



## **Krohne Automation Solutions for Biofuels Industry**

**This guide is designed to provide some background on the technologies involved, the potential for this growing market, the processes and the applications where Krohne measurement solutions can be used.**

## Introduction

An industry segment showing a large growth in recent years has been the production of Biofuels. Biodiesel and Bioethanol are the two strategic products produced from agricultural based crops and are the world's attempt at reducing the reliance on fossil fuels. These processes are well known but it is only recently that investments on a large scale are making the production of these fuels economically viable.

KROHNE has been working together with some of the world's major companies in this industry and has been supplying measurement solutions in the process and custody transfer measurements in many plants worldwide. Our instruments have been accepted as the workhorse for process measurement (flow, level, temperature, pressure) solutions e.g. Our Coriolis meters are reliable flow measurement devices which measure the mass flow independent of the temperature, density and viscosity of that product, unlike volumetric flow meters. They also provide the added benefit of being able to measure the density and temperature of the product thus making it suitable to use for volumetric calculations (as many traditional standards still require) as well as the capability of measuring the density of the fluid. This can be used to calculate the concentration of a product mixture for quality control purposes or determine glycerine purity or catalyst strength.

KROHNE has developed the well known OPTIMASS range of Coriolis meters which are eminently suitable for this industry with many meters installed to date. The pioneering OPTIMASS 7000 series single straight tube meter is ideal for measuring the flow of viscous glycerine, a by-product of Biodiesel production or % solids, syrup etc on Bio-ethanol process. Optimass & Optisonic solutions are also in use on Custody Transfer /fiscal metering of blend products (E100, B100), blending skids (E10, B2 etc), oil feedstock, rawmaterial unloading & phase separation.



A fiscal metering station complete with air eliminator and a batch controller.

**KROHNE is a competent partner in this business and has 80 years of process measurement experience to back this up.**

## What are Biofuels?

Biofuels are fuels produced from agricultural crops such as soybean, corn, peanuts, olive oil, sunflower, rapeseed, sugar cane or sugar beet and many more. Biofuels can also be produced from MSW, corn stovers, switchgrass, biomass, wood chips, algae oil, etc.

The two fuels produced from crops are mainly bioethanol, mostly from corn, wheat, cane etc and biodiesel, from rape-seed, soy, palm, cotton seed, etc.

This technology is gaining attention in the North America after reaching a considerable level of success in Europe. It is also gaining popularity elsewhere in the world, where governments are trying to reduce their reliance on fossil fuels and boost the local agri economy.

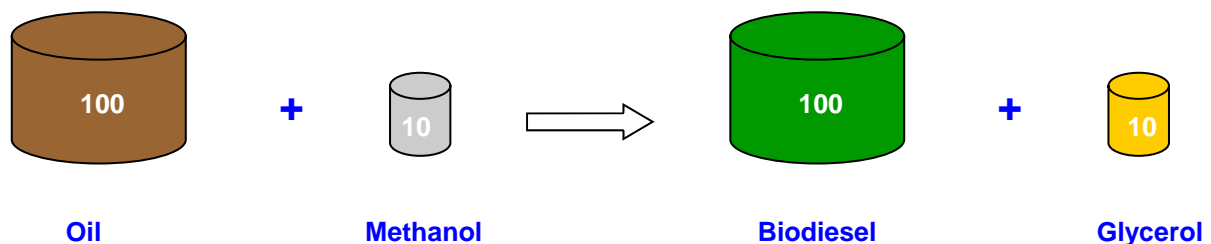
MTBE has been added to petroleum fuels for years to boost the octane levels, today it is being banned and substituted with ethanol. Biodiesel can be used in most diesel engines without requiring extensive modifications. It is also being added to standard diesel in small percentages (B2, B5 blends) to enhance lubricity of low sulfur Diesel.

## How Biodiesel is made?

The basic process is chemically reacting a fat or oil (vegetable oil) with an alcohol, in the presence of a catalyst. The result of this reaction is a mixture of methyl esters, known as biodiesel and glycerol, which is a high value co-product. This glycerol can also be further refined to a high end pharmaceutical grade glycerine.

This main process reaction is known as **esterification** (base-trans or acid).

The basic relationship for the prediction of biodiesel from fats and oils is as follows:



**There are typically five steps in a typical biodiesel process. These are:**

- Single or Two stage reaction to make biodiesel
- Separation of the biodiesel after trans-esterification
- Purification of the biodiesel & byproducts ( Glycerin, soap, etc)
- Methanol (or water recovery) from all products and by-products
- Feedstock pre-treatment ( Degumming, neutralization, refining etc) for mutifeedstock processes

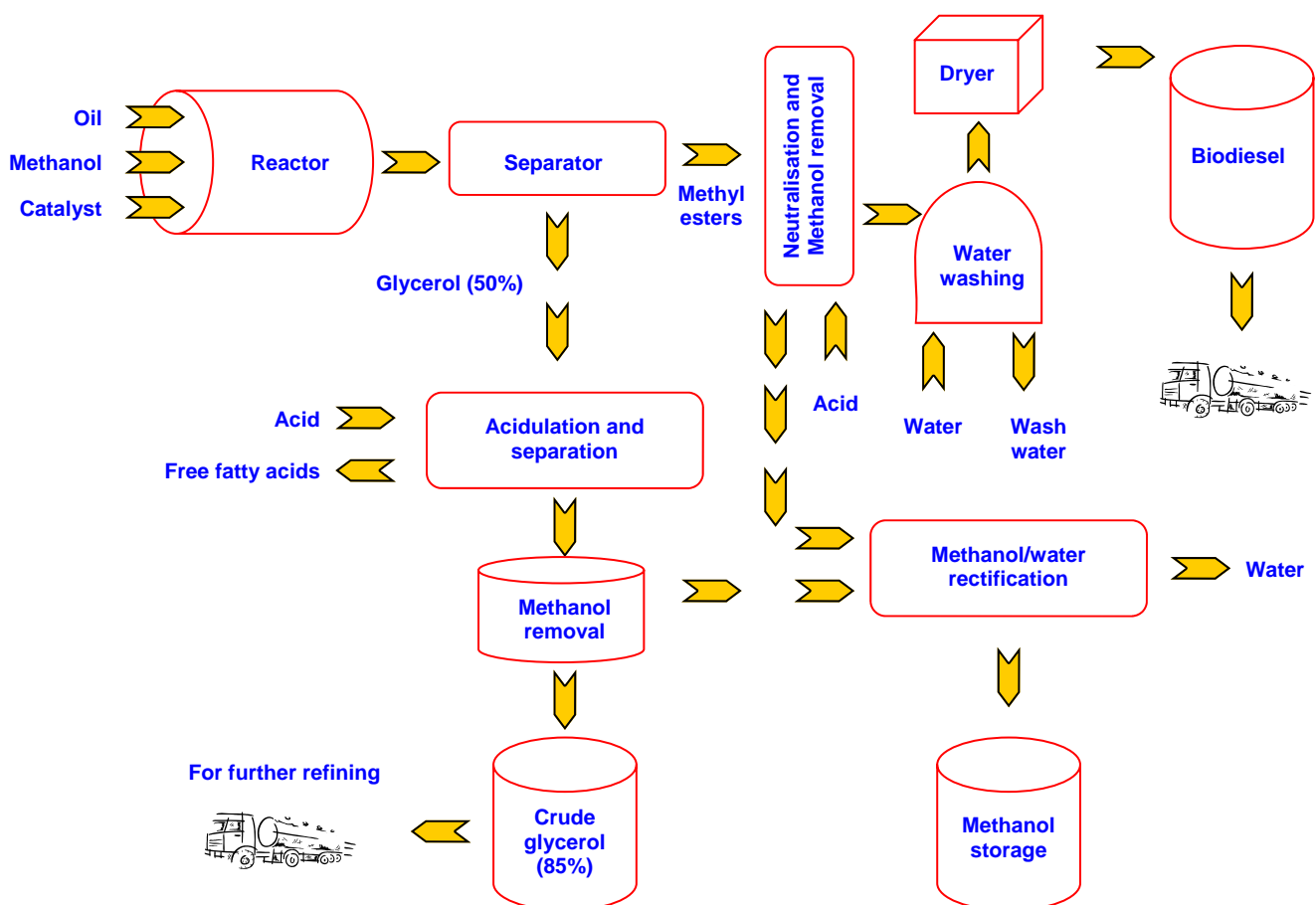
## A typical plant and schematic for biodiesel

Most new plants are designed for continuous biodiesel production and the various stages are all interdependent. Most processes use alkali catalyst based transesterification where oil, catalyst and alcohol are combined in a reactor and agitated at temperature. The reaction is sometimes done in two steps where approximately 80% of the alcohol and catalyst is added to the first stage reactor. The product stream from this reactor then goes through a glycerol removal step before entering a second reactor. The remaining 20% of the alcohol and catalyst is then added thus providing a complete reaction with the potential of using less alcohol. Following this reaction, the glycerol is removed from the methyl esters. Due to the low solubility of glycerol in the esters, this separation generally occurs quickly and may be accomplished with either a settling tank or a centrifuge. Water is sometimes added to the reaction mixture after the transesterification to improve the separation of the glycerol.

After separation from the glycerol, the methyl esters enter a neutralisation step and then pass through a methanol stripper before water washing. Acid is added to the biodiesel to neutralise any residual catalyst. The water washing step (if used) is intended to remove any remaining catalyst, soap, salts, methanol, or free glycerol from the biodiesel. After the wash process any remaining water is removed from the biodiesel by a vacuum flash process. Water washing is fast replacing with magnesol purification as a preferred choice

The glycerol leaving the separator is only about 50% glycerol and still contains the excess methanol, catalyst and soap. This then needs further refining.

The methanol that is removed from the methyl ester and glycerol streams tends to collect any water that may have entered the process. This water is then normally removed in a distillation column before the methanol is returned to the process.



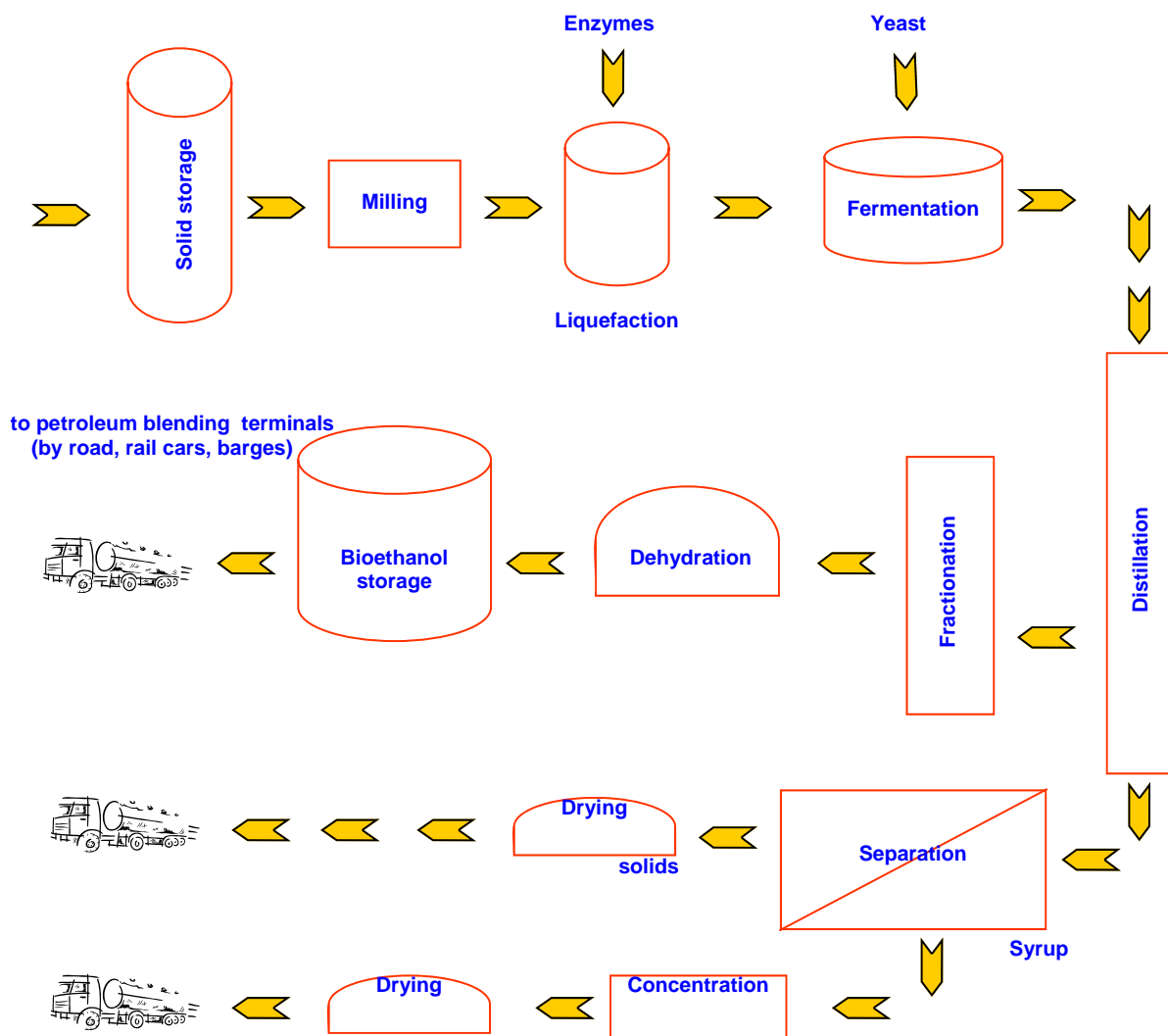
## A Typical plant and schematic for bioethanol

The production of bioethanol is typically a batch process where time has to be allowed for fermentation of a sugar based product (cane or beet). It is a relatively standard process which is well known. Production needs to be on fairly large scale to make it economically viable. Brazil has been at the forefront in Bioethanol production for many years and a large percentage of their sugar cane crop is turned into bioethanol and used as an additive to petroleum.

Bioethanol can also be made from a variety of different crops specially grown for this purpose. These include corn, maize, wheat crops, waste straw, willow and polar trees, various grasses, sorghum plants etc.

The processing is done by milling the product, passing it to a liquefaction process where enzymes are added. This liquid is then passed on to a fermentation stage, where the product is allowed to ferment where the dilute ethanol is produced (ethyl alcohol). From here it is distilled and the light fraction (ethanol) is sent to a fractionation process and eventually through dehydration before being pumped to storage as bioethanol. CO<sub>2</sub> released during fermentation is sometimes captured and liquified for sale as a byproduct

The heavier fractions from the distillation process is sent through a separator where the stillage is centrifuged and solids dried then sent to storage for further uses. The syrup component is concentrated, then dried and stored for further use as DDGC. Very little goes to waste as most of the by-products are used.



## KROHNE Solutions for a Biodiesel Process

As mentioned before, the main flow products in a biodiesel plant are normally Coriolis meters. Many other measuring points are also required such as steam flow, level and pressure measurement. KROHNE is your competent partner for these measurements. Volumetric measurements can be accomplished with UFM, MAGs

### The Coriolis family of meters - Optimass

**1000 Series**      The general purpose process meter for the continuous measurement of feedstock, esters & transfer between process stages. Available in 4 sizes with duplex SS as wetted parts.  
Max. Temp. 130°C/266°F  
Pressure rating 100 Bar/2540 psi.



**7000 Series**      The meter for the high accuracy transfer of product, density and concentration measurement as well as for the Custody Transfer, catalyst addition or glycerin loadout. Available in 7 sizes for process applications. Also suitable for phase separation control of methylester/glycerol. The CT version available in 5 sizes and certified to OIML R117 Accuracy class 0.3. Temperature to 150°C/302°F. Pressures up to 100 bar/2540 psi. Wetted materials available are Titanium, Hasteloy C22 and duplex SS.  
**Note: Titanium is not compatible with Methanol as contact with methanol leads to stress corrosion.**



**8000 Series**      The high temperature meter for the flow of product to and from the distillation Processes and applications where temperatures are above that which can be handled by the 7000 Series. Available in 5 sizes from 15mm/1/2" to 100mm/4". Pressures up to 200 bar/5080 psi. Temperatures from -180 to 230°C/-290 to 446°F



## Approvals and certification

As a reputable supplier of process instrumentation and solutions, all KROHNE Optimass meters are approved for use in hazardous area locations and carry certificates from ATEX, FM & CSA. All products also comply with the requirements of the European Pressure Equipment Directive (PED) as well as design approvals to ASME.

The Optimass meters are calibrated to the highest levels of traceability in a UKAS accredited laboratory. In addition the 7000 CT Series are also approved for use in Custody Transfer applications to OIML R117 to the highest accuracy class 0.3 for mass and volume flow.

### Hazardous Area



**Approvals**  
Quality System Registration



All our calibration rigs are certified and traceable according to NIST / ISO standards

## Communication options for the control system



## What do the plants look like?

There is a lot of similarity to the chemical plants that KROHNE has been supplying for 80 years!



Biofuel plant under construction



Separation process

## Bio Ethanol Applications

The applications are many and varied. Mostly the product movement between sections of the process is important to maintain maximum efficiency, particularly in continuous processes.

% Solids measurement is important in slurry preparation, liquefaction process before fermentation and also syrup draw. This determines the amount of enzymes & yeast addition and efficiency of extraction. This also minimises the wastage of enzyme & yeast which are the expensive ingredients. Syrup control on evaporator draw has demonstrated significant energy savings by improving dryer efficiency significantly.



Steeping Feedstock flow in a wet milling bioethanol plant



Fermentation feedstock( liquefied mash) in a Dry Grind bioethanol plant

## Custody Transfer Applications

Biodiesel and Bioethanol like all other fuels qualify for tax credits. Accurate measurement of the transfer is therefore important as the correct credits need to be paid and also for precise inventory control. Further the purchaser of the biofuel needs to be confident that what he is paying for is the correct quantity. This measurement can be done volumetrically or by mass. (weight).

KROHNE has a wealth of experience in this field and would be happy to advise contractors and end users on the best method of installing the flow meter and the ancillary equipment to get the best performance from the measuring system. Our solutions encompass high performance coriolis( mass) and UFM( volume) meters



**Top: Meters installed in a Custody Transfer application. Note the air eliminators upstream of the flow meters.**

**Right: Meters installed in a facility for the measurement of fuels.**



**Left: A mobile volumetric calibration system to verify the meters after installation. Normally witnessed by a representative from the local weights and measures authority .**

## Additional solutions from KROHNE

### Flow



Magnetic Flow meters  
In a wide range of materials and sizes



Ultrasonic flow meters



Vortex flow meters for the utilities. Built in pressure and temperature compensation for steam and air flow measurement.



Variable area flow meters for local indication with a wide range of options and materials.

### Level



Radar level for those difficult applications where non contact is preferred



Guided Radar or TDR level for those applications where interface measurement is also required. Ideal for separation processes.



Level switches/Gauges for tank indication/overflow protection

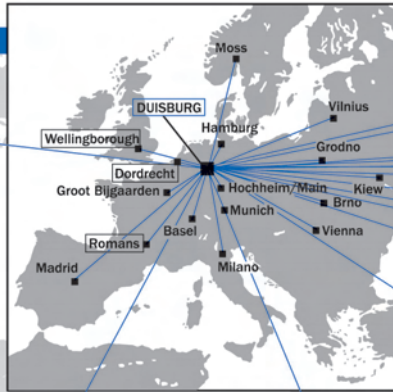


Pressure & Temperature "SMART" transmitters

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