liquefied to pyrolysis oil using a process roughly similar to that being offered by the UOP-Ensyn RTP™ process, which has previously been studied on bagasse at reported yield rates of 75 to 81 weight percent. An average conversion rate of 78% was used for this study, therefore the 300,000 ton supply of bagasse would be dried to 10% moisture and then pyrolyzed to yield 130,000 gallons of pyrolysis oil.

Materials Handling Considerations for Pyrolysis Oil

Transportation and handling of pyrolysis oil are covered by an industry standard, ASTM D7544. Caution is urged due to both acid content and a risk of static electricity generation and dissipation. Pyrolysis oil is acidic, with a pH <2, has a moderate density at 1.195 grams per cubic centimeter, and is stable at the ambient temperatures experienced in Hawaii.

Option 3: Isotainer shipping of pyrolysis oil

If isotainers were used exclusively to transport all the pyrolysis oil, it would be transported from Maui to Oahu in 26.4 tons per isotainer, for a range of 4400 to 4950 trips per year. The regulated inter-island fare for 20-foot containers is exactly half of the fare for 40-foot open-top containers discussed above, a $587.50 shipping charge from Kahului Harbor, Maui to Honolulu Harbor, Oahu and a $53.50 empty container return fee. To estimate the incremental capital cost for the isotainers, it was estimated that the isotainers could be “turned” in one week, i.e. loaded, shipped, unloaded, and returned within seven calendar days, leading to a requirement for 90-100 isotainers to be in service in any given week.

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Assuming 100% availability, a purchase price midway between the low and high points quoted above, a weighted average cost of capital of 8% per year, and an amortization period of five years, the incremental capital cost for the isotainers came to $6.21 per ton. Adding the incremental isotainer capital cost to the per-unit shipping cost netted a transportation cost of $30.54 per ton of pyrolysis oil and an aggregate annual shipping cost of $4 million.

Isotainers are most commonly available in 20-foot container equivalent sizes, and are designed to carry hazardous chemicals. There are 20 and 40-foot isotainers advertised for sale from several Asian suppliers on Alibaba.com at prices ranging from $8,000 to $60,000 each, with volume capacities that range from 5,300 to 6,600 gallons and payload capacity of 3.7 to 30 tons. Isotainers tend to be specially designed for specific cargo types, and designs can vary depending on the pressure, density, and cryogenics needed for shipping, so weight and volume capacity can vary widely.

Capacity is constrained on the upper end by road weight limits, as is the case for the ISO open-top containers discussed above. One California-based shipper stated that 20-foot isotainers are used in the U.S. for road transport and 40-foot containers for rail, in order to not exceed the gross vehicle weight limit for public roads.

Due to the acidity of pyrolysis oil, the isotainer tank would have to be stainless steel or polymer but not pressurized, heated, or cryogenic. Sample isotainers designed to carry sulfuric acids were used for this study. A 20-foot container has roughly 20 cubic meters of volume capacity and 29.4 short tons of payload weight capability, while a 40-foot isotainer designed for use on public roads has twice the volume capacity but a reduced payload weight capability of 25.4 short tons. A 20-foot isotainer could carry more oil per shipment than a 40-foot container (26.4 versus 25.4 tons) due to the density of pyrolysis oil, so 20-foot isotainers were used as the basis for the cost calculations in this study.

**Option 4: Fuel barge shipping of liquid feedstock**

Assuming the entire average 60,000 barrel capacity of a large black products barge could be used to transport 130,000 tons of pyrolysis oil per year from Maui to Oahu, it would take 9 trips per year at an estimated cost of $23 per ton of pyrolysis oil or 15 cents per gallon of crude oil equivalent. Density of pyrolysis oil does not appear to constrain the amount of feedstock that can be carried per trip, unlike the volume constraints that had to be applied to the bulk solids options for bagasse.

**Materiel handling considerations fuel barge transport of liquid feedstock**

All of the lines used to load petroleum products onto barges on Oahu and offload those products to terminals on the neighbor islands are bi-directional, however each terminal’s ability to pump to the barge differs. For the purpose of this case study, it is assumed that making the pumping capacity at Kahului Harbor bidirectional would be a relatively simple one-time cost, especially when compared to the need to expand the harbor’s fuel facilities in general, and could be built into expansion plans.

---

44 Various supplier advertisements on www.alibaba.com
45 Interview with sales representative at KD MES Inc (www.kdmes.com), an advertiser on Alibaba.com
On arrival at Oahu, the pyrolysis oil could theoretically be pumped from the barge into a holding tank via the black products terminal manifolds at either Honolulu or Kalaeloa harbor. In addition to those facilities, the mooring points that the two refineries use to offload petroleum crude oil can also be bidirectional and are occasionally used to feed small amounts of refined fuel out to the delivering tanker, however the capacity of this line is so large that the relatively small initial shipments of green crude would be “lost” in the pipeline from the mooring to the tank farm. While such dilution would allow biocrude to displace petroleum crude for the purposes of meeting Hawaii’s state clean energy goals and make incremental refining and downstream distribution costs negligible, any quality control tracking criteria would not be workable.\(^{46}\) It would also prevent any resulting refined fuel from meeting a specific blending target like the 50% biofuel/50% petroleum fuel blend desired by the U.S. Navy.

**Regulatory considerations for liquid feedstock**

While the facilities discussed above are capable of physically transporting pyrolysis oil from island to island, material transport regulations have not yet been updated to consider the various types of biofuels and biofuel feedstock. By default they must still be treated as a “chemical,” which triggers special requirements when transporting via ocean barge or vessel.\(^{47}\) (Note: Transport via isotainer is a currently approved method for chemicals and thereby for biofuel feedstock; the gap in regulation is for transportation via bulk liquid vessel.)

**Port capacity concerns for liquid feedstock**

The simple analysis in this case study indicates a relatively modest 5-6% increase over current port capacity is needed to add backhaul loads of liquid feedstock from neighbor islands to Oahu.

More detailed analysis of demand volume per week, load port location, delivery port location, and storage capacity at both ports needs to be done in order to determine feasibility within current port capacity. As with the bulk solid shipping options, port facility capacity is tight and adjustments to schedules and implementation of port expansion plans would be needed. For Oahu ports, some of the inter-island fuel barges dock at Barbers Point Kalaeloa Harbor and the remainder dock at Honolulu Harbor. The harbor capacity at Barber’s Point Kalaeloa Harbor is very tight and crowded because the ports at the neighbor islands have limited capacity, so the ships tend to idle in Barber’s point to minimize costly steaming time en route to the other islands and having to wait for a berth there upon arrival. On Maui, the Kahului port capacity was highly stressed when the cruise ships were docking regularly during the pre-2008 tourism/economic boom, but there is more slack capacity now. The fuel pier at Kahului is impacted by the tide so deliveries need to be scheduled carefully. Any loading of pyrolysis oil from Maui would also be constrained by the tide if done in the near term.\(^{48}\) On the positive side, the State of Hawaii Department of Transportation has formally studied several options to expand fuel loading/unloading at all harbors to include Kahului and Kalaeloa; several of the options considered take a robust biofuel inter-island transport scenario into consideration.\(^{49}\) A sample expansion option from the study for Kahului Harbor is depicted below.

\(^{46}\) Interviews and site visits with plant manager and staff of the two Hawaii refineries, July 2011.

\(^{47}\) Interview with a Hawaii petroleum product distribution manager, June 2012.

\(^{48}\) Interview with a Hawaii petroleum product distribution manager, June 2012.

One fuel facility expansion option for Kahului Harbor, Maui from the Hawaii state master plan.\(^5^0\)

**Cost estimation method for liquid feedstock transport via fuel barge**

To estimate the cost for liquid feedstock to be transported from neighbor islands to Oahu in otherwise empty black products compartments, an assumption was made that the marginal cost would be the same on a per-gallon basis regardless of direction or fuel type. While the return legs of the empty barge compartments are already “paid for” by the outgoing petroleum fuel shipments, the additional incremental costs of pier time, labor, pipeline and manifold scheduling, and terminal tank availability to load and unload new feedstock volumes at either end would close some of that credit.

Since transporting pyrolysis oil via fuel barge from Maui to Oahu is not currently done, a quote could not be obtained. Instead, the analyses below were used to approximate the current inter-island transportation cost for refined petroleum products as 6 to 15 cents per gallon.

A comparison of retail gasoline prices between Oahu and the neighbor islands as reported on GasBuddy.com™ over a three year period (shown below) showed that retail prices across the state are 10-15 cents higher than prices on Oahu.

---

Retail gasoline prices reported on the American Automobile Association’s (AAA) Tripadvisor™ website during the month of June 2012 alone showed an 8 to 10 cent premium on Maui over Oahu. Like the GasBuddy.com comparison above, retail prices include the entire logistical chain from the refinery to the gas station pump, and so these price premiums were discounted slightly by two cents per gallon to remove the ground transportation costs.

A detailed study for the State of Alaska’s legislature on maritime fuel distribution costs in 2010 determined that the difference between retail pump prices and wholesale refinery prices throughout its state were generally a reflection of marginal cost, consisting of the functions of barge and tug capacity, pier time, steaming distance and time from point to point, scale volume of delivered fuel, storage required at either end, and cost of delivery via pipeline or truck to the final destination. The highest marginal costs in Alaska for maritime delivery were $2.40 per gallon and were for relatively small volumes (275,000 gallons) at several weeks’ steaming distance from the supply point. The lowest marginal costs and operational considerations were $0.06 per gallon for delivery points within one days’ steaming distance and much larger barge capacities (2.5 to 3.5 million gallons). 51 As stated above, Maui is a one-day steaming distance from Oahu and is currently served by large barges with 1.6 to 3.3 million gallons of capacity, making the lowest Alaska marginal costs relatively similar to Maui-to-Oahu marginal costs.

For this scenario, a transportation cost of 12 cents per gallon of pyrolysis oil was used, representing the midpoint between 6 cents per gallon as the low case and 17 cents as the high case. Seventeen cents per gallon is the sum of 12 cents per gallon operating cost plus an uneducated guess of a five cent per gallon “handicap” to cover capital improvements to the barge such as polymer liners for the compartments and lines that would carry pyrolysis oil. Twelve (12) cents per gallon transportation cost translates into a 15-cent cost of crude oil equivalent per gallon.

Appendices

Sample specification sheets

1. Container barge
2. Open-top container
3. Isotainer
4. Fuel barge

Sample Material Safety Data Sheets (MSDS)

5. Bagasse
6. Banagrass (draft)
7. Pyrolysis oil from biomass
8. Vegetable oil
9. Ethanol
Barge **HO`OMAKA HOU**

*“New Beginning”*

<table>
<thead>
<tr>
<th>Official Number</th>
<th>1205188</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dimensions (LxBxD)</td>
<td>340.0'-00&quot;x 90'-00&quot;x 20'-00&quot;</td>
</tr>
<tr>
<td>Built</td>
<td>2007</td>
</tr>
<tr>
<td>Builder</td>
<td>US Barge LLC.</td>
</tr>
<tr>
<td>Gross Tons</td>
<td>4,511 GT/1353 Net</td>
</tr>
<tr>
<td>Deep Draft</td>
<td>15'-4&quot;</td>
</tr>
<tr>
<td>Light Draft</td>
<td>4'-06&quot;</td>
</tr>
<tr>
<td>Type</td>
<td>Flat Deck Barge</td>
</tr>
<tr>
<td>Capacity</td>
<td>8581 Long Ton Capacity</td>
</tr>
<tr>
<td>Open Cargo Area</td>
<td>26,900 sq ft total</td>
</tr>
<tr>
<td>Under Cover</td>
<td>None</td>
</tr>
<tr>
<td>Remarks</td>
<td>Cargo Dead Weight - 11,700 Long Tons, 616 TEU Capacity</td>
</tr>
</tbody>
</table>

“Your Neighbor Island Partner”
Open Top

Open tops do not have a solid roof; instead they are covered with a removable, weatherproof tarpaulin that can be secured with ropes. The metal beam above the door can be opened to the right or left and can also be dismantled from the container. Lashing rings at the inside base of the container are used to secure and prevent shifting of cargo during movement. This type of container is suitable for over-height and/or lengthy cargo.

**OPEN TOP CONTAINER - 20 FEET**

<table>
<thead>
<tr>
<th>Specifications for 8'6&quot; / 24,000kg</th>
<th>Specifications for 8'6&quot; / 30,480kg</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Inside Measurement</strong></td>
<td></td>
</tr>
<tr>
<td>Length (mm)</td>
<td>5,888</td>
</tr>
<tr>
<td>Width (mm)</td>
<td>2,350</td>
</tr>
<tr>
<td>Height (mm)</td>
<td>2,354</td>
</tr>
<tr>
<td><strong>Door Opening</strong></td>
<td></td>
</tr>
<tr>
<td>Width (mm)</td>
<td>2,341</td>
</tr>
<tr>
<td>Height (mm)</td>
<td>2,244</td>
</tr>
<tr>
<td><strong>Roof Header</strong></td>
<td></td>
</tr>
<tr>
<td>Width (mm)</td>
<td>1,862</td>
</tr>
<tr>
<td><strong>Roof Opening</strong></td>
<td></td>
</tr>
<tr>
<td>Length (mm)</td>
<td>5,757</td>
</tr>
<tr>
<td>Width (mm)</td>
<td>2,230</td>
</tr>
<tr>
<td><strong>Load Capacity</strong></td>
<td></td>
</tr>
<tr>
<td>(m³)</td>
<td>32.6</td>
</tr>
<tr>
<td><strong>Container Weight</strong></td>
<td></td>
</tr>
<tr>
<td>(kg)</td>
<td>2,320</td>
</tr>
<tr>
<td><strong>Max. Load Weight</strong></td>
<td></td>
</tr>
<tr>
<td>(kg)</td>
<td>21,680</td>
</tr>
</tbody>
</table>

**OPEN TOP CONTAINER - 40 FEET**

<table>
<thead>
<tr>
<th>Specifications for 8'6&quot; / 30,480kg</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Inside Measurement</strong></td>
</tr>
<tr>
<td>Length (mm)</td>
</tr>
<tr>
<td>Width (mm)</td>
</tr>
<tr>
<td>Height (mm)</td>
</tr>
<tr>
<td><strong>Door Opening</strong></td>
</tr>
<tr>
<td>Width (mm)</td>
</tr>
<tr>
<td>Height (mm)</td>
</tr>
<tr>
<td><strong>Roof Header</strong></td>
</tr>
<tr>
<td>Width (mm)</td>
</tr>
<tr>
<td><strong>Roof Opening</strong></td>
</tr>
<tr>
<td>Length (mm)</td>
</tr>
<tr>
<td>Width (mm)</td>
</tr>
<tr>
<td><strong>Load Capacity</strong></td>
</tr>
<tr>
<td>(m³)</td>
</tr>
<tr>
<td><strong>Container Weight</strong></td>
</tr>
<tr>
<td>(kg)</td>
</tr>
<tr>
<td><strong>Max. Load Weight</strong></td>
</tr>
<tr>
<td>(kg)</td>
</tr>
</tbody>
</table>
ISO Container Tank
General Specification Sheet

Capacity: 17,500 – 26,000 liters / 5,300 – 6,600 gallons

Type: IMO-1, IM-101, DOT 407-412 Hazardous materials tank
Tare Weights: Up to 7,400 lbs / 3,000 – 3,350 kg

Construction: 316 Stainless steel barrel
Thickness: Barrell @4.5MM, teak heads @5.5MM
Insulation Urethane foam 2”, Rock Wool 2”

Working Pressure: 3 bar- 43.5 psi 4 bar-58 psi

Maximum Loading Temp 240o F – 300o F

Dimensions: Outer - 20’ x 8’ x 8’-6” Interior 18’-10” x 7’-8” x 7’-9”

Other: Bottom outlet equipped with 3” male Kamloc
Tanks meet DOT, FRA, AAR, and CTS specifications
**Globalsecurity.org Specification Sheet**

**Military YON - Liquid Cargo Barge**

YON is a non-self-propelled liquid cargo barge with nominal dimensions of 165 foot by 40 foot and designed to carry liquid petroleum products for refueling ships. This class is designed as an all purpose liquid cargo carrier capable of handling a clean product fuel (AVCAS, Jet fuel, Diesel oil or Navy special fuel oil). Thus the design incorporates treating coils needed to raise the viscosity of NSFO to an acceptable level for pumping as well as a chemical treated cargo tank designed to insure minimum contamination of fuel from foreign particles. The eight cargo tanks (four port and four starboard) have a total capacity of 8400 barrels.

A new series of double hull YONs are being built starting with YON 318 in 1994.

Specifications

This craft is built to Specifications for Building Fuel Oil Barge YON-245 Class (258-262 series) (Non Self-propelled) dated 4 Feb 1964.

### PRINCIPAL CHARACTERISTICS

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Length, Overall</td>
<td>165'</td>
</tr>
<tr>
<td>Beam, molded</td>
<td>40'</td>
</tr>
<tr>
<td>Draft, light</td>
<td>1'-10&quot;</td>
</tr>
<tr>
<td>Draft, full load (fuel oil)</td>
<td>8'-8&quot;</td>
</tr>
<tr>
<td>Draft, full load (diesel oil)</td>
<td>7'-11&quot;</td>
</tr>
<tr>
<td>Depth (molded) to deck at side</td>
<td>10'-6&quot;</td>
</tr>
<tr>
<td>Depth (molded) to deck centerline</td>
<td>11'-3&quot;</td>
</tr>
<tr>
<td>Displacement, full load (fuel oil)</td>
<td>1445 tons</td>
</tr>
<tr>
<td>Displacement, full load (diesel oil)</td>
<td>1300 tons</td>
</tr>
<tr>
<td>Displacement, light</td>
<td>250 tons</td>
</tr>
</tbody>
</table>

### PRINCIPAL MACHINERY and EQUIPMENT

One liquid cargo pump, diesel driven

- **Towing** bridle
- Capstan
- Anchor
- Anchor chain
- Mooring/towing lines

### HULL

Craft is built on a longitudinal system of framing with frames spaced two feet on centers. Structure contains five oil tight transverse bulkheads and one centerline oil tight bulkhead which provide the boundaries for the eight cargo tanks. Each rake end contains two additional transverse watertight bulkheads. The centerline structure in rake ends contains lightening holes.

Plating sizes follow: main deck - 15.3#; side - 15.3#; bottom - 15.3#; oil tight transverse bulkhead - 10.2#; watertight transverse bulkhead - 8.92#; oil tight centerline bulkhead - 10.2#; deckhouse is 7.63#. Four longitudinal truss sections are built into each rake end compartment to strengthen barge for open sea towing for purposes of reassignment.

A deckhouse for housing a diesel driven cargo pump is built on aft end of craft.
1. IDENTIFICATION OF THE MATERIAL AND SUPPLIER

<table>
<thead>
<tr>
<th>Supplier Name</th>
<th>SUCROGEN LIMITED</th>
</tr>
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<tbody>
<tr>
<td>Address</td>
<td>Level 8 100 Pacific Highway, North Sydney, NSW, AUSTRALIA, 2060</td>
</tr>
<tr>
<td>Telephone</td>
<td>+61 1300 997 624</td>
</tr>
<tr>
<td>Fax</td>
<td>+61 2 8362 9026</td>
</tr>
<tr>
<td>Emergency</td>
<td>000</td>
</tr>
<tr>
<td>Synonym(s)</td>
<td>SUCROGEN BAGASSE</td>
</tr>
</tbody>
</table>

Use(s) COMPOST • FEED MATERIAL • FUEL
SDS Date 29 Jun 2011

2. HAZARDS IDENTIFICATION

NOT CLASSIFIED AS HAZARDOUS ACCORDING TO SAFE WORK AUSTRALIA CRITERIA

NOT CLASSIFIED AS A DANGEROUS GOOD BY THE CRITERIA OF THE ADG CODE

<table>
<thead>
<tr>
<th>UN No.</th>
<th>None Allocated</th>
<th>DG Class</th>
<th>None Allocated</th>
<th>Subsidiary Risk(s)</th>
<th>None Allocated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Packing Group</td>
<td>None Allocated</td>
<td>Hazchem Code</td>
<td>None Allocated</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

3. COMPOSITION/ INFORMATION ON INGREDIENTS

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Formula</th>
<th>CAS No.</th>
<th>Content</th>
</tr>
</thead>
<tbody>
<tr>
<td>CELLULOSE</td>
<td>Not Available</td>
<td>Not Available</td>
<td>40-50%</td>
</tr>
<tr>
<td>SUGAR</td>
<td>Not Available</td>
<td>Not Available</td>
<td>2-4%</td>
</tr>
<tr>
<td>TRACE ELEMENTS</td>
<td>Not Available</td>
<td>Not Available</td>
<td>Not Available</td>
</tr>
<tr>
<td>WATER</td>
<td>H2O</td>
<td>7732-18-5</td>
<td>Not Available</td>
</tr>
</tbody>
</table>

4. FIRST AID MEASURES

**Eye**
If in eyes, hold eyelids apart and flush continuously with running water. Continue flushing until advised to stop by a Poisons Information Centre, a doctor, or for at least 15 minutes.

**Inhalation**
If inhaled, remove from contaminated area. Apply artificial respiration if not breathing.

**Skin**
Exposure is considered unlikely. Skin irritation is not anticipated.

**Ingestion**
For advice, contact a Poison Information Centre on 13 11 26 (Australia Wide) or a doctor (at once). Due to product form and application, ingestion is considered unlikely.

**Advice to Doctor**
Treat symptomatically.

5. FIRE FIGHTING MEASURES

**Flammability**
Combustible. May evolve toxic gases (carbon oxides, hydrocarbons) when heated to decomposition. Finely divided dust may form explosive mixtures with air.

**Fire and Explosion**
Evacuate area and contact emergency services. Toxic gases may be evolved in a fire situation. Remain upwind and notify those downwind of hazard. Wear full protective equipment including Self Contained Breathing Apparatus (SCBA) when combating fire. Use waterfog to cool intact containers and nearby storage areas.

**Extinguishing**
Dry agent, carbon dioxide, foam or water fog. Prevent contamination of drains or waterways.
6. ACCIDENTAL RELEASE MEASURES

Spillage
If spilt (bulk), use personal protective equipment. Moisten with water to prevent a dust hazard and place in sealable containers for disposal.

7. STORAGE AND HANDLING

Storage
Store in a cool, dry, well ventilated area, removed from alkalis, heat or ignition sources and foodstuffs. Ensure containers are adequately labelled, protected from physical damage and sealed when not in use. Check regularly for damage to containers.

Handling
Before use carefully read the product label. Use of safe work practices are recommended to avoid eye or skin contact and inhalation. Observe good personal hygiene, including washing hands before eating. Prohibit eating, drinking and smoking in contaminated areas.

8. EXPOSURE CONTROLS/ PERSONAL PROTECTION

Exposure Stds
No exposure standard(s) allocated.

Biological Limits
No biological limit allocated.

Engineering Controls
Avoid inhalation. Use in well ventilated areas. Maintain dust levels below the recommended exposure standard.

PPE
Wear PVC or rubber gloves. When using large quantities or where heavy contamination is likely, wear: dust-proof goggles and coveralls. Where an inhalation risk exists, wear: a Class P1 (Particulate) respirator.

9. PHYSICAL AND CHEMICAL PROPERTIES

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Appearance</td>
<td>STRAW LIKE SOLID</td>
</tr>
<tr>
<td>Odour</td>
<td>ODOURLESS WHEN FRESH</td>
</tr>
<tr>
<td>pH</td>
<td>NOT AVAILABLE</td>
</tr>
<tr>
<td>Vapour Pressure</td>
<td>NOT AVAILABLE</td>
</tr>
<tr>
<td>Vapour Density</td>
<td>NOT AVAILABLE</td>
</tr>
<tr>
<td>Boiling Point</td>
<td>NOT AVAILABLE</td>
</tr>
<tr>
<td>Melting Point</td>
<td>NOT AVAILABLE</td>
</tr>
<tr>
<td>Evaporation Rate</td>
<td>NOT AVAILABLE</td>
</tr>
<tr>
<td>Autoignition Temperature</td>
<td>NOT AVAILABLE</td>
</tr>
<tr>
<td>Partition Coefficient</td>
<td>NOT AVAILABLE</td>
</tr>
</tbody>
</table>

Solubility (water)       | INSOULABLE
Specific Gravity        | NOT AVAILABLE
% Volatiles             | NOT AVAILABLE
Flammability             | COMBUSTIBLE
Flash Point              | NOT AVAILABLE
Upper Explosion Limit    | NOT AVAILABLE
Lower Explosion Limit    | NOT AVAILABLE
Decomposition Temperature| NOT AVAILABLE
Viscosity                | NOT AVAILABLE

10. STABILITY AND REACTIVITY

Chemical Stability
Stable under recommended conditions of storage.

Conditions to Avoid
Avoid heat, sparks, open flames and other ignition sources.

Material to Avoid
Incompatible with oxidising agents (e.g. hypochlorites).

Hazardous Decomposition Products
May evolve toxic gases (carbon oxides, hydrocarbons) when heated to decomposition.

Hazardous Reactions
Polymerization is not expected to occur.
BAGASSE

11. TOXICOLOGICAL INFORMATION

<table>
<thead>
<tr>
<th>Health Hazard Summary</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low toxicity. Under normal conditions of use, adverse health effects are not anticipated. However, if dust is generated, over exposure may result in irritation of the eyes, nose, throat and skin.</td>
<td></td>
</tr>
<tr>
<td>Eye</td>
<td>Low irritant. Contact with dust may result in slight eye irritation.</td>
</tr>
<tr>
<td>Inhalation</td>
<td>Low irritant. Over exposure to dust may result in irritation of the nose and throat, with coughing. If bagasse is stored in damp conditions, a mould (Thermoactinomycetes sacchari) may grow, it is this mould that can give rise to bagassosis (an influenza-like illness). Symptoms of bagassosis include dry cough, shortness of breath and an inflammation of the lungs.</td>
</tr>
<tr>
<td>Skin</td>
<td>Low irritant. Prolonged or repeated exposure to dust may result in irritation and dermatitis.</td>
</tr>
<tr>
<td>Ingestion</td>
<td>Ingestion is considered unlikely due to product form.</td>
</tr>
<tr>
<td>Toxicity Data</td>
<td>No LD50 data available for this product.</td>
</tr>
</tbody>
</table>

12. ECOLOGICAL INFORMATION

<table>
<thead>
<tr>
<th>Environment</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Limited ecotoxicity data was available for this product at the time this report was prepared. Ensure appropriate measures are taken to prevent this product from entering the environment.</td>
<td></td>
</tr>
</tbody>
</table>

13. DISPOSAL CONSIDERATIONS

<table>
<thead>
<tr>
<th>Waste Disposal</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reuse where possible. No special precautions are required for this product.</td>
<td></td>
</tr>
<tr>
<td>Legislation</td>
<td>Dispose of in accordance with relevant local legislation.</td>
</tr>
</tbody>
</table>

14. TRANSPORT INFORMATION

**NOT CLASSIFIED AS A DANGEROUS GOOD BY THE CRITERIA OF THE ADG CODE**

<table>
<thead>
<tr>
<th>Shipping Name</th>
<th>None Allocated</th>
</tr>
</thead>
<tbody>
<tr>
<td>UN No.</td>
<td>None Allocated</td>
</tr>
<tr>
<td>Packing Group</td>
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<tr>
<td>DG Class</td>
<td>None Allocated</td>
</tr>
<tr>
<td>Hazchem Code</td>
<td>None Allocated</td>
</tr>
<tr>
<td>Subsidiary Risk(s)</td>
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</tbody>
</table>

15. REGULATORY INFORMATION

<table>
<thead>
<tr>
<th>Poison Schedule</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A poison schedule number has not been allocated to this product using the criteria in the Standard for the Uniform Scheduling of Drugs and Poisons (SUSDP).</td>
<td></td>
</tr>
<tr>
<td>AICS</td>
<td>All chemicals listed on the Australian Inventory of Chemical Substances (AICS).</td>
</tr>
</tbody>
</table>

16. OTHER INFORMATION

<table>
<thead>
<tr>
<th>Additional Information</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>The trace elements in this product include boron, calcium, chloride, copper, iron, magnesium, manganese, phosphorus, potassium, sodium and sulphur.</td>
<td></td>
</tr>
<tr>
<td>COMBUSTIBLE - EXPLOSIVE CARBONACEOUS DUST: Carbonaceous/organic dusts have the potential, with dispersion, to present an explosion hazard if an ignition source exists. All equipment used to handle, transfer or store this product MUST BE cleaned thoroughly prior to cutting, welding, drilling or exposure to any other form of heat or ignition sources. If bulk stored, containers should be ventilated on a routine basis to avoid vapour accumulation (where applicable, eg for flocculants).</td>
<td></td>
</tr>
<tr>
<td>RESPIRATORS: In general the use of respirators should be limited and engineering controls employed to avoid exposure. If respiratory equipment must be worn ensure correct respirator selection and training is undertaken. Remember that some respirators may be extremely uncomfortable when used for long periods. The use of air powered or air supplied respirators should be considered where prolonged or repeated use is necessary.</td>
<td></td>
</tr>
<tr>
<td>EXPOSURE STANDARDS - TIME WEIGHTED AVERAGE (TWA) or WES (WORKPLACE EXPOSURE STANDARD) (NZ): Exposure standards are established on the premise of an 8 hour work period of normal intensity, under normal climatic conditions and where a 16 hour break between shifts exists to enable the body to eliminate absorbed contaminants. In the following circumstances, exposure standards must be reduced: strenuous work conditions; hot, humid climates; high altitude conditions; extended shifts (which increase the exposure period and shorten the period of recuperation).</td>
<td></td>
</tr>
<tr>
<td>ABBREVIATIONS:</td>
<td></td>
</tr>
<tr>
<td>ACGIH - American Conference of Industrial Hygienists.</td>
<td></td>
</tr>
<tr>
<td>ADG - Australian Dangerous Goods.</td>
<td></td>
</tr>
<tr>
<td>BEI - Biological Exposure Indice(s).</td>
<td></td>
</tr>
</tbody>
</table>
HEALTH EFFECTS FROM EXPOSURE:
It should be noted that the effects from exposure to this product will depend on several factors including: frequency and duration of use; quantity used; effectiveness of control measures; protective equipment used and method of application. Given that it is impractical to prepare a ChemAlert report which would encompass all possible scenarios, it is anticipated that users will assess the risks and apply control methods where appropriate.

PERSONAL PROTECTIVE EQUIPMENT GUIDELINES:
The recommendation for protective equipment contained within this ChemAlert report is provided as a guide only. Factors such as method of application, working environment, quantity used, product concentration and the availability of engineering controls should be considered before final selection of personal protective equipment is made.

Report Status
This document has been compiled by RMT on behalf of the manufacturer of the product and serves as the manufacturer's Safety Data Sheet ('SDS').

It is based on information concerning the product which has been provided to RMT by the manufacturer or obtained from third party sources and is believed to represent the current state of knowledge as to the appropriate safety and handling precautions for the product at the time of issue. Further clarification regarding any aspect of the product should be obtained directly from the manufacturer.

While RMT has taken all due care to include accurate and up-to-date information in this SDS, it does not provide any warranty as to accuracy or completeness. As far as lawfully possible, RMT accepts no liability for any loss, injury or damage (including consequential loss) which may be suffered or incurred by any person as a consequence of their reliance on the information contained in this SDS.

Prepared By
Risk Management Technologies
5 Ventnor Ave, West Perth
Western Australia 6005
Phone: +61 8 9322 1711
Fax: +61 8 9322 1794
Email: info@rmt.com.au
Web: www.rmt.com.au

SDS Date 29 Jun 2011
End of Report
SECTION 1: PRODUCT AND COMPANY IDENTIFICATION

PRODUCT NAME: Chopped Banagrass
SYNONYMS: N/A
PRODUCT CODES: N/A
MANUFACTURER: University of Hawaii
DIVISION: Hawaii Natural Energy Institute
ADDRESS: 1680 East-West Rd., POST 109, Honolulu, HI 96822
EMERGENCY PHONE: 808-956-2346
CHEMTREC PHONE: N/A
OTHER CALLS: N/A
FAX PHONE: 808-956-2336
CHEMICAL NAME: N/A
CHEMICAL FAMILY: N/A
CHEMICAL FORMULA: N/A
PRODUCT USE: Fuel
PREPARED BY: Scott Turn

SECTION 1 NOTES:

SECTION 2: COMPOSITION/INFORMATION ON INGREDIENTS

INGREDIENT: Banagrass

<table>
<thead>
<tr>
<th>CAS NO.</th>
<th>% WT</th>
<th>% VOL</th>
</tr>
</thead>
<tbody>
<tr>
<td>N/A</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

SECTION 2 NOTES: Materials is chopped banagrass free of pesticides or herbicides containing roughly 10% free moisture.

SECTION 3: HAZARDS IDENTIFICATION

EMERGENCY OVERVIEW: Product is chopped banagrass. Product is finely divided and may release dust if agitated, poured, or otherwise disturbed.

ROUTES OF ENTRY: Inhalation

POTENTIAL HEALTH EFFECTS

EYES: Mild Irritant
SKIN: Mild Irritant
INGESTION: Mild Irritant
INHALATION: Mild Irritant

ACUTE HEALTH HAZARDS: Should not be handled by asthma suffers or those with respiratory illness.

CHRONIC HEALTH HAZARDS: Should not be handled by asthma suffers or those with respiratory illness.

MEDICAL CONDITIONS GENERALLY AGGRAVATED BY EXPOSURE: Asthma or chronic pulmonary obstructive disease.

CARCINOGENICITY: Noncarcinogenic

SECTION 3 NOTES:
SECTION 4: FIRST AID MEASURES

EYES: If irritation occurs, flush with water for 10 minutes. If irritation persists, seek medical attention.

SKIN: If irritation occurs, flush with water for 10 minutes. If irritation persists, seek medical attention.

INGESTION: Wash out of mouth with water. If irritation occurs, seek medical attention.

INHALATION: Remove from exposure by exiting the area where dust is present. If irritation persists, seek medical attention.

NOTES TO PHYSICIANS OR FIRST AID PROVIDERS:

SECTION 4 NOTES:

SECTION 5: FIRE-FIGHTING MEASURES

FLAMMABLE LIMITS IN AIR, UPPER: N/A
(% BY VOLUME) LOWER: N/A

FLASH POINT:
F: N/A
C: N/A

METHOD USED:

AUTOIGNITION TEMPERATURE:
F: N/A
C: N/A

NFPA HAZARD CLASSIFICATION
HEALTH: 1 FLAMMABILITY: 1 REACTIVITY: 0 OTHER: 0

HMIS HAZARD CLASSIFICATION
HEALTH: 1 FLAMMABILITY: 1 REACTIVITY: 0 PROTECTION: N/A

EXTINGUISHING MEDIA: Water, dry chemical, or foam

SPECIAL FIRE FIGHTING PROCEDURES: Fire fighter should wear self-contained breathing apparatus and impervious protective clothing. Fire fighters should avoid inhaling any combustion products.

UNUSUAL FIRE AND EXPLOSION HAZARDS: An accumulation of dust could present a fire hazard. Product will ignite upon exposure to an ignition source.

HAZARDOUS DECOMPOSITION PRODUCTS:

SECTION 5 NOTES:

SECTION 6: ACCIDENTAL RELEASE MEASURES

ACCIDENTAL RELEASE MEASURES: Contain by any means necessary. Vacuum or sweep up material as necessary. Keep unnecessary people out of release area. Remove sources of ignition during clean up.

SECTION 6 NOTES:

SECTION 7: HANDLING AND STORAGE

HANDLING AND STORAGE: Place in sealed container or impermeable bag. Store in cool, dry place away from moisture, excessive heat, and sources of ignition.
MATERIAL SAFETY DATA SHEET

NAME OF PRODUCT: Chopped Banagrass

OTHER PRECAUTIONS:

SECTION 7 NOTES:

SECTION 8: EXPOSURE CONTROLS/PERSONAL PROTECTION

ENGINEERING CONTROLS: Use as necessary to avoid contact with sources of ignition

VENTILATION: Transfer product in well ventilated area.

RESPIRATORY PROTECTION: When necessary, appropriate NIOSH/MSHA approved respiratory protection should be used.

EYE PROTECTION: Wear safety glasses, goggles, or other appropriate eye/face protection.

SKIN PROTECTION: Normal work clothing and gloves are recommended.

OTHER PROTECTIVE CLOTHING OR EQUIPMENT: N/A

WORK HYGIENIC PRACTICES: Sweep or vacuum area to remove dust. Wet if necessary for dust control.

EXPOSURE GUIDELINES: Keep dust formation to a minimum. See General Product Information.

SECTION 8 NOTES:

SECTION 9: PHYSICAL AND CHEMICAL PROPERTIES

APPEARANCE: Chopped, finely divided banagrass fibers.

ODOR: Dry banagrass

PHYSICAL STATE: Solid

pH AS SUPPLIED: N/A
pH (Other): N/A

BOILING POINT: N/A

MELTING POINT: N/A

FREEZING POINT: N/A

VAPOR PRESSURE (mmHg): N/A

VAPOR DENSITY (AIR = 1): N/A

SPECIFIC GRAVITY (H2O = 1): N/A

EVAPORATION RATE: N/A

SECTION 9: PHYSICAL AND CHEMICAL PROPERTIES (con't)

SOLUBILITY IN WATER: N/A

PERCENT SOLIDS BY WEIGHT: 90

PERCENT VOLATILE:

0% BY WT @ F: 68 F
C:

VOLATILE ORGANIC COMPOUNDS (VOC): N/A

WITH WATER: LBS/GAL
WITHOUT WATER: LBS/GAL
SECTION 10: STABILITY AND REACTIVITY

STABILITY: STABLE
CONDITIONS TO AVOID (STABILITY): Temperatures in excess of 300C (550F)
INCOMPATIBILITY (MATERIAL TO AVOID): N/A
HAZARDOUS DECOMPOSITION OR BY-PRODUCTS: N/A
HAZARDOUS POLYMERIZATION: Hazardous polymerization will not occur.
CONDITIONS TO AVOID (POLYMERIZATION):

SECTION 10 NOTES:

SECTION 11: TOXICOLOGICAL INFORMATION

TOXICOLOGICAL INFORMATION: No data available for this product.

SECTION 11 NOTES:

SECTION 12: ECOLOGICAL INFORMATION

ECOLOGICAL INFORMATION: No data available for this product.

SECTION 12 NOTES:

SECTION 13: DISPOSAL CONSIDERATIONS

WASTE DISPOSAL METHOD: Dispose of waste material in accordance with all Federal, State, or local environmental regulation.
RCRA HAZARD CLASS: N/A

SECTION 13 NOTES:

SECTION 14: TRANSPORT INFORMATION

U.S. DEPARTMENT OF TRANSPORTATION
PROPER SHIPPING NAME: Not regulated as a hazardous material
HAZARD CLASS: Not regulated as a hazardous material
ID NUMBER: Not regulated as a hazardous material
PACKING GROUP: Not regulated as a hazardous material
LABEL STATEMENT: Not regulated as a hazardous material

SECTION 14 NOTES:

SECTION 15: REGULATORY INFORMATION

U.S. FEDERAL REGULATIONS
TSCA (TOXIC SUBSTANCE CONTROL ACT): N/A
CERCLA (COMPREHENSIVE RESPONSE COMPENSATION, AND LIABILITY ACT): N/A
SARA TITLE III (SUPERFUND AMENDMENTS AND REALAUTHORIZATION ACT): N/A

311/312 HAZARD CATEGORIES: N/A

313 REPORTABLE INGREDIENTS: N/A

STATE REGULATIONS: Agricultural inspection departing or entering Hawaii

INTERNATIONAL REGULATIONS: N/A

SECTION 15 NOTES:

SECTION 16: OTHER INFORMATION

OTHER INFORMATION:

PREPARATION INFORMATION:

DISCLAIMER: As the conditions and methods of use are beyond our control, the University of Hawai and the Hawaii Natural Energy Institute and their employees do not assume any responsibility and expressly disclaim any liability for use of this material. Information contained herein is believed to be true and accurate, but all statements or suggestions are made without warranty, expressed or implied, regarding accuracy of the information, the hazards connected with the use of this material, or the results to be obtained thereof. Compliance with all federal, state, and local laws and regulations remains the responsibility of the user.
MATERIAL SAFETY DATA SHEET

1. CHEMICAL PRODUCT AND COMPANY INFORMATION

Product Name: RTP Green Fuel Intermediate and Final Products

Product Use: Chemical - Fuel (Experimental)

NOTE: This sample is for research and development purposes only. The handling and use of this material must be supervised by qualified individuals. The chemical, physical and toxicological properties of this material have not been fully investigated. Use due precaution in handling, storage and disposal.

UOP LLC
25 E. Algonquin Road
Des Plaines, IL 60017-5017
USA
Tel: +1-847-391-2000
Fax: +1-847-391-2953

UOP CH Sàrl
Z.A. La Pièce 16
1180 Rolle
Switzerland
Tel: +41-21-6953039
Fax: +41-21-6953189

UOP Ltd.
"Liongate", Ladymead
Guildford, Surrey GU1 1AT
UK
Tel: +44-1483-304-848
Fax: +44-1483-466-336

Emergency Assistance - 24 hour Emergency Telephone Numbers:
Medical (PROSAR) : 1-800-498-5701 or +1-651-523-0309
Transportation or other emergencies (CHEMTREC) : +1-703-527-3887

2. HAZARDS IDENTIFICATION

Emergency Overview:
The product is considered harmful via ingestion. Avoid breathing the product. Keep away from heat, sparks, and flame. The product is combustible and toxic vapors may be given off in a fire.

Form: Liquid
Color: Black

Potential Health Effects:

Primary Routes of Exposure: Contact with skin, eyes and inhalation of product vapor. Product ingestion is unlikely to occur if proper safety/hygiene procedures are followed.

Eye Contact: Repeated or prolonged exposure may cause eye irritation.

Skin Contact: Causes mild skin irritation.

Ingestion: May be harmful if swallowed.

Inhalation: Inhalation of product vapors or mist may cause irritation of the respiratory system.

Chronic Effects: None known.
Carcinogenicity Classification:

International Agency for Research on Cancer (IARC):
Neither the product nor the components are classified.

U.S. National Toxicology Program (NTP):
Neither the product nor the components are classified.

U.S. Occupational Safety and Health Administration (OSHA):
Neither the product nor the components are classified or regulated.

American Conference of Governmental Industrial Hygienists (ACGIH):
Neither the product nor the components are classified.

### 3. COMPOSITION/INFORMATION ON INGREDIENTS

<table>
<thead>
<tr>
<th>INGREDIENT</th>
<th>% WEIGHT</th>
<th>ACGIH TLV- TWA</th>
<th>OSHA PEL- TWA</th>
<th>UNITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pyroligenous acids</td>
<td>100</td>
<td>N.E.</td>
<td>N.E.</td>
<td>N.A.</td>
</tr>
<tr>
<td>8030-97-5</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Abbreviations:

- N.A. - Not Applicable
- N.E. - None Established
- RD - Respirable Dust
- R - Respirable Fraction
- I - Inhalable
- Fu - Fume
- FuD - Fume and Dust
- TD - Total Dust
- SC - Soluble Compounds
- IS - Insoluble
- STEL - Short Term Exposure Limit
- F - Respirable Fibers
4. FIRST AID MEASURES

Eye contact: Flush immediately with plenty of water, also under the eyelids, for at least 15 minutes. Consult a physician.

Skin contact: REMOVE FROM SKIN IMMEDIATELY. Take off all contaminated clothing immediately. Remove adhering matter immediately. Use waterless hand cleaner. Then wash with lots of water and soap. Consult a physician.

After inhalation: Remove the victim into fresh air. If symptoms persist, call a physician.

After ingestion: Do not induce vomiting. Call a physician immediately.

Notes to physician: In the unlikely event that large quantities of the product are ingested, gastric lavage should be considered. Aspiration into the lungs may cause chemical pneumonia. An activated charcoal slurry taken within 30 minutes of product ingestion may reduce the toxicity of the chemical. A 5:1 ratio of charcoal to material ingested is the recommended dosage. Activated charcoal should not be considered as an antidote; normal symptomatic treatment is recommended with or without the administration of activated charcoal.

5. FIRE FIGHTING MEASURES


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

Fire and explosion hazards: In the event of fire and/or explosion do not breathe fumes. Cool containers / tanks with water spray. Heating/burning can release hazardous gases: carbon oxides (CO, CO₂) and various hydrocarbons.

Special protective equipment: Wear protective clothing. In case of respirable dust and/or fumes, use self-contained breathing apparatus.

Flash Point: 143.6°F (62°C)

6. ACCIDENTAL RELEASE MEASURES

Personal protection: See Section 8.

Environmental precautions: Prevent product from entering drains. Do not flush into surface water or sanitary sewer system. Avoid subsoil penetration.

Clean-up: Remove all sources of ignition. Stop leak at source. Keep people away from and upwind of spill/leak. Contain material using temporary measures such as sand bags, booms or adsorbent socks. Soak up with inert absorbent material (e.g. sand, silica gel, universal binder, sawdust). Never use spilled product.

Spilled product should be disposed of in accordance with all applicable government regulations. (See Section 13). Small amounts: Soak up with inert absorbent material and dispose of in accordance with applicable regulations.
7. HANDLING AND STORAGE

Handling: Use only in well-ventilated areas. Wear personal protective equipment. In case of insufficient ventilation, wear suitable respiratory equipment (see Section 8 of MSDS). Keep away from open flames, hot surfaces and sources of ignition.

Storage: Keep containers tightly closed in a cool, well-ventilated place. Store in original container. Keep away from heat and sources of ignition.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Engineering measures: Ensure adequate ventilation, especially in confined areas.

Personal protection equipment: Avoid contact with skin, eyes and clothing. Handle in accordance with good industrial hygiene and safety practice.

  Eye protection: Tightly fitting safety goggles. Face-shield.

  Hand protection: Solvent-resistant gloves.

  Skin and body protection: Solvent-resistant apron and boots. Protective suit. Remove and wash contaminated clothing and gloves, including the inside, before re-use.

  Respiratory protection: In case of insufficient ventilation, wear suitable respiratory equipment. Air-purifying respirator with NIOSH classification N-100 filter or P-100 (or equivalent) if oil/liquid aerosols are present (42 CFR 84).

9. PHYSICAL AND CHEMICAL PROPERTIES

These data do not represent technical or sales specifications.

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Form</td>
<td>Liquid</td>
</tr>
<tr>
<td>Odor</td>
<td>Distinct smokey odor</td>
</tr>
<tr>
<td>Boiling point/range</td>
<td>208.4 - 212°F (98 - 100°C)</td>
</tr>
<tr>
<td>Flash point</td>
<td>143.6°F (62°C)</td>
</tr>
<tr>
<td>Bulk density</td>
<td>N.D.</td>
</tr>
<tr>
<td>Vapor pressure</td>
<td>N.D.</td>
</tr>
<tr>
<td>Water solubility</td>
<td>Miscible in water at concentrations &lt;30% water</td>
</tr>
<tr>
<td>Color</td>
<td>Black</td>
</tr>
<tr>
<td>pH</td>
<td>&gt;2.5</td>
</tr>
<tr>
<td>Melting point/range</td>
<td>N.A.</td>
</tr>
<tr>
<td>Autoignition temperature</td>
<td>N.D.</td>
</tr>
<tr>
<td>Explosion limits</td>
<td>N.A.</td>
</tr>
<tr>
<td>Relative density/Specific Gravity</td>
<td>1.11 - 1.28 g/cm³ @ 20°C</td>
</tr>
<tr>
<td>Viscosity</td>
<td>N.D.</td>
</tr>
<tr>
<td>Abbreviations:</td>
<td>N.D. - Not Determined</td>
</tr>
<tr>
<td></td>
<td>N.A. - Not Applicable</td>
</tr>
</tbody>
</table>

10. STABILITY

Stability: Stable at normal conditions. Decomposes on heating.

Hazardous decomposition products: No decomposition if used as directed. Under conditions giving incomplete combustion, hazardous gases produced may consist of carbon oxides (CO, CO₂) and various hydrocarbons.
Conditions/Materials to avoid: Keep away from ignition sources. Incompatible with acids. Incompatible with oxidizing agents.

11. TOXICOLOGICAL INFORMATION

Acute toxicity:

LD50/oral/rat: No data available.

LD50/dermal/rabbit: No data available.

LC50/inhalation/rat: No data available.

Chronic toxicity: Classification of Ingredients

EC Carcinogenic: Not listed.

Carcinogenicity (ACGIH): Not listed.

EC Mutagenic: Not listed.

IARC classification: Not listed.


Routes of exposure: Exposure may occur via inhalation, contact with skin and eyes.

Irritation:

Skin (rabbit): No data available.

Eye (rabbit): No data available.

Additional product information: Avoid repeated and prolonged exposure.

Additional component information: No data available.
12. ECOLOGICAL INFORMATION

Mobility: No data available.

Bioaccumulation: No data available.

Biodegradation: No data available.

Aquatic toxicity: No data available.

Further Information: No information available.

13. DISPOSAL CONSIDERATIONS


Disposal information: Dispose of in compliance with all applicable regulations. Waste material may exhibit the U.S. EPA's RCRA hazardous waste characteristic of Ignitability (D001) if representative sample of the waste has a flash point of less than 140°F (60°C).

14. TRANSPORT INFORMATION

<table>
<thead>
<tr>
<th>UN-No.: NA1993</th>
<th>Proper shipping name: Combustible liquid, n.o.s. (contains Pyroligenous acids)</th>
<th>Packing group: III</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transport Mode</td>
<td>Class</td>
<td>Additional Information</td>
</tr>
<tr>
<td>----------------</td>
<td>--------------------------------</td>
<td>-----------------------------</td>
</tr>
<tr>
<td>U.S. DOT:</td>
<td>Comb. liq.</td>
<td>Reportable</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Quantity:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Marine Pollutant DOT:</td>
</tr>
<tr>
<td>ADR/RID:</td>
<td>Not regulated.</td>
<td>Danger Code:</td>
</tr>
<tr>
<td>IMDG:</td>
<td>Not regulated.</td>
<td>Marine pollutant:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>EmS:</td>
</tr>
<tr>
<td>IATA:</td>
<td>Not regulated.</td>
<td></td>
</tr>
</tbody>
</table>

RTP Green Fuel Intermediate and Final Products

Revision Number: 0

X00159

March 2012

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15. REGULATORY INFORMATION

United States

Toxic Substances Control Act (TSCA): All the ingredients of this mixture are registered on the TSCA Chemical Substance Inventory.

CERCLA (Comprehensive Environmental Response, Compensation, and Liability Act) Reportable Quantity:
The following component(s) of this product is/are subject to release reporting under 40 CFR 302 when release exceeds the Reportable Quantity (RQ):
-- None --

CWA (Clean Water Act):
Any spill or release of this product to navigable waters or adjoining shoreline sufficient to cause a sheen or deposit of a sludge or emulsion is subject to the Discharge of Oil Notification requirements under 40 CFR 110.6.

SARA Title III (Superfund Amendments and Reauthorization Act of 1986):
Section 302 (Extremely Hazardous Substances):
The following component(s) of this product is/are subject to the emergency planning provisions of 40 CFR 355 when there are amounts equal to or greater than the Threshold Planning Quantity (TPQ):
-- None --

Section 313 (Toxic Chemicals):
The following component(s) have been specified as Toxic Chemicals under SARA Section 313 and may be subject to the Toxic Release Inventory (TRI) reporting requirements under 40 CFR 372:
-- None --

The following components are listed in U.S. State Regulations:

<table>
<thead>
<tr>
<th>State Reg Reference</th>
<th>State Reg Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>California - Proposition 65:</td>
<td>None.</td>
</tr>
<tr>
<td>Massachusetts Right-To-Know:</td>
<td>None.</td>
</tr>
<tr>
<td>New Jersey Right-To-Know:</td>
<td>None.</td>
</tr>
<tr>
<td>Pennsylvania Right-To-Know:</td>
<td>None.</td>
</tr>
</tbody>
</table>

Note: Other U.S. State Regulations may exist, check your local sources if available or contact the UOP Product Stewardship Manager (see Section 16).
Canada

**Canadian Hazardous Products Act:**
This product is classified as a Combustible Liquid - Class B, Division 3.
This product is classified as a material causing Other Toxic Effects - skin and eye irritation - Class D, Division 2, Subdivision B.

The above classification(s) is/are in accordance with the regulations pursuant to the Federal Hazardous Products Act (e.g. WHMIS)

**Canadian Environmental Protection Act:** None of the ingredients of this mixture is notified to CEPA or on the DSL/NDSL.

European Union (EU)

**European Inventory of Existing Commercial Chemical Substances:** All components of this product are included in EINECS/ELINCS.

**Council of European Communities Directive on Classification, Packaging and Labelling of Dangerous Substances/Preparation (67/548/EEC & 1999/45/EC, as amended):**
Not determined.

**Additional Governmental Inventories**

- **Australia - Inventory of Chemical Substances (AICS):** Not determined.
- **China:** Not determined.
- **Japan - Existing and New Chemical Substances (ENCS):** Not determined.
- **Korea - Existing and Evaluated Chemical Substances (ECL):** Not determined.
- **Philippines - Inventory of Chemicals and Chemical Substances (PICCS):** Not determined.
16. OTHER INFORMATION

Summary of changes: New MSDS
Supersedes: None.
Prepared by: UOP Health, Safety & Environmental Department

HMIS™ - Hazardous Material Identification System:
HMIS™ Ratings: 0- minimal hazard, 1- slight hazard, 2- moderate hazard, 3- serious hazard, 4- severe hazard.

HEALTH : 2
FLAMMABILITY : 2
REACTIVITY : 0

For additional information concerning this product, contact the following:

For health, safety and environmental information, please contact:
Product Stewardship Manager
UOP LLC
25 E. Algonquin Road
Des Plaines, IL 60017-5017
USA
Tel: +1-847-391-3095
Fax: +1-847-391-2953

For technical or purchasing information, please contact:
Product Stewardship Europe
UOP N.V.
Noorderlaan 147
B-2030 Antwerpen
Belgium
Tel: +32-3-5409-971
Fax: +32-3-5417-806

PRODUCT EMERGENCIES

If you have a product-related emergency, resulting in an incident such as a spill or release of product or human exposure and need assistance from UOP, please contact the following number:

24-Hour EMERGENCY NUMBER (CHEMTREC) : +1-800-424-9300 or +1-703-527-3887;
for MEDICAL EMERGENCY (PROSAR): +1-800-498-5701 or +1-651-523-0309

The data and recommendations presented in this data sheet concerning the use of our product and the materials contained therein are believed to be accurate and are based on information which is considered reliable as of the date hereof. However, the customer should determine the suitability of such materials for his purpose before adopting them on a commercial scale. Since the use of our products by others is beyond our control, no guarantee, express or implied, is made and no responsibility assumed for the use of this material or the results to be obtained therefrom. Information on this form is furnished for the purpose of compliance with Government Health and Safety Regulations and shall not be used for any other purposes. Moreover, the recommendations contained in this data sheet are not to be construed as a license to operate under, or a recommendation to infringe, any existing patents, nor should they be confused with state, municipal or insurance requirements, or with national safety codes.
MATERIAL SAFETY DATA SHEET

1 PRODUCT AND COMPANY IDENTIFICATION

Product Name: Agri-Pure® Gold Blown Vegetable Oil Series

Manufacturer Name: Industrial Oils & Lubricants
12201 Torrence Avenue
Chicago, Illinois 60617
IOLCustomerService@cargill.com

Emergency Telephone: 1-800-424-9300
Non-emergency Telephone: 1-800-842-3631

Intended Use: Industrial use

2 HAZARDS IDENTIFICATION

Emergency Overview
Physical State: Liquid
Color: Brown
Odor: Mild

CAUTION!
Prolonged or repeated skin contact may cause drying, cracking, or irritation.

Potential Health Effects

Inhalation: In high concentrations, vapors may be irritating to the respiratory system.

Eye Contact: May cause temporary eye irritation.

Skin Contact: Prolonged contact may cause dryness of the skin.

Ingestion: No harmful effects expected in amounts likely to be ingested by accident.

OSHA Regulatory Status: This product is not hazardous according to OSHA 29CFR 1910.1200.

3 COMPOSITION / INFORMATION ON INGREDIENTS

<table>
<thead>
<tr>
<th>Chemical Name</th>
<th>CAS-No.</th>
<th>Concentration*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fats and glyceridic oils, vegetable, polynd., oxidized</td>
<td>68918-91-2</td>
<td>100%</td>
</tr>
</tbody>
</table>

* All concentrations are in percent by weight unless ingredient is a gas. Gas concentrations are in percent by volume.
4 FIRST AID MEASURES

Inhalation: If symptomatic, move to fresh air. Get medical attention if symptoms persist.

Eye Contact: Any material that contacts the eye should be washed out immediately with water. If easy to do, remove contact lenses. Get medical attention promptly if symptoms occur after washing.

Skin Contact: Wash skin with soap and water. Get medical attention promptly if symptoms occur after washing.

Ingestion: First aid is normally not required. However, if greater than 1/2 liter (pint) ingested, seek medical attention.

5 FIRE-FIGHTING MEASURES

Extinguishing Media: Extinguish with alcohol-resistant foam, carbon dioxide, dry powder or water fog.

Unsuitable Extinguishing Media: None.

Special Fire Fighting Procedures: Self-contained breathing apparatus and full protective clothing must be worn in case of fire.

Unusual Fire & Explosion Hazards: None known.

Hazardous Combustion Products: Carbon Oxides

6 ACCIDENTAL RELEASE MEASURES

Personal Precautions: Wear appropriate personal protective equipment.

Spill Cleanup Methods: Absorb spill with vermiculite or other inert material, then place in a container for chemical waste. Large Spillages: Flush area with water. Prevent runoff from entering drains, sewers, or streams. Dike for later disposal.

Environmental Precautions: Avoid discharge into drains, water courses or onto the ground.

7 HANDLING AND STORAGE

Handling: No special precautions are necessary beyond normal good hygiene practices. See Section 8 of the MSDS for additional personal protection advice when handling this product.

Storage: Store away from incompatible materials.

8 EXPOSURE CONTROLS / PERSONAL PROTECTION

Exposure Limits: No exposure limits noted for ingredient(s).

Engineering Controls: Good general ventilation (typically 10 air changes per hour) should be used. Ventilation rates should be matched to conditions. If applicable, use process enclosures, local exhaust ventilation, or other engineering controls to maintain airborne levels below recommended exposure limits.
If exposure limits have not been established, maintain airborne levels to an acceptable level.

**Respiratory Protection:** If engineering controls do not maintain airborne concentrations below recommended exposure limits (where applicable) or to an acceptable level (in countries where exposure limits have not been established), an approved respirator must be worn. In the United States of America, if respirators are used, a program should be instituted to assure compliance with OSHA Standard 63 FR 1152, January 8, 1998. Respirator type: Air-purifying respirator with an appropriate, government approved (where applicable), air-purifying filter, cartridge or canister. Contact health and safety professional or manufacturer for specific information.

**Eye Protection:** Risk of contact: Wear approved safety goggles.

**Hand Protection:** It is a good industrial hygiene practice to minimize skin contact.

**Skin Protection:** Apron and long sleeves are recommended.

**Hygiene Measures:** Always observe good personal hygiene measures, such as washing after handling the material and before eating, drinking, and/or smoking. Routinely wash work clothing and protective equipment to remove contaminants.

**Environmental Exposure Controls:** Environmental manager must be informed of all major spillages.

<table>
<thead>
<tr>
<th>9</th>
<th>PHYSICAL AND CHEMICAL PROPERTIES</th>
</tr>
</thead>
</table>

**Color:** Brown  
**Odor:** Mild  
**Odor Threshold:** No data available.  
**Physical State:** Liquid  
**pH:** Not applicable  
**Melting Point:** No data available.  
**Freezing Point:** No data available.  
**Boiling Point:** No data available.  
**Flash Point:** >215°C (419°F) (Cleveland Open Cup)  
**Evaporation Rate:** No data available.  
**Flammability (Solid):** No data available.  
**Flammability Limit - Upper (%):** No data available.  
**Flammability Limit - Lower (%):** No data available.  
**Vapor Pressure:** No data available.  
**Vapor Density (Air=1):** No data available.  
**Specific Gravity:** 0.92 - 0.94 (25°C)  
**Solubility in Water:** No data available.  
**Solubility (Other):** No data available.  
**Partition Coefficient (n-Octanol/water):** No data available.  
**Autoignition Temperature:** No data available.  
**Decomposition Temperature:** No data available.  
**Volatile Organic Compounds (VOC):** No data available.  
**Viscosity:** No data available.  
**Explosive Properties:** No data available.
10 STABILITY AND REACTIVITY

Stability: Stable.

Conditions to Avoid: None known.

Incompatible Materials: Strong oxidizing agents.

Hazardous Decomposition Products: No data available.

Possibility of Hazardous Reactions: Will not occur.

11 TOXICOLOGICAL INFORMATION

Specified Substance(s)
Acute Toxicity:
Test Results: No test data available for the ingredients.

Listed Carcinogens: None.

Product Information
Acute Toxicity:
Test Results: No test data available for the product.

Other Acute: No additional adverse health effects noted.

Chronic Toxicity: No additional adverse health effects noted.

12 ECOLOGICAL INFORMATION

Ecotoxicity: Not expected to be harmful to aquatic organisms. No data available.

Mobility: No data available.

Persistence and Degradability: No data available.

Other Adverse Effects: No data available.

13 DISPOSAL CONSIDERATIONS

General Information: Do not discharge into drains, water courses or onto the ground. Discharge, treatment, or disposal may be subject to national, state, or local laws. Empty containers may contain product residues.

Disposal Methods: No specific disposal method required.

Container: Since emptied containers retain product residue, follow label warnings even after container is emptied.
14 TRANSPORT INFORMATION

**DOT** Not regulated.

**TDG** Not regulated.

**IATA** Not regulated.

**IMDG** Not regulated.

15 REGULATORY INFORMATION

**Canadian Controlled Products Regulations:** This product has been classified according to the hazard criteria of the Canadian Controlled Products Regulations, Section 33, and the MSDS contains all required information.

**WHMIS Classification:** This is not a WHMIS controlled product.

**Mexican Dangerous Statement:** This product is not dangerous according to Mexican regulations.

**Inventory Status**

This product or all components are listed or exempt from listing on the following inventory: TSCA

This product or one or more component(s) are not listed on the following inventory: DSL

**US Regulations**

**CERCLA Hazardous Substance List (40 CFR 302.4):** Not regulated.

**SARA Title III**

**Section 311/312 (40 CFR 370):**
- [ ] Acute (Immediate)
- [ ] Chronic (Delayed)
- [ ] Fire
- [ ] Reactive
- [ ] Pressure Generating

**Section 313 Toxic Release Inventory (40 CFR 372):** Not regulated.

**Clean Air Act (CAA) Section 112(r) Accidental Release Prevention (40 CFR 68.130):** Not regulated.

**Clean Water Act Section 311 Hazardous Substances (40 CFR 117.3):** Not regulated.

**Drug Enforcement Act:** Not regulated.

**TSCA**

**TSCA Section 4(a) Final Test Rules & Testing Consent Orders:** Not regulated.

**TSCA Section 5(a)(2) Final Significant New Use Rules (SNURs) (40 CFR 721, Subpt. E):** Not regulated.
TSCA Section 5(e) PMN-Substance Consent Orders: Not regulated.


State Regulations


Massachusetts Right-To-Know List: Not regulated.


Minnesota Hazardous Substances List: Not regulated.

New Jersey Right-To-Know List: Not regulated.

Pennsylvania Right-To-Know List: Not regulated.

Rhode Island Right-To-Know List: Not regulated.

16 OTHER INFORMATION

HAZARD RATINGS

<table>
<thead>
<tr>
<th></th>
<th>Health Hazard</th>
<th>Fire Hazard</th>
<th>Instability</th>
<th>Special Hazard</th>
</tr>
</thead>
<tbody>
<tr>
<td>NFPA</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>NONE</td>
</tr>
</tbody>
</table>

Hazard rating: 0 - Minimal; 1 - Slight; 2 - Moderate; 3 - Serious; 4 - Severe
NFPA Label colored diamond code: Blue - Health; Red - Flammability; Yellow - Instability; White - Special Hazards

<table>
<thead>
<tr>
<th></th>
<th>Health Hazard</th>
<th>Flammability</th>
<th>Physical Hazard</th>
<th>Personal Protection</th>
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<tbody>
<tr>
<td>HMIS</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>--</td>
</tr>
</tbody>
</table>

Hazard rating: 0 - Minimal; 1 - Slight; 2 - Moderate; 3 - Serious; 4 - Severe
HMIS Label colored bar code: Blue - Health; Red - Flammability; Orange - Physical Hazards; White - Special

Issue Date: 06-Jan-2010
Supercedes Date: 24-Mar-2009
SDS No.: 1025766

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

**Synonyms:** Denatured Alcohol; Denatured Ethanol  
**CAS No.:** Not applicable to mixtures.  
**Molecular Weight:** Not applicable to mixtures.  
**Chemical Formula:** Not applicable to mixtures.

2. === Composition/Information on Ingredients ===

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>CAS No</th>
<th>Percent</th>
<th>Hazardous</th>
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<tr>
<td>Ethyl Acetate</td>
<td>141-78-6</td>
<td>1</td>
<td>Yes</td>
</tr>
<tr>
<td>Methyl Isobutyl Ketone</td>
<td>108-10-1</td>
<td>1</td>
<td>Yes</td>
</tr>
<tr>
<td>Methyl Alcohol</td>
<td>67-56-1</td>
<td>4 - 6</td>
<td>Yes</td>
</tr>
</tbody>
</table>

3. === Hazards Identification ===

**Emergency Overview**

**POISON! DANGER! VAPOR HARMFUL. MAY BE FATAL OR CAUSE BLINDNESS IF SWALLOWED. CANNOT BE MADE NONPOISONOUS. HARMFUL IF INHALED OR ABSORBED THROUGH SKIN. FLAMMABLE LIQUID AND VAPOR. AFFECTS CENTRAL NERVOUS SYSTEM. CAUSES IRRITATION TO SKIN, EYES AND RESPIRATORY TRACT. MAY AFFECT LIVER, BLOOD, KIDNEYS, GASTROINTESTINAL TRACT AND REPRODUCTIVE SYSTEM.**

- Health Rating: 2  
- Flammability Rating: 3  
- Reactivity Rating: 0  
- Contact Rating: 2 - Moderate  
- Lab Protective Equip: GOGGLES & SHIELD; LAB COAT & APRON; VENT HOOD; PROPER GLOVES; CLASS B EXTINGUISHER  
- Storage Color Code: Red (Flammable)
Potential Health Effects
----------------------------------

Inhalation:
Causes irritation to the respiratory tract. Symptoms may include coughing, shortness of breath. Prolonged exposures to high concentration may cause drowsiness, loss of appetite, and inability to concentrate.

Ingestion:
Cause headaches, gastritis, intoxication, blindness and, in acute cases, death.

Skin Contact:
Causes skin irritation, cracking or flaking due to dehydration and defatting action.

Eye Contact:
Can cause eye irritation. Splashes may cause temporary pain and blurred vision.

Chronic Exposure:
Prolonged skin contact causes drying and cracking of skin. May affect the nervous system, liver, kidneys, blood, g.i. tract and reproductive system. Continued ingestion of small amounts could result in blindness.

Aggravation of Pre-existing Conditions:
Persons with pre-existing skin disorders or eye problems or impaired liver or kidney function may be more susceptible to the effects of the substance.

4. ===First Aid Measures ===

Inhalation:
Remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Get medical attention.

Ingestion:
Induce vomiting immediately as directed by medical personnel. Never give anything by mouth to an unconscious person. Get medical attention immediately.

Skin Contact:
Immediately flush skin with plenty of water for at least 15 minutes while removing contaminated clothing and shoes. Get medical attention. Wash clothing before reuse. Thoroughly clean shoes before reuse.

Eye Contact:
Immediately flush eyes with plenty of water for at least 15 minutes, lifting lower and upper eyelids occasionally. Get medical attention immediately.

5. === Fire Fighting Measures ===

Fire:
Flash point: 13C (55F) CC
Autoignition temperature: 463C (865F)
Flammable limits in air % by volume:
lel: 3.3; uel: 19.0
Flammable liquid and vapor!
Dangerous fire hazard when exposed to heat or flame.

Explosion:
Above flash point, vapor-air mixtures are explosive within flammable limits noted above. Vapors can flow along surfaces to distant ignition source and flash back. Sealed containers may rupture when heated.

Fire Extinguishing Media:
Water spray, dry chemical, alcohol foam, or carbon dioxide. Water may be ineffective.

Special Information:
In the event of a fire, wear full protective clothing and NIOSH-approved self-contained breathing apparatus with full facepiece operated in the pressure demand or other positive pressure mode. Water spray can be used to extinguish fires and cool fire-exposed containers. Water may be used to flush spills away from exposures and to dilute spills to non-flammable mixtures.
6. **Accidental Release Measures**

Ventilate area of leak or spill. Remove all sources of ignition. Wear appropriate personal protective equipment as specified in Section 8. Isolate hazard area. Keep unnecessary and unprotected personnel from entering. Contain and recover liquid when possible. Use non-sparking tools and equipment. Collect liquid in an appropriate container or absorb with an inert material (e.g., vermiculite, dry sand, earth), and place in a chemical waste container. Do not use combustible materials, such as saw dust. Do not flush to sewer! US Regulations (CERCLA) require reporting spills and releases to soil, water and air in excess of reportable quantities. The toll free number for the US Coast Guard National Response Center is (800) 424-8802.

7. **Handling and Storage**

Protect against physical damage. Store in a cool, dry well-ventilated location, away from any area where the fire hazard may be acute. Outside or detached storage is preferred. Separate from incompatibles. Containers should be bonded and grounded for transfers to avoid static sparks. Storage and use areas should be No Smoking areas. Use non-sparking type tools and equipment, including explosion proof ventilation. Containers of this material may be hazardous when empty since they retain product residues (vapors, liquid); observe all warnings and precautions listed for the product. Do Not attempt to clean empty containers since residue is difficult to remove. Do not pressurize, cut, weld, braze, solder, drill, grind or expose such containers to heat, sparks, flame, static electricity or other sources of ignition: they may explode and cause injury or death.

8. **Exposure Controls /Personal Protection**

**Airborne Exposure Limits:**
- OSHA Permissible Exposure Limit (PEL):
  - ethyl alcohol = 1000 ppm (TWA);
  - methyl alcohol = 200 ppm;
  - ethyl acetate = 400 ppm (TWA);
  - methyl isobutyl ketone = 100 ppm.

- ACGIH Threshold Limit Value (TLV):
  - ethyl alcohol = 1000 ppm (TWA);
  - methyl alcohol = 200 ppm (TWA), 250 ppm (STEL);
  - ethyl acetate = 400 ppm (TWA);
  - methyl isobutyl ketone = 50 ppm (TWA), 75 ppm (STEL);
  - gasoline = 300 ppm (TWA), 500 ppm (STEL), A3 - animal carcinogen.

**Ventilation System:**
A system of local and/or general exhaust is recommended to keep employee exposures below the Airborne Exposure Limits. Local exhaust ventilation is generally preferred because it can control the emissions of the contaminant at its source, preventing dispersion of it into the general work area. Please refer to the ACGIH document, *Industrial Ventilation, A Manual of Recommended Practices*, most recent edition, for details.

**Personal Respirators (NIOSH Approved):**
If the exposure limit is exceeded, wear a supplied air, full-facepiece respirator, airlined hood, or full-facepiece self-contained breathing apparatus.

**Skin Protection:**
Wear impervious protective clothing, including boots, gloves, lab coat, apron or coveralls, as appropriate, to prevent skin contact.

**Eye Protection:**
Use chemical safety goggles and/or a full face shield where splashing is possible. Maintain eye wash fountain and quick-drench facilities in work area.

9. === Physical/Chemical Properties ===

**Appearance:**
Clear, colorless liquid.

**Odor:**
Pleasant odor.

**Solubility:**
Appreciable (> 10%)

**Specific Gravity:**
0.79 @ 20C/4C

**pH:**
No information found.

**% Volatiles by volume @ 21C (70F):**
100

**Boiling Point:**
77C (171F)

**Melting Point:**
No information found.

**Vapor Density (Air=1):**
1.6

**Vapor Pressure (mm Hg):**
45 @ 20C (68F)

**Evaporation Rate (BuAc=1):**
3.3

10. === Stability and Reactivity Data ===

**Stability:**
Stable under ordinary conditions of use and storage.

**Hazardous Decomposition Products:**
Carbon dioxide and carbon monoxide may form when heated to decomposition.

**Hazardous Polymerization:**
Will not occur.

**Incompatibilities:**
Strong oxidants, silver salts, acid chlorides, alkali metals, metal hydrides, hydrazine, and many other substances.

**Conditions to Avoid:**
Heat, flames, ignition sources and incompatibles.

11. === Toxicological Information ===

**Toxicological Data:**
Ethyl alcohol: oral rat LD50= 7060mg/kg; inhalation rat LC50= 20,000ppm/10H; investigated as a tumorigen, mutagen, reproductive effector.

Methyl alcohol: oral rat LD50= 5628mg/kg; inhalation rat LC50= 64000ppm/4H; skin rabbit LD50= 15800mg/kg; investigated as a tumorigen, mutagen, reproductive effector.

Ethyl acetate: oral rat LD50= 5620mg/kg; inhalation rat LC50= 200gm/m3; skin rabbit LD50= > 20ml/kg; investigated as a mutagen.

Methyl isobutyl ketone: oral rat LD50= 2080 mg/kg; skin rabbit LD50= > 20ml/kg;
investigated as a reproductive effector.

Gasoline: inhalation rat LC50= 300 gm/m3/5M.

**Reproductive Toxicity:**
Ethanol has been linked to birth defects in humans.

**Carcinogenicity:**
Gasoline: NIOSH considers this substance to be a potential occupational carcinogen.

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Known</th>
<th>Anticipated</th>
<th>IARC Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ethyl Alcohol (64-17-5)</td>
<td>No</td>
<td>No</td>
<td>None</td>
</tr>
<tr>
<td>Ethyl Acetate (141-78-6)</td>
<td>No</td>
<td>No</td>
<td>None</td>
</tr>
<tr>
<td>Methyl Isobutyl Ketone (108-10-1)</td>
<td>No</td>
<td>No</td>
<td>None</td>
</tr>
<tr>
<td>Methyl Alcohol (67-56-1)</td>
<td>No</td>
<td>No</td>
<td>None</td>
</tr>
</tbody>
</table>

12. ***Ecological Information***

**Environmental Fate:**
Following data for ethanol: When released into the soil, this material is expected to readily biodegrade. When released into the soil, this material may leach into groundwater. When released into water, this material is expected to quickly evaporate. When released into water, this material is expected to readily biodegrade. When released into the air, this material is expected to be readily degraded by reaction with photochemically produced hydroxyl radicals. When released into the air, this material is expected to be readily removed from the atmosphere by wet deposition.

Following data for methanol: When released into the soil, this material may biodegrade to a moderate extent. When released into the soil, this material is expected to leach into groundwater. When released into water, this material may biodegrade to a moderate extent. When released into the air, this material may be moderately degraded by reaction with photochemically produced hydroxyl radicals. When released into air, this material is expected to have a half-life between 10 and 30 days.

Following data for ethyl acetate: When released into the soil, this material may biodegrade to a moderate extent. When released into the soil, this material may leach into groundwater. When released into water, this material may evaporate to a moderate extent. When released into water, this material may biodegrade to a moderate extent. When released to water, this material is expected to quickly evaporate. When released into the water, this material is expected to have a half-life of less than 1 day. This material is not expected to significantly bioaccumulate. When released into the air, this material is expected to be readily degraded by reaction with photochemically produced hydroxyl radicals. When released into the air, this material is expected to have a half-life between 1 and 10 days.

Following data for methyl isobutyl ketone: When released into the soil, this material may biodegrade to a moderate extent. When released into the soil, this material may evaporate to a moderate extent. When released into the soil, this material is expected to leach into groundwater. When released to water, this material is expected to quickly evaporate. When released into water, this material may biodegrade to a moderate extent. This material is not expected to significantly bioaccumulate. When released into the air, this material is expected to be readily degraded by photolysis. When released into the air, this material is expected to be readily degraded by reaction with photochemically produced hydroxyl radicals.

**Environmental Toxicity:**
This material is not expected to be toxic to aquatic life. For ethanol, methanol, ethyl acetate and methyl isobutyl ketone: The LC50/96-hour values for fish are over 100 mg/l.
13. === Disposal Considerations ===

Whatever cannot be saved for recovery or recycling should be handled as hazardous waste and sent to a RCRA approved incinerator or disposed in a RCRA approved waste facility. Processing, use or contamination of this product may change the waste management options. State and local disposal regulations may differ from federal disposal regulations. Dispose of container and unused contents in accordance with federal, state and local requirements.

14. === MSDS Transport Information ===

Domestic (Land, D.O.T.)

-----------------------
Proper Shipping Name: Alcohols, N.O.S.
Hazard Class: 3
UN/NA: UN 1987
Packing Group: II
Information reported for product/size:

International (Water, I.M.O.)

-----------------------
Proper Shipping Name: Alcohols, N.O.S.
Hazard Class: 3
UN/NA: UN1987
Packing Group: II
Information reported for product/size:

International (Air, I.C.A.O.)

-----------------------
Proper Shipping Name: Alcohols, N.O.S.
Hazard Class: 3
UN/NA: UN1987
Packing Group: II
Information reported for product/size:

15. === Regulatory Information ===

--------\Chemical Inventory Status - Part 1\-----------------------------------------------
Ingredient                               TSCA  EC   Japan  Australia
-----------------------------------------------  ----  ---  -----  ---------
Ethyl Alcohol (64-17-5)                  Yes  Yes   Yes      Yes
Ethyl Acetate (141-78-6)                 Yes  Yes   Yes      Yes
Methyl Isobutyl Ketone (108-10-1)       Yes  Yes   Yes      Yes
Methyl Alcohol (67-56-1)                 Yes  Yes   Yes      Yes

--------\Chemical Inventory Status - Part 2\-----------------------------------------------
Ingredient                               Korea  DSL  NDSL  Phil.
-----------------------------------------------  -----  ---   ----  -----  --Canada--
Ethyl Alcohol (64-17-5)                  Yes  Yes   No     Yes
Ethyl Acetate (141-78-6)                 Yes  Yes   No     Yes
Methyl Isobutyl Ketone (108-10-1)       Yes  Yes   No     Yes
Methyl Alcohol (67-56-1)                 Yes  Yes   No     Yes

http://www.hvchemical.com/msds/deal.htm
### Federal, State & International Regulations - Part 1

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<td>Ethyl Acetate (141-78-6)</td>
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<tr>
<td>Methyl Isobutyl Ketone (108-10-1)</td>
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<td>Methyl Alcohol (67-56-1)</td>
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### Federal, State & International Regulations - Part 2

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<th>8(d)</th>
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<th>TSCA</th>
<th>CDTA</th>
<th>SARA 311/312</th>
<th>Fire</th>
<th>Pressure</th>
<th>Reactivity</th>
<th>(Mixture / Liquid)</th>
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<tr>
<td>Ethyl Acetate (141-78-6)</td>
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<td>Methyl Isobutyl Ketone (108-10-1)</td>
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<td>U161</td>
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</table>

Chemical Weapons Convention: No TSCA 12(b): Yes CDTA: No

SARA 311/312: Acute: Yes Chronic: Yes Fire: Yes Pressure: No

Reactivity: No

**Australian Hazchem Code:** 2[S]E

**Poison Schedule:** S5

**WHMIS:**

This MSDS has been prepared according to the hazard criteria of the Controlled Products Regulations (CPR) and the MSDS contains all of the information required by the CPR.

### 16. Other Information

**NFPA Ratings:** Health: 2 Flammability: 3 Reactivity: 0

**Label Hazard Warning:**

POISON! DANGER! VAPOR HARMFUL. MAY BE FATAL OR CAUSE BLINDNESS IF SWALLOWED. CANNOT BE MADE NONPOISONOUS. HARMFUL IF INHALED OR ABSORBED THROUGH SKIN. FLAMMABLE LIQUID AND VAPOR. AFFECTS CENTRAL NERVOUS SYSTEM. CAUSES IRRITATION TO SKIN, EYES AND RESPIRATORY TRACT. MAY AFFECT LIVER, BLOOD, KIDNEYS, GASTROINTESTINAL TRACT AND REPRODUCTIVE SYSTEM.

**Label Precautions:**

Keep away from heat, sparks and flame.
Avoid contact with eyes, skin and clothing.
Avoid breathing vapor.
Keep container closed.
Use only with adequate ventilation.
Wash thoroughly after handling.

**Label First Aid:**

If swallowed, induce vomiting immediately as directed by medical personnel. Never give anything by mouth to an unconscious person. Get medical attention immediately. If inhaled, remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. In case of contact, immediately flush eyes or skin with plenty of water for at least 15 minutes while removing contaminated clothing and shoes. Wash clothing before reuse. In all cases, get medical attention.

**Product Use:**

Laboratory Reagent.
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