REGION OF PEEL
Waste Management Division

Biodiesel Program
2012 SWANA Special Waste Excellence Award
EXECUTIVE SUMMARY

Since 2008, the Waste Operations section in the Region of Peel has produced biodiesel from waste cooking oils collected from residents at the Region’s five permanent household hazardous waste drop-off locations. Peel’s biodiesel program operates via a cradle to cradle cycle, where Peel residents can dispose of their vegetable oil and used cooking oil safely and free of charge and, in turn, the waste cooking oil that is received is run through a four-stage process which converts it to biodiesel that is used to power the Waste Management division’s fleet of vehicles. The biodiesel program provides an environmentally-sound method of utilizing waste cooking oil while, at the same time, offers a cost-effective approach to powering a small fleet of vehicles.

The Region of Peel prides itself as a leader in the development, implementation and continued education of programs and initiatives designed to emphasize the importance of the 4Rs to the Region of Peel’s residents and customers. Peel’s Waste Management division implements waste management programs, systems, services, and technologies that minimize environmental impacts and maximize resource recovery from all waste streams. The following application will highlight the operation and innovation of the Region of Peel’s biodiesel program.
SECTION I: Design of Collection Facility/Management System

Background of the Region of Peel’s Biodiesel Program

The Region of Peel’s Long-Term Waste Management Strategy was developed to provide an environmentally responsible and cost-effective system for managing municipal solid waste, including household hazardous waste (HHW) generated within the Region of Peel. To help achieve this goal, the Waste Operations section of the Waste Management division operates a biodiesel program as a means of diverting used cooking oil from disposal and providing an economically efficient way to power a fleet of Waste Management division vehicles. The biodiesel program was first introduced in 2008 and it is constantly reviewed for efficiency. Alterations are made whenever areas for improvement to the process are identified.

Used cooking oil is accepted through the Region of Peel’s HHW program from residents and small businesses at all five of Peel’s Community Recycling Centres (CRCs). Up to 120 litres (32 gallons) of used cooking oil per resident or small business may be dropped off each day at any of Peel’s CRCs, free of charge. A processing system is located at the Battleford CRC, where HHW staff converts the used oil to biodiesel fuel for use in the aforementioned vehicles.

Operational Design of the Region of Peel’s Biodiesel Program

Biodiesel is produced by municipal HHW staff members who have been trained to do so. HHW staff members possess either a college or university degree in a chemical or environmental program. Their educational background enables them to understand and easily carry out the biodiesel production process, while, at the same time, identifying opportunities to improve the process.

The Region’s HHW drop-offs are located in areas that maximize exposure and minimize travel time. The high volume of residents utilizing the Region of Peel’s HHW facilities
to drop-off used cooking oil supports the high frequency of biodiesel production. Biodiesel is made during Battleford CRC’s opening hours, seven days per week. Once waste cooking oil is received, it goes through a four-stage conversion process that involves transesterification, separation, cleaning, and filtering, before the final product is created.

![Diagram of biodiesel production process](image)

**Figure 1**: The four-stage biodiesel production process

One constraint to the biodiesel production process is the location of the final product. Currently, finished biodiesel is available at the Battleford and Fewster CRCs; however, the Region is currently in the process of making the final product available at multiple Region-operated sites in an effort to increase accessibility to biodiesel and improve efficiency in travel times and emissions required to refuel Peel biodiesel-powered vehicles. Another challenge faced in the production process is that it is limited by the amount of used cooking oil received at the HHW drop-offs. To date, the amount of used cooking oil has no: impeded the biodiesel production process, as there has always been more than enough waste oil with which to produce biodiesel; however, as production levels continue to increase, this may be of concern.

The financial and environmental costs to address and remediate the environmental impacts of not managing waste cooking oil far exceed the cost to manage and run the biodiesel program.
SECTION II: Environmental Benefits & Regulatory Compliance

Environmental Benefits

The goal of the biodiesel program is to minimize environmental impacts by keeping waste cooking oil out of landfill, ground water and waste water systems, while also providing a cost-effective and environmentally-sound means of powering the Waste Management division’s fleet of vehicles. Biodiesel is a biodegradable fuel that can be used to power diesel-engine vehicles. Additionally, biodiesel burns cleaner than traditional fuels, emits fewer toxic compounds (i.e. sulphur, hydrocarbons and carbon monoxide) into the air, decreases ozone, and decreases smog.

In addition to providing an alternative to the disposal of waste cooking oil, the biodiesel created using the waste oil is used in the Waste Management division’s fleet of six cars and five light trucks. This fleet has been given a new appearance and is clearly identified with Powered by Peel Biodiesel decals. The vehicles use either a 5 percent or a 20 percent biodiesel blend, depending on the type of vehicle and the manufacturer’s warranty. In addition to the car and light truck fleet, biodiesel is also used in operational equipment at the Battleford CRC, including a front-end loader, a roll-off truck and a tractor trailer.

Figure 2: Powered by Peel Biodiesel vehicle
Other Benefits

Numerous other benefits result from the use of Peel-produced biodiesel in the Waste Management's vehicle fleet. Engines experience reduced wear due to the added lubrication provided by waste cooking oil-derived biodiesel. Unlike regular diesel, biodiesel does not leave carbon deposits in the engine; instead, it acts as a solvent and cleans out residue left from diesel usage. Additionally, it is safer to handle and use due to a higher flash point (150°C) than that of petro diesel (51°C). Finally, because the chemical properties of Peel’s biodiesel are very similar to those of regular diesel, our biodiesel can be used in any diesel engine.

Source Reduction/Waste Diversion

Essentially, the biodiesel program provides a cradle to cradle cycle, wherein Peel residents get rid of their old cooking oil, which, in turn, is run through a four stage process to convert all of the used cooking oil that is received at the CRCs to biodiesel that is used to power Region vehicles. The Region of Peel’s Public Education and Outreach staff, through dialogue at community events and the use of printed literature, promote the safe disposal of used cooking oil at the five HHW drop-offs at the CRCs. The biodiesel program is a green alternative to disposing waste cooking oil in the landfill, ground water or waste water systems.

Regulatory Compliance

The CRCs, including the HHW drop-offs where used cooking oil is received and biodiesel is produced, operate under the Provisional Certificates of Approval issued by Ontario’s Ministry of the Environment. The Region of Peel operates in compliance with all of the terms and conditions set forth in these governing documents. HHW staff members conduct daily site inspections and track incoming and stored material to ensure that specified limits outlined in the Certificates of Approval are adhered to and, therefore,
not exceeded. HHW staff have been trained and certified in the Transportation of Dangerous Goods in order to handle hazardous waste, including waste cooking oil.

The biodiesel program complies with the Occupational Health and Safety Act's requirements of having Material Safety Data Sheets (MSDS) for all chemicals used on-site readily available. Each of the HHW drop-off locations have easily identifiable binders containing site-specific MSDSs for all chemicals that are present, thus, the Battleford CRC has additional MSDSs pertaining to each of the chemicals utilized in the biodiesel production process. The MSDS binders are updated periodically by HHW staff to ensure that all MSDSs are current within the last three years. Additionally, HHW staff members who produce biodiesel are provided with an array of personal protective equipment to ensure that they are in compliance with Sections 25, 27 and 28 of the Occupational Health and Safety Act when performing any duties related to the biodiesel production process.

As Peel-produced biodiesel is blended with clear diesel for vehicular use, our program also meets the requirements of American Society for Testing and Materials (ASTM International) D6751, which recommends specific properties of biodiesel at the point of delivery. This specification prescribes the chemical composition of biodiesel and the chemical analyses that shall be performed. The five on-site quality control tests that are performed at the Region of Peel, as well as subsequent laboratory analyses, test for the 18 recommended parameters outlined in the ASTM D6751 in order to be in compliance with this specification.

The Region of Peel is diligent in ensuring regulatory compliance from collection to disposal. Facility tours are periodically conducted by Peel staff to ensure that each stage of the biodiesel process is continually running safely and efficiently.
SECTION III: Program Planning

The biodiesel program is a component of the Region of Peel’s Long-Term Waste Management Strategy (LTWMS), which is a 20 year plan that addresses the waste management needs and infrastructure for the municipality’s growing population. The LTWMS is an environmentally responsible strategy that minimizes the potential impacts of the municipally-run waste management system on the natural and built environments, as well as on the health of Peel Region and facility host communities. CRC locations have been effectively located in conveniently accessible areas in an effort to minimize travel time and to best serve Peel residents’ waste management needs.

Since its inception in 2008, the biodiesel program has been a collaborative effort amongst Region of Peel Waste Management Division staff at all levels. Through research and a common interest in developing the program into one which is environmentally responsible and financially efficient, staff have improved both the quality and quantity of the finished product over the past four years. In 2011, all HHW staff completed a two-day training course conducted by Rex Newkirk, PhD., the Director of Biofuels and Feed at the Canadian International Grains Institute and a leader in the biodiesel production process. Informational material, such as handbooks and PowerPoint presentations pertaining to the biodiesel program, are accessible by staff if clarification on any part of the production process is required. Additionally, a Standard Operating Procedure (SOP) is available in hard copy form at the Battleford HHW drop-off location, as well as on all HHW staff computers (see Appendix 1).

Figure 3: Biodiesel undergoing processing.
SECTION IV: Performance, Economics and Cost Effectiveness

Operation Efficiency and Performance

The biodiesel program, through the diversion of waste cooking oil and providing a cost efficient way to power diesel-fueled vehicles, meets the goals of Peel’s LTWMS. Waste disposal costs are kept to a minimum by keeping old cooking oil out of the waste stream, while fuel costs are also reduced by using the same cooking oil to create an alternative fuel that is used to power the aforementioned fleet of Region of Peel vehicles. As no other municipally-run biodiesel program exists in the province of Ontario, it is difficult to assess the relative efficiency of Peel’s program in comparison to others. Currently, the Region of Peel is able to produce an annual average of 30,000 litres of biodiesel.

Program Budget

Sound financial management and careful planning are key elements in the Region’s mandate to provide cost-effective services, especially since the biodiesel program receives no revenue from its operation. Rather, it is used as a cost-effective and environmentally-beneficial means of powering the Waste Management division’s fleet of vehicles.

Costs

The most important material in the production process – waste vegetable oil – is provided by residents of Peel, free of charge. The main costs involved in producing biodiesel include those associated with purchasing additional chemicals required to produce a high-quality final product, as well as the cost of acquiring and maintaining processing equipment. Per 100 litres of biodiesel produced, on average $4 of sodium hydroxide is used, about $26 of methanol, and about $5 of magnesium silicate is used. This equates to approximately $0.55 per litre of biodiesel. The current price of diesel commercially is about $1.30 per litre, which indicates a large price difference between biodiesel and
petro diesel. Last year, the Region of Peel consumed approximately 600,000 litres of diesel within the Waste Management division, so this difference in costs is quite significant.

Table 1: Costs associated per 1000 litres of different biodiesel blends (assuming $0.35/L and $1.30/L for biodiesel and diesel respectively)

<table>
<thead>
<tr>
<th>Biodiesel Blend %</th>
<th>Price to Buy/Produce 1,000L</th>
<th>Savings Compared to 100% Commercial Diesel</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>$1300</td>
<td>$0</td>
</tr>
<tr>
<td>5</td>
<td>$1252.50</td>
<td>$47.50</td>
</tr>
<tr>
<td>20</td>
<td>$1110</td>
<td>$190</td>
</tr>
<tr>
<td>50</td>
<td>$825</td>
<td>$475</td>
</tr>
<tr>
<td>100</td>
<td>$350</td>
<td>$950</td>
</tr>
</tbody>
</table>

Table 2: Percent savings per year using different biodiesel blends (assuming $0.35/L and $1.30/L for biodiesel and diesel as well as a fuel consumption of 600,000 litres)

<table>
<thead>
<tr>
<th>Biodiesel Blend %</th>
<th>Yearly Cost with Biodiesel</th>
<th>Cost of Diesel Without</th>
<th>Percent Savings per Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>$751 000</td>
<td>$780 000</td>
<td>3.7%</td>
</tr>
<tr>
<td>20</td>
<td>$666 000</td>
<td>$780 000</td>
<td>14.6%</td>
</tr>
<tr>
<td>50</td>
<td>$495 000</td>
<td>$780 000</td>
<td>36.5%</td>
</tr>
<tr>
<td>100</td>
<td>$210 000</td>
<td>$780 000</td>
<td>73.1%</td>
</tr>
</tbody>
</table>
Savings per Year Using Various Biodiesel Blends

Figure 4: Graphical Results of Table 2.

Table 1 shows an example of savings if 1,000 litres of fuel is used by Region of Peel vehicles. More significant savings can be obtained using higher blend percentages. Table 2 shows the amount of savings per year with each blend assuming that we are able to produce 30,000 litres of biodiesel in that given year. The second column shows the amount of total fuel that can be mixed at each blend using the 30,000 litres of biodiesel. The plotted graph clearly shows the significant increase in savings as the blend percentage increases. Currently using a 5 percent biodiesel blend, the annual demand for the Region of Peel for diesel consumption can just be met. To accommodate a 20 percent biodiesel mix, the current procedure will have to be amplified to meet the demand and produce four times more biodiesel than the amount that is currently produced at the Battleford CRC. The savings increase as the share of the biodiesel in the blend increases, but, due to manufacturer warranties, we can currently use a maximum of only 20 percent biodiesel blend. With the volume of waste vegetable oil generated by the community, it would not be a problem, both financially and logistically, to increase the production of biodiesel to meet greater needs.
SECTION V: Utilization of Equipment/Systems and Technologies

Bearing mind that the biodiesel production process requires the use of hazardous materials, it is essential that handling and storing these materials are done with the utmost caution. To protect employees and the environment, the Region of Peel has employed the use of the following equipment in the biodiesel program.

Personal Protective Equipment

In accordance with the Region of Peel’s safety policy, all employees working in the biodiesel production area have been provided with and must don the following safety apparel:

- Safety glasses
- Protective gloves
- Safety boots
- Protective coveralls/apron/lab coat
- Face shield
- Dust mask

Collection and Storage Equipment

Once waste cooking oil is received at the HHW drop-offs, it is poured into a 1000L portable plastic tote. Any debris in the oil is filtered out through a mesh filter placed over the top of the tote. Other chemicals and equipment (ie. test tubes) used in the production process are stored in a fire-resistant cabinet. The final product is stored in a tote similar to that in which the used cooking oil is stored. From this storage tote, the finished biodiesel is pumped into fuel storage tanks at the Battleford and Fewster CRCs so that it is accessible to staff needing to refuel their biodiesel-powered vehicles.
Material Handling Equipment

To decrease the amount of energy used to produce biodiesel, some steps utilize a hydraulic lift to help material flow from one drum to another by using the force of gravity. Hoses and pumps are also used to process raw materials until the final product has been created. A pump cart is used to transport the portable tote containing the finished biodiesel to the fuel storage tanks.

Safety Equipment

The biodiesel production area at the Battleford CRC is equipped with an emergency shower and eyewash station. Fire extinguishers and fire blankets are also available in the HHW drop-off. Contained sumps are located in both the receiving and storage areas of the HHW drop-off to collect and spilled or leaking material. All equipment used in the process is rated as explosion proof, including the use of pneumatic pumps, a self contained flow through heater and in areas where there is the potential for a static electricity build-up, the use of grounding wires. Also, the area in which there is a potential for hazardous fume accumulateation is protected with a large fume hood.

Figure 5: Safety Equipment including fume hood, flow through heater and pneumatic pump and cart.
Biodiesel Production Process

As stated previously, Peel’s biodiesel production process involves four main steps: transesterification, separation, cleaning, and filtering (for detailed procedures required to complete each stage, please refer to Appendix 1). Each part of the process is completed in a tank dedicated to that specific stage to ensure that the production flows consistently and efficiently while minimizing the potential for error. Although the production process is not fully automated, it requires very few man-hours, allowing HHW operators to complete other tasks while simultaneously producing biodiesel.

Quality Assurance/Quality Control

In order to ensure that the biodiesel that is produced is of the highest quality, QA/QC is performed at the Battleford CRC, as well as at the Region of Peel’s laboratory. Five quality control tests, namely pH testing, titrations, cloud point measurement, water and impurity testing, and a 27/3 test, are conducted as part of the production process at Battleford CRC. The pH and titration testing verifies the neutrality of biodiesel as well as the presence of excess free fatty acids or unreacted hydroxide. The cloud point test will determine if the produced biodiesel will meet the cold weather demands that it is used in. Water and impurities must be detected if present which will degrade the quality of the fuel. The 27/3 test works on the basis that biodiesel is soluble in methanol while waste vegetable oil is not. If the product separates after being mixed with methanol, then there has been an incomplete reaction. (see Appendix 1 for specific instructions on each method). A sample of the finished product is then sent to the Region of Peel’s laboratory to analyze various parameters to ensure that the biodiesel that has been produced is suitable for use in the Region’s fleet of biodiesel-powered vehicles.
SECTION VI: Worker Health & Safety

Employee health and safety are of the utmost importance to the Region of Peel. It is committed to providing its employees with a healthy and safe workplace and it supports the belief that healthy employees help to create a healthy work environment and, in turn, a healthy work environment enhances the overall well-being of employees.

In accordance with the Occupational Health and Safety Act, the Region of Peel provides its employees with a safe and healthy workplace. Supervisors ensure that staff complies with the Act and its regulations by conducting site inspections and providing staff with monthly safety talks pertaining to safe workplace practices. Safety talks provide a forum for supervisors to educate staff and for staff to ask questions and raise any safety concerns.

Employees are encouraged to participate in the Joint Health and Safety Committee (JHSC) and are provided with training opportunities to become a certified member. Every facility has a Health and Safety bulletin board where information such as the minutes from the JHSC meetings, healthy workplace tips and workplace safety legislation are posted and made available to staff.

Training

All staff that work at the CRCs are trained in First Aid, Emergency Response and the Workplace Hazardous Materials Information Systems (WHMIS). HHW staff members also receive training in basic spill response, the transportation of dangerous goods and have attended the SWANA HHW Facility Management course. HHW staff have undergone a two-day training course conducted by Rex Newkirk, PhD., the Director of Biofuels and Feed at the Canadian International Grains Institute and a leader in the biodiesel production process. The Region of Peel has recently finished a biodiesel production-specific health and safety training module that all employees who work on or around the production area will be required to complete. There are many hazards
associated with biodiesel production, including physical, chemical and ergonomic hazards. While it is not possible to eliminate these hazards completely, it is Peel’s goal to reduce the risk as much as possible.

Staff are trained and educated on modern biodiesel methods. Since our current biodiesel demand is being met, research into new and more efficient techniques can be attempted. With careful quality control and an emphasis on employee safety, an environmentally friendly and high quality fuel can be produced all while diverting chemical waste submitted by the community.

Figure 6: Biodiesel Training with Rex Newkirk
SECTION VII: Public Acceptance, Appearance and Aesthetics

The Region of Peel’s HHW drop-offs are an integral component of the biodiesel program, as they are the sole source of waste cooking oil that is used in the biodiesel production process. Residents who live in the Region of Peel are educated on the proper disposal of waste cooking oil (and other HHW material) via promotional and educational material, such as pamphlets, and by providing an accessible and free disposal service for all municipal hazardous and special waste (MHSW) at the Region’s CRCs.

Peel’s biodiesel program has received substantial media coverage since its inception in 2008. The program has appeared in local newspapers, the Environmental Science and Engineering Magazine, the National Post, and it has been featured on The Weather Network. In 2010, the Region of Peel received a Green Fleet Leadership Award from Fleet Challenge Ontario for recognition of excellence in green fleet management.

The biodiesel production facility is located within the household hazardous waste section of the Region of Peel’s Battleford CRC. Due, to its location, it is readily visible to the public, although the site is kept clean and is landscaped in order to improve its aesthetics. The production area is degreased after each use and is kept in a tidy manner as stated in the SOPs and Health and Safety training. There are regular tours that come through the production area so this is kept as a priority in order to enhance the region’s image.

The biodiesel program is promoted through the Region of Peel website, frontline staff and Powered by Peel Biodiesel decals on Peel biodiesel-powered vehicles. Each year a waste management guide is mailed to residents to ensure they have consistent and up-to-date information about the Region’s waste management services, including the biodiesel program. The Customer Contact Centre associates provide helpful information about services available to residents over the phone. Residents who have online access can visit Peel’s website to find information on all of Peel’s services and departments, including the biodiesel program.
Appendix 1: Biodiesel Standard Operating Procedures

BIODIESEL STANDARD OPERATING PROCEDURES

Methods

Titration:

PPE Required: Face shield, nitrile gloves, tyvek suit (or lab coat) and chemical resistant apron.

- Make sure fume hood is on
- Wear appropriate PPE (face shield, elbow length gloves chemical resistant gloves, tyvek suit and chemical resistant apron).
- If no NaOH solution is premade, measure 1 g of NaOH and add 1 L of distilled water to make 0.1% NaOH solution.
- In a beaker, add 10 mL of methanol and 1 mL of WVO.
- Stir to dissolve.
- Add phenolphthalein as instructed on indicator bottle.
- While stirring WVO solution, add NaOH solution drop by drop until indicator just turns pink and holds its colour.
- The number of drops needed indicates the amount of NaOH needed to neutralize the free fatty acids.

With no free fatty acids, approximately 3.5 g/L of NaOH is needed for the reaction. 1 g/L of NaOH per WVO will need to be added per mL of titrant used.

Ex: 100 L of WVO is to be converted into biodiesel. 3.5 g/L of NaOH is needed so 350 g is added. The titration uses 2 mL of NaOH solution so an extra 2 g/L of NaOH is needed. So for 100 L of oil, and extra 200 g is needed totalling 550 g of NaOH.

Methanol Solution:

PPE Required: Face shield, elbow length chemical resistant gloves, tyvek suit (or lab coat) and chemical resistant apron, N95 dust mask.

- Wheel orange cart out to flammable material shed
- Measure out 25 L of methanol into the mixing container.
- Clean Up any spills.
- Wheel cart back and ensure that the cart is under the fume hood and the fume hood is operational.
- Measure out calculated weight of NaOH while wearing dust mask.
- Add calculated amount of NaOH.
- Mix using the pneumatic mixer for about 20 minutes to dissolve.
Transesterification Reaction:

**PPE Required:** Face shield, elbow length chemical resistant gloves, tyvek suit (or lab coat) and chemical resistant apron.

- Add 100 L of pre-filtered waste vegetable oil into the reaction drum.
- Wheel drum underneath the fume hood.
- Clean any spills or leaks immediately to prevent slips.
- Heat oil to about 60°C.
- With the drum still under the fume hood, add methanol/hydroxide solution by raising the cart (using the foot pump) to a level where the hose valve is above the drum putting the hose into the bung opening and opening the valve.
- Allow to mix for 1 hour while maintaining the temperature.
- Allow brief cooling time then transfer to settling tank.

Settling:

**PPE Required:** Safety goggles, nitrile gloves, tyvek suit (or lab coat).

- Let mixture settle for about 12 hours.
- Glycerol will settle to bottom, drain off and discard.
- Clean any spills or leaks immediately to prevent slips.
- Wash with water as necessary, water will settle on bottom and can be drained off.
- Transfer to next tank for Magnesol filtering.

Magnesol Filtering:

**PPE Required:** Face shield, elbow length chemical resistant gloves, tyvek suit (or lab coat) and chemical resistant apron, N95 dust mask (when working with Magnesol).

The amount of soap that was produced must be determined and filtered out from the biodiesel by adding a sufficient amount of Magnesol. A titration of the biodiesel product can be performed using hydrochloric acid as the titrant and bromphenol blue as an indicator. The dissolved soap will be in an anionic form so the addition of acid will neutralize the charge. Once sufficient HCl is added, all of the soap will be neutralized and additional acid will begin to alter pH and show in the indicator.

- Place flask on scale and measure out 10 g of sample to be tested.
- Add 100 mL of isopropyl alcohol and 12 drops of bromphenol blue.
- While swirling the flask, add drop wise 0.01M HCl.
- Once indicator just starts to and remains yellow, record amount of HCl used.
- Calculate concentration of soap in ppt thus determining about how much Magnesol is needed.
Calculation:

\[
\text{ppt soap} = \text{HCl (mL)} \times 304.4 \\
\text{% Magnesol by weight of WVO} = \text{soap ppt / 1000} \\
\text{Weight of WVO} = (\text{WVO in L})(\text{WVO density in kg/L})
\]

Amount of Magnesol needed = (%Magnesol)(weight of WVO)

Ex/ 100 L of WVO at a density of 0.87 kg/L is 87 kg. If 1mL of HCl is used in the titration then the ppt of soap is 304.4. The percent of Magnesol would be 304.4ppt/1000 equalling 0.3044%. That percentage times 87 kg of oil is 265 grams of Magnesol.

- Add the calculated amount of Magnesol into filter.
- Turn on pump and circulate for about 30 minutes.
- Transfer biodiesel to final tank for final filtration and quality control.
- Clean any spills of leaks immediately to prevent slips

Quality Control

Since the biodiesel is being used in Regional vehicles, it is important to perform extensive quality control to prevent any impurities being added to the straight diesel.

pH Testing:

A pH test can be performed on the finished biodiesel to determine if there is any residual catalyst present. Clean biodiesel should be pretty close to a neutral pH. If a high pH is recorded than there are hydroxide ions left that didn’t separate out with the glycerol. Caustic fuel can cause corrosion in fuel systems and should be avoided. Washing gently with water should help to pull the hydroxide out of the fuel. Make sure that appropriate time is allowed to allow separation of the waste water. If the fuel measures acidic then it is an indication that there are free fatty acids still present. A sodium hydroxide titration can be performed to determine if this is the case. Further Magnesol filtering or water washing may help to pull out the acids. If not than calculated treatment may be needed with more sodium hydroxide.

Titrations:

Titrations can be preformed to determine if there is any free fatty acids left or if there is any soap not filtered out. Follow the titration procedure for determining soap concentration. If soap is still present then further Magnesol filtering is needed as well as more water washing should dissolve the soap and wash it out. If there are still free fatty acids then it may need to be treated with more sodium hydroxide.

Cloud Point Measurement:
A cloud point measurement can be taken to see how the biodiesel handles cold. If the initial vegetable oil was high in saturated fats, then the final product may solidify in cold weather. B100 is not appropriate to use in cold weather no matter how well it is produced, so try doing a cloud point test on B20. To make B20 just mix 80mL of clear diesel with 20mL of your biodiesel and place this mixture in a freezer. If your B20 can handle cold temperatures without becoming cloudy, then it should be fit for RoP vehicle fuel systems.

Water and Impurity Test:

Water is denser than biodiesel and will eventually settle out of the fuel. To hasten this process, a sample of biodiesel is spun in the centrifuge. First, fill a centrifuge tube with your biodiesel sample and place it in the centrifuge. Make sure that the centrifuge is balanced, either with another sample or a water blank. Spin at high speed for about ten minutes. If there is any water in the sample, it will have been pushed to the bottom of the tube creating a distinct water phase. In addition to water, other heavier impurities will also be pushed to the bottom of the tube. Sediment would suggest that further filtration of Magnesol would be needed. If there is water still present in the diesel than not enough settling time was given after washing. If your fuel has an orange juice opacity, then it is still full of water and more settling time is needed. Specifications dictate that there must be less than 0.05% of water or sediment in biodiesel. See time elapsed figure below for water separation.

27/3 Test:

The 27/3 test is a great, quick test for qualitatively determining the completeness of the transesterification reaction. It works on the simple principle that biodiesel is soluble in methanol while WVO is not. If there is only partial conversion of the vegetable oil to biodiesel, small globules of vegetable oil will be observed at the bottom of the tube.

In a centrifuge tube, add 3 mL of your biodiesel to 27 mL of methanol. Shake the sample well and then let settle. If a density gradient is not formed, there has been complete conversion.
Biodiesel Theory

Biodiesel is a biofuel derived from plant oils and animal fats through a reaction with an alcohol. This process, called transesterification, converts the lipid molecule - a triglyceride, featuring three long-chain fatty acids bonded to a glycerol backbone (Fig. 1) - into three discrete fatty esters and one glycerol.

\[
\begin{align*}
\text{CH}_2\cdot\text{O}\cdot\text{C}\cdot\text{R}_1 \quad & \quad \text{CH}_3\cdot\text{O}\cdot\text{C}\cdot\text{R}_1 \\
\quad & \quad \text{CH}_3\cdot\text{OH} \\
\text{CH}\cdot\text{O}\cdot\text{C}\cdot\text{R}_2 + 3 \text{CH}_3\text{OH} \rightarrow \quad & \quad \text{CH}_3\cdot\text{O}\cdot\text{C}\cdot\text{R}_2 \quad - \quad \text{CH}_2\cdot\text{OH} \\
\text{CH}_2\cdot\text{O}\cdot\text{C}\cdot\text{R}_3 \quad & \quad \text{CH}_3\cdot\text{O}\cdot\text{C}\cdot\text{R}_3 \\
\quad \quad \text{triglyceride} \quad \text{methanol} \quad \text{mixture of fatty esters} \quad \text{glycerol}
\end{align*}
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Figure 1: Transesterification Reaction

The transesterification reaction is a two part process. First, a catalytic amount of sodium hydroxide is completely dissolved in methanol to form sodium methoxide. The sodium methoxide is then added to the waste vegetable oil (WVO) – the primary feedstock for the Region of Peel’s biodiesel program. Though the transesterification reaction is thermodynamically unfavourable, the addition of heat, agitation, an excess of methanol, and the removal of glycerol are used to drive the reaction forward.

The freed fatty esters form a liquid that is much less viscous than the incipient lipids, and are thus more desirable for use in conventional fuel systems. The viscosity of the fuel itself is determined by the liquid’s temperature; length of the fatty ester’s alkyl chains; and the degree of their unsaturation (the number of double-bonds present in the alkyl chains) (Fig. 2). Shorter alkyl chains (R-groups) and higher degrees of unsaturation result in lower viscosity oils which present lower risks of solidifying at lower temperatures.

Figure 2: Saturated and Unsaturated Alkyl Chains
Since our WVO feedstock comes from a variety of sources, care must be taken to screen low quality or undesirable lipids. Solid fats, overly viscous vegetable oils, extremely darkly coloured oils, and oils with a definite watery phase should not be used as a feedstock.

When vegetable oils and fats have been subject to the intense heat involved in deep frying, the resulting oil can be deformed and broken apart. Often, fatty acids will be cleaved from the glycerol backbone, generating free fatty acids (FFA’s). These FFA’s can cause problems during the biodiesel process because they consume the catalyst, significantly slowing or halting the transesterification reaction. Therefore free fatty acids must be neutralized with excess sodium hydroxide so the transesterification may proceed uninhibited.

A titration is performed to determine the amount of FFA’s present in the oil and thus how much excess hydroxide is required for FFA neutralization (see Titration Method). These titrations must be performed carefully, in triplicate, to ensure an accurate amount sodium hydroxide is calculated for each specific batch. Excessive additions of NaOH will result in saponification of the WVO; and a dearth of NaOH will translate into poor yields.

Generally, oils subject to higher cooking temperatures and longer duration of use will have higher concentrations of FFA’s. This oil – which is usually very dark in colour - is a poor biodiesel feedstock due to its low yield potential and the significant added cost of large scale FFA neutralization, and should not be used as a feedstock.

After sufficient reaction time has elapsed under the correct conditions, all the fatty acids will be stripped off of the glyceride backbone and converted to methyl esters, biodiesel. The primary by-product, glycerol, is denser than biodiesel and will sink to the bottom of the tank over time, forming a distinct dark-brown phase. This liquid will also contain glycerol-soluble molecules, like unreacted methanol, and precipitates, such as soap. After a sufficient settling time, the by-products are drained from the tank.

Impurities remaining in the biodiesel are removed by washing the biodiesel. The HHW biodiesel program employs two methods of biodiesel washing – water washing, and dry washing. The water wash entails adding a large volume of room-temperature water to the fuel, in which polar molecules, i.e. soap, methanol, glycerol, preferentially solubilize. A significant separation time must be allowed for this step to allow emulsified biodiesel to exit the aqueous phase, lest the product be lost when the water phase is drained. In most cases, three water washes are performed.

The dry wash method involves adding a finely ground adsorbant, magnesium silicate (Magnesol™), to the biodiesel under constant agitation. The adsorbant removes trace water, methanol, soap, and other charged molecules from the biodiesel and is easily filtered to yield the clean final product.
Peel's Community Recycling Centres

Used Cooking Oil & Biodiesel Fuel

The Region of Peel has developed a new waste management program that accepts used cooking oil from residents at Peel's Community Recycling Centres where it is converted to biodiesel fuel for use in Regional vehicles.

Peel residents and small business may drop off up to 120 l (32 gal.) of used cooking oil per day at any of Peel's Community Recycling Centres (CRCs), free of charge. The oil is put through a four stage conversion process that involves transesterification, separation, cleaning and filtering, before the final product is created.

![Conversion Process]

Used cooking oil collected at Peel's Community Recycling Centres goes through a four stage process before it becomes biodiesel.

The biodiesel is used in the Waste Management Division's car and light truck fleet, which has been given a new look and is clearly identified with Powered by Peel Biodiesel decals. The vehicles use an even mix of biodiesel and petrodiesel in warmer temperatures, and a 20 per cent biodiesel mix during the winter months.
Regional vehicles that are Powered by Peel Biodiesel are easy to spot on the roads.

Biodiesel is a biodegradeable fuel that can be used to power diesel-engine vehicles. It's made from biological sources such as vegetable oil, used cooking oils and animal fat.

When compared to the petrodiesel used in most vehicles, biodiesel fuel...

- burns cleaner,
- emits fewer toxic compounds into the air,
- decreases ozone, and
- decreases smog.

Waste Diversion as seen on the Weather Network

The Waste Diversion segment featured on The Weather Network gives a guided tour of the biodiesel creation process at one of Peel's Community Recycling Centres.

Disposing used cooking oil

Used cooking oil should never be poured down the sink, drain or toilet because it can negatively impact the system of sewer pipes in your home and neighbourhood, causing sewer backups.

Peel residents and small business may drop off up to 120 l (32 gal.) of used cooking oil per day at any of Peel's Community Recycling Centres (CRCs), free of charge.

Residents who are unable to dispose of their used cooking oil at a CRC should freeze it or let it harden, and dispose the frozen or hardened oil in their organics recycling green bin.

The Region is currently diverting more than 45 per cent of Peel's waste from disposal. With your continued support and participation, we are moving closer to our target of diverting 70 per cent of waste from landfill by 2016.

http://www.peelregion.ca/pw/waste/crc/cooking-oil.htm 11/04/2012
2012 Applications must be submitted to SWANA no later than Friday, April 13, 2012

*** PLEASE NOTE THAT ENTRY REQUIREMENTS HAVE CHANGED ***

Application Checklist (Please make sure the following items are included in your submittal packet)

- Completed release statement (this page), to be scanned and included in digital submission
- Check (made payable to SWANA) or credit card payment for nomination fee (in U.S. dollars) via Excellence Award Nominations
- At least 2 pictures of your operation (may be included in nomination text)
- One copy of your award submittal uploaded using your purchased 2012 SWANA Excellence Awards Application Uploading Instructions
- If you would like to mail your submission, please contact Jesse Maxwell, Program Coordinator, at jmaxwell@swana.org or (240) 494-2237.

Release Statement: I certify that the information provided in this application is accurate and correct to the best of my knowledge. SWANA reserves the right to publish the enclosed information. Nominations become the property of SWANA. My signature gives SWANA the right to reprint or make available for purchase any portion of this submittal.

Signature: [Signature] Date: 04/11/2012