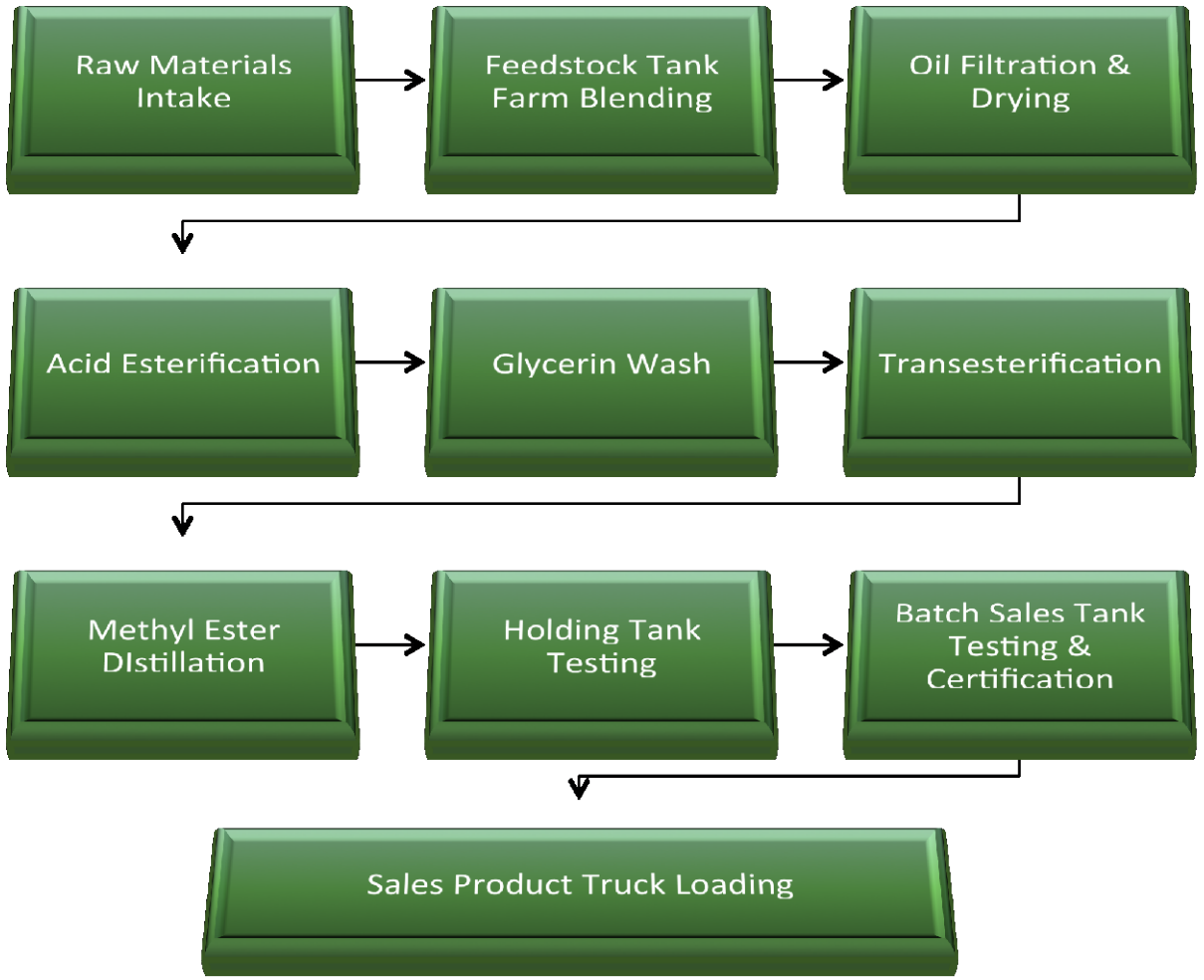
Plant Process



Plant Process

- **(1) Raw Materials Intake**

Raw materials are accepted at Invigor in several forms. Our process makes use of bulk materials of feedstocks, methanol, sodium methoxide and sulphuric acid. Also, smaller volumes of anti-oxidant additive are used.

The bulk materials are delivered by tanker truck. Once on site, bulk trucks are directed to our offloading platform, and connected to the piping appropriate for the material. For methanol and sodium methoxide, Invigor provides trucks with a nitrogen gas blanket for offloading.

The offloading pumps, valves, and tanks can be directed from the main control room, or from a panel at the offloading area.

- **(2) Feedstock Tank Farm Blending**

Feedstock materials can be directed from the offload piping to any of seven different holding tanks. This allows Invigor to blend feedstocks to achieve optimal input material for our process, while still allowing the acceptance and purchase of low grade and cost effective raw materials to maximize profit margins.

By using Invigor's on-site laboratory, all incoming feedstock is tested. The lab is then able to determine a blend ratio that can keep our process running smoothly, while at the same time incorporating cheaper feedstocks that may be below our quality threshold by themselves. The blending process is directed from the main control room, using radar level detection transmitters and automatic valves to achieve the targeted blend ratios.

- (3) **Oil Filtration & drying**

The first stage of our biodiesel production process is the filtration and preparation of the feedstock. Lower-quality feedstocks often contain large amounts of moisture, which can adversely affect the acid esterification process. To rectify this issue, the incoming feedstock is fed into an oil drying system.

Feedstock is pumped from the tank farm into the process building and through a series of filters to catch any larger particulates or insoluble materials. After the filtration, it is sent to the dryer, and steam heated to approximately 230 degrees Fahrenheit. In our oil dryer, water and other undesirable volatiles are evaporated, and the dried oil is sent to a temporary holding tank, ready to be fed through the acid esterification reactor.

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- (3) **Oil Filtration & Drying (cont'd)**

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During transfer to the dry oil tank, excess heat is removed from the oil utilizing an economizer heat exchanger, cooling the exiting oil, and preheating the fresh feedstock. Invigor utilizes several such systems to keep our plant operating as efficiently as possible.

- (4) **Acid Esterification (AE System)**

Cheaper, low-quality feedstocks often contain higher percentages of free fatty acids (FFA's) than their more refined counterparts. This is a problem for processes utilizing only base-catalyzed transesterification. We employ an acid catalyst process prior to the main trans-esterification process to more-fully and efficiently process high FFA feedstocks.

Low-quality, dry oil is prepared for trans-esterification (the major unit operation for producing methyl ester (biodiesel)) by converting 90 to 95 percent of FFA to ME in the acid esterification process. Dry oil, methanol and a small amount of sulfuric acid (catalyst) is fed into the AE reactor where the acid esterification reaction occurs over a four-hour period. All materials are then transferred to a settling tank.

During settling, a wet esterified oil layer (bottom) and an acidic methanol layer (top) will begin to develop and mature over another period of four hours. Some of the acidic methanol is sent back through the acid esterification system and reblended with fresh reactants to increase efficiencies, and the oil layer is sent to a glycerin wash system for final preparation for the trans-esterification reaction.

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- (5) **Glycerin Wash**

Further processing of the oil is required following the AE reactor and settler to remove moisture, residual mineral acid, residual FFA and other impurities that could inhibit the basic methylate catalyst reaction. The wet esterified oil from the AE reaction is combined with glycerin coming from the trans-esterification reaction, fully described in step six. These two streams are thoroughly mixed, and then decanted. A dry esterified oil layer will rise to the top and a glycerin layer will sink to the bottom, converting the residual acids and pulling impurities and moisture out of the oil. The dry esterified oil layer that results from the decanting is now ready for the trans-esterification reaction.

The bottom glycerin layer is transferred to a mix tank, where it will be mixed with acidic methanol from the AE reaction. This mixture is neutralized and then transferred for processing to recover excess methanol and purify the glycerin.

- (6) **Trans-esterification (TE System)**

The main reaction in the conversion of oil to biodiesel is called trans-esterification. The trans-esterification process reacts an alcohol (methanol) with the triglyceride oils contained in vegetable oils, animal fats, or recycled greases, forming fatty acid methyl esters (biodiesel) and glycerin. The reaction requires heat and a strong base catalyst (sodium hydroxide).

Invigor utilizes a two-stage trans-esterification reaction system, or what is sometimes referred to as an 80-20 system. In the first stage, a reaction rate of approximately 80% is the goal. Invigor utilizes a state of the art automatic dosing system incorporating smart valves, variable flow pumps, and Siemens Coriolis Mass Flowmeters to precisely measure the reactants introduced to the TE system. All resulting fluids are then transferred to a settling tank, where all the lighter methyl esters and un-reacted esterified oils rise to the top, and are sent to the second stage for further refinement. The heavier settled layer is the glycerin byproduct. This glycerin is sent back into the Glycerin Wash system for further processing as needed, and the rest is transferred to the Glycerin neutralization tanks for processing and purification.

The second stage of the TE System targeting the remaining 20% is almost identical to the first, only the chemical doses are further refined, as there is less of a reaction remaining. This two-stage process has been proven to be a much more efficient way of achieving the highest reaction rates with the lowest impurities, in the lowest amount of time.

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- **(7) Methyl Ester Distillation**

Methyl ester distillation is regarded as the optimal process to make the purest possible biodiesel. By distilling methyl ester (biodiesel) into its vapor phase, it can leave behind most of the “bad actors” which cause problems in ASTM testing. Also, with distressed feedstocks, such as used cooking oil or brown grease, it is the only effective way to remediate the typical dark color of these feedstocks. Finally, it is the separation technique that has any reasonable impact on final product sulfur content.

Invigor Bioenergy utilizes a process that breaks the distillation into four major stages. First, crude methyl ester from the transesterification reactors is “flashed” under atmospheric conditions and temperatures of 130-150°C to remove most of the residual methanol. After this initial flash, the remaining methanol, moisture, and other low-boiling compounds are then removed in the flash deaerator. Temperatures are around 150°C, in a vacuum environment. Heat is provided primarily by interchange with hot ester from the main still packed condenser section, again utilizing an economizer heat exchanger to limit waste energy as much as possible.

After flashing off the low-boiling compounds, the methyl ester liquid enters the stripping column and is heated to approximately 180°C. Here, the hot ester trickles down through the packing, absorbing ester and releasing smaller contaminant gases. When the liquid reaches the bottom of the stripping column, it is further heated to around 215°C. At this temperature, residual glycerin will auto-catalytically react, as will residual elemental sulfurs and sulfides. The vapors resulting from these reactions pass up and through the column.

Finally, the hot reacted ester is now ready to be distilled. It is pumped from the bottom of the stripping column into the bottom heating loop of the main still. The ester is heated up to 240°C under a vacuum, where the vast majority of the methyl ester vaporizes and heads up the column. “Bad actor” residues are left in the bottom of the column. As the vapor passes through the first packed section, excess color bodies, monoglycerides, and sulfurs, are washed out. From this lower packing, the vapor passes up into a packed condensing section which uses condensed, sub-cooled ester to condense the ester vapor and discharge the condensate at high temperatures near its boiling point (165-185°C). This hot ester then becomes instrumental in preheating the feed to the deaerator, the stripping column, and, if desired, the initial methanol flash-off of the reactors. Once the hot ester has surrendered most of its useful heat, it is transferred to the Shift Holding tanks for testing.

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- **(8) Holding Tank Testing**

Before any produced biodiesel is transferred to the large batch tanks for testing, it is held in a series of “Shift Tanks”. Once one of these tanks is full, several critical tests are performed on the product to ensure that everything is meeting ASTM specification. These “shift tanks” are integral in Invigor’s quality management system, as they provide an intermediary testing stage for our finished product. In the unlikely event that biodiesel in these tanks is found to be outside of ASTM specification, the biodiesel can be transferred from these “shift tanks” back into our facility for reprocessing.

This ability for Invigor to reprocess off-spec material, means that even if a system performs inadequately, no finished product is lost. The off-spec material, tested and identified as to what ASTM quality it is lacking, is slowly blended back into the plant’s in-process stream.

This blending can occur at two different stages, depending on the ’weakness’ in the product. If a higher reaction rate is required, the off-spec material is injected back into the second stage of the TE System, and through the rest of the plant. If it is an impurity issue, the off-spec material can be re-routed to simply pass through the Methyl Ester Distillation process again, slowly blended into the existing product stream.

- (9) **Batch Sales Tank Testing & Certification**

Once the product biodiesel in the Shift Tanks passes Invigor’s quality tests, it is transferred to one of our 3000bbl Batch Sales Tanks. As a major part of our quality management process, Invigor has four of these large batch tanks. Our final product biodiesel is collected in these tanks, and once full, the batch is put through all critical ASTM testing, per BQ-9000 standards.

BQ-9000 Quality Management Policy calls for several “Critical Tests” that must be performed on every biodiesel batch for a Certificate of Analysis to be issued. Invigor has designed its quality management system to accomplish all these critical tests on-site at our facility, in our quality control and process laboratory. This capability means that Invigor controls the timelines and logistics that are necessary to ensure all product is shipped exceeding ASTM quality standards, and done so on time.

Once a batch has passed the full spectrum of required testing, the results of the testing for that batch are issued in a Certificate of Analysis, which is issued with every load of biodiesel leaving our facility. Our quality management system allows for full traceability of our product, including the feedstock batches it was derived from, to ensure our customers can have full confidence in the product we deliver to them.

Plant Process

- **(10) Sales Product Truck Loading**

Invigor has two sales product truck loading systems, both approved by Alberta Weights and Measures for the sale of biodiesel. These systems utilize Coriolis mass flowmeter systems to measure not only flow velocity and volume through the meter, but also product mass. This advance technology gives Invigor the ability to load trucks by final volume or by final weight, whichever is preferred by the customer.

Once loaded, the trucking company is issued a Bill of Lading with the loading system printouts, and a Certificate of Analysis that matches the loaded biodiesel batch. A sample of the loaded material is taken and retained by Invigor for quality assurance purposes, and the load is sealed with a numbered lead seal to prevent any tampering along the delivery route.