PENN STATE EXPERIENCES: BIO-BASED LUBRICANTS, B100 & SVO
New England Farm Energy Conference
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Farm Operations & Services
Penn State
University Park, PA
email
PSU Farm Operations & Services

- Services to the College of Agriculture
  - Farms ~1,500 acres of cropland
  - Hay, corn, soybeans, oats, wheat, cover crops
  - Gaining experience with crops for biomass & biofuels
  - Manure hauling & spreading
  - Bussing for laboratory classes
  - Operates agricultural arena
  - Supports research, education and outreach
Gaining Experience with New Crops

- **Biomass**
  - Switchgrass
  - Sudan grass
  - Miscanthus

- **Biofuels**
  - Camelina
  - Canola
  - Flax
  - Safflower
  - Sunflower
  - Biodiesel
Penn State Experiences

- Bio-based hydraulic oils
- Biodiesel blends and B100
- Straight vegetable oil
Most farms are highly self-sufficient in food & energy.

Farm energy is 100% renewable: biomass, wind, water, animals.
Early 1900’s

1900
- Rudolph Diesel demonstrates his new engine at the World’s Fair in Paris, running on peanut oil.

1908
- Henry Ford unveils his Model T, designed to run on either gasoline or ethanol, “the fuel of the future.”
US opts for petroleum instead of plant-based fuels.
BIODEGRADABLE HYDRAULIC FLUID STUDIES

Glenn Cauffman - Farm Operations
Joseph M. Perez Sr. - Chemical Engineering Department
Hydraulic fluids are used in a variety of equipment.
Unfortunately, when neglected hydraulic lines sometimes leak
Petroleum-based hydraulic fluid releases or spills...

- occur often
- may contain regulated substances that cause pollution to soil, surface water, and groundwater
- are always cleaned up at Penn State but are often not cleaned up elsewhere
Biodegradable hydraulic fluids

- Hydraulic systems lose fluids to the environment during normal use
- Biodegradable fluids are environmentally friendly
- Biodegradable fluids reduce costs of spill cleanups
Why use a more expensive bio-lubricant when petroleum lubricants provide satisfactory performance?

Cost of inadvertent spill cleanups led to consideration of use of biolubricants
Cost comparison...

**Tractor Supply**
5 gal UTF (Universal Tractor Fluid)
$36.99
($7.40/gal)

**John Deere**
Bio HyGard
$127.50
($25.50/gal)

**Settled on...**
BioBlend Flo UTF
$959.75/55 gal
$17.45/gal
Why use biodegradable hydraulic fluids?

- Vegetable-based renewable resource
- Supports agriculture
- Reduces dependence on foreign oil
- Compatible with petroleum-based hydraulic fluids
- Increased lubricity - lower operating temperatures
Bio-hydraulic fluid usage

- Started in fall of 2003
- Involved 200+ pieces of farm equipment
Program started - summer 2003
Obtained information on available fluids from suppliers
Reviewed OEM requirements
Collaboration
Cost factors
Initial trial – Fall 2003
Obtained Pennsylvania DEP approval for use
Changeover of all equipment – Summer 04
Periodic analysis 2005 – Project 1 (Pa Soybean Board)
Periodic analysis 2006 – Project 2 (Pa Soybean Board)
## OEM Specifications for Hydraulics, Transmissions, Differentials, Wet Brakes, and PTO Clutches

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Brand Specification</th>
</tr>
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<tbody>
<tr>
<td>Case</td>
<td>MS-1204, MS-1205, MS-1206, MS-1207, MS-1210</td>
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<tr>
<td>John Deere</td>
<td>J20A, J20C, J14C, J21A</td>
</tr>
<tr>
<td>Caterpillar</td>
<td>TO-2</td>
</tr>
<tr>
<td>Massey Ferguson</td>
<td>M1135, M1141, M1110, M1127, M1129-A</td>
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<tr>
<td>Fiat</td>
<td>Tuttella Muti F</td>
</tr>
<tr>
<td>Kubota</td>
<td>UDT Fluid</td>
</tr>
</tbody>
</table>
## Typical chemical & physical hydraulic fluid properties

<table>
<thead>
<tr>
<th>Property</th>
<th>Test Method</th>
<th>Cargill THF</th>
<th>Petr. Oil</th>
</tr>
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<tbody>
<tr>
<td>ISO Grade</td>
<td></td>
<td>46</td>
<td>46</td>
</tr>
<tr>
<td>Viscosity 40°C, cSts</td>
<td>ASTM D-445</td>
<td>48.44</td>
<td>46</td>
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<tr>
<td>100°C, cSts</td>
<td>ASTM D-445</td>
<td>9.887</td>
<td>6.8</td>
</tr>
<tr>
<td>@ -35°C, cP</td>
<td></td>
<td>25,000</td>
<td></td>
</tr>
<tr>
<td>Viscosity Index</td>
<td>ASTM D-2270</td>
<td>196</td>
<td>98</td>
</tr>
<tr>
<td>Density, 15.6°C</td>
<td>ASTM D-1298</td>
<td>0.9089</td>
<td>0.876</td>
</tr>
<tr>
<td>C.O.C Flash, °C (°F)</td>
<td>ASTM D-92</td>
<td>251 (483)</td>
<td>218 (424)</td>
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<tr>
<td>Pour Point, °C (°F)</td>
<td>ASTM D-97</td>
<td>-36 (-33)</td>
<td>-30 (-22)</td>
</tr>
<tr>
<td>Biodegradability, %</td>
<td>CEC L 33-A-93</td>
<td>82</td>
<td>(15-30)</td>
</tr>
</tbody>
</table>
The following are areas of concern:

• Hydrophilic nature of biobased materials
• Corrosivity
• Greater solvency
• Microbial growth
• Stability over long term storage
• Material compatibility issues
• Bulk modulus elasticity
• Temperature range of materials
New & used oil analyses

- Metals Content
- Oxidation Stability
- Friction and Wear
- Particle Counts
- Viscosity
- Acid Number
- Water
- FTIR (Fourier transform infrared spectroscopy)
Four-ball Wear Test
Four-ball Tests: Three used oil samples were run on the four-ball. The samples exhibit no change in wear or friction compared to the new oil. The wear values after three years were 0.36 mm respectively. The coefficient of friction for all samples was 0.090.
2006 Penn State University began converting all hydraulic equipment to bio-hydraulic fluid – including the elevators in buildings. This has been completed.
How do we know fluid is petroleum or a different synthetic fluid? FTIR
Infra-red Analysis (FTIR)
Unit Test Data - Total Metals

PPM

UNIT Hours

Transmission – Not BioTHF

- Fendt
- NH
- JD
- WS

Jmp 2- 2007
FIG. 3. JD UNITS

- Total Metals
- Fe
- Cu
- Pb

"OIL" Hours

ppm
Properties – Acid No. & Visc/10

Acid No.

40°C Visc/10

Jmp 2 - 2007
Update 2009

Cost of fluid too high

Search for lower cost but OK fluid

Selected a few via sales folks

Tested for metals

All exceeded PA Dept. of Environmental Protection limits

Worked with supplier(s) – changed additive package

Re-tested and okayed
Tractors without Tankers
Tractors without Tankers

- Testing 100% biodiesel and SVO in agricultural tractors
In collaboration with New Holland, four new tractors ran 3 years on B100 – 1 continues on B100, others have been returned to New Holland.

2 new tractors running SVO

Exploring long term effects of high levels of biodiesel and SVO
Biodiesel and Straight Vegetable Oil (SVO)

- Discover the pros and cons
- Disseminate information based on experience through Cooperative Extension and Outreach
In 2002 biodiesel discouraged by most equipment manufacturers

Penn State College of Ag Sciences Farm Operations began using B20
The Greening of Penn State

- Reduce greenhouse gas emissions
- Improve environmental air quality
- Reduce diesel smoke irritation for operators
- Renewable energy and carbon credits
- Support agricultural producers
## Comparison with other fuels

<table>
<thead>
<tr>
<th>Fuel Type</th>
<th>BTU/US gallon</th>
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</thead>
<tbody>
<tr>
<td>Regular gasoline</td>
<td>125,000</td>
</tr>
<tr>
<td>Ethanol</td>
<td>84,600</td>
</tr>
<tr>
<td>Methanol</td>
<td>64,600</td>
</tr>
<tr>
<td>Gasohol (10% ethanol)</td>
<td>120,900</td>
</tr>
<tr>
<td>Diesel</td>
<td>138,700</td>
</tr>
<tr>
<td>Biodiesel</td>
<td>126,200</td>
</tr>
<tr>
<td>Vegetable oil</td>
<td>123,000</td>
</tr>
<tr>
<td>Liquified natural gas</td>
<td>90,800</td>
</tr>
</tbody>
</table>
Environmental Impacts of Biodiesel

Large Reductions in:
- CO2
- SOx
- Particulates
- Odor

Slight Increase in:
- NOx
- Engine crankcase oil analysis
- Observe power and performance
- Note tasks performed and operator observations
- Dismantle engines and measure internal effects
Penn State University converted diesel fuel station for all diesel fuel to B20 in 2006

Received the Governors Renewable Energy Leadership Award in 2006

New Holland endorses B100 in 2007
New Holland TC40 injectors after 2 years on B100
Straight Vegetable Oil (SVO) Use at Penn State Farm Operations

From the Fryer to the Fuel Tank
The Complete Guide to Using Vegetable Oil as an Alternative Fuel
Joshua Tickell
SVO Straight Vegetable Oil

- May require engine modifications
- Heated to change the viscosity
- Start engine on petro-diesel fuel
- Shut down on petro-diesel fuel
Vegetable oils have high viscosity which leads to injector coking and eventual engine failure.

This is not biodiesel but straight vegetable oil (SVO) fuel.
Case 621E Loader
(146 net HP)

New Holland T7060
(180 PTO HP)
Types of SVO systems

Single tank

Double tank

Small lift with single tank setup
Fuel type (diesel or SVO) criteria

**Sensors**
- Engine coolant temperature sensor
- Exhaust temperature sensor

**Logic**
- Engine cold – runs on petroleum diesel
- Engine warmed up
  - Below 25% engine load – runs on petroleum diesel
  - Above 25% engine load – runs on SVO
Engine startup and shutdown

Start on petroleum diesel

Run on SVO or diesel (depends on engine load)

Shutdown – 10 minutes running on petroleum diesel, then shutdown
operator's manual

New Holland T7000 series

ELSBETT Technologie GmbH, Weißenburger Str. 15, D-91177 Thalmässing
Für Informationen: +49 (0)9173/79445-0
www.elsbett.com
service@elsbett.com
1) Warranty

Please look up the terms and conditions of the warranty under "general terms of business" at www.elsbett.com

2) Straight Vegetable Oil (SVO)
- Only use Rapeseed Oil which fulfills the requirements laid out in the rapeseed-oil Standard (DIN V 51605).
  It is possible to mix SVO and Diesel in the main tank to any degree.
- In wintertime when temperatures are below 32 °F a minimum of 10% Diesel must be added to the SVO, below 5 °F the vehicle must be operated on 100% Diesel.
- Bio Diesel is not SVO und must not be used in an ELSBETT SVO- System!
- SVO must never be mixed with Bio diesel!
  Damage to engine will be done by mixing SVO and Bio Diesel.

3) Diesel
- Only use pure Diesel (DIN EN 590) in the spare tank.
- SVO, Bio Diesel or Diesel with raising part of Bio Diesel in the Diesel Tank will eventually lead to damages to the engine.

4) Change of engine oil
- Change the lubrication oil with the oil filter after half of the normal service- interval recommended by the Vehicle Manufacturer, not exceeding 150 hours.
  - Please refer to the original manual.
  - Check the engine oil level daily before starting to work.
  - If the Engine-oil level increases, immediately inform your supervisor and contact your ELSBETT Service Partner. Change the lubrication oil (take oil sample) and contact ELSBETT in Germany.
    
    It is not sufficient to drain the excess oil without changing the oil, as the percentage of fuel in the engine oil may be too high already, which can lead to polymerisation of the engine oil. That means that the lubrication oil goes to a black, not fluid substance!

5) Operating the system

- Running your vehicle on SVO is only possible if:
  1. The switch is in Position “SVO” (green LED on).
  2. Operating temperature of the engine is reached (blue LED off).
  3. The exhaust temperature is high enough (indicator for the load of the engine).
- The switch can be switched to “SVO” immediately after starting up the engine, but the green LED shows only the position of the switch!

  When the yellow LED is on, the engine run on Diesel. When the yellow LED is off, the engine run on SVO!
The electronic control unit of the system automatically activates the system when the switch is on “SVO” (green LED on), the right operation temperature (blue LED off) and the exhaust temperature are reached. The system is activated by electronically starting the PPO-Pump. The yellow LED (Diesel) must turn off.

6) The operating module

Green LED: - lights up when switch is in Position “SVO”
- lights up in depend of engine temperatures, as the system is turned on automatically only after reaching operating temperatures.

Red LED: - only shows the state of the SVO Filter, if red LED lights up change the SVO Filter. If the red LED lights up even though the Filter is still clean (the engine only run on SVO) you can regulate the pressure switch by turning the screw on the pressure switch inwards.

Attention: Is the red LED on, the engine gets SVO and Diesel!
Look at the fuel level indicator on the ELSBETT - Switch/Indicator Unit!

Blue LED: - goes off after engine reached operating temperature.

Yellow LED: - is always on when switch is in position “Diesel”
- goes off when switch is in Position “SVO” and the engine reached operating temperatures.

- Fuel level indicator

When the Diesel Tank is full all 5 LED’s of the fuel level indicator are on.
You should fill up the Diesel Tank if only the yellow/led LED’s of the fuel level indicator are on!
The fuel level indicator can only function properly if the sender unit gives a resistance of 3 Ohm when tank is empty and 180 Ohm when tank is full.

7) Operating the Vehicle

- Flushing the system

Frequent non-flushing of the system will damage your engine severely!

Before switching off, the engine must run on Diesel until there is only Diesel Fuel in the Injection-System! ELSBETT advises a minimum flushing time on Diesel of 10 minutes. To activate flushing switch the switch back to “Diesel”. If you forget to switch back to Diesel a buzzer will sound when turning off the ignition. You can only turn this buzzer off by switching to “Diesel”.

Important: Sufficient flushing of the system is not possible when the engine is idling, only when the engine is under load.
- Running the engine on 100% Diesel
  - If you want to run the vehicle 100% on Diesel (Diesel in the Main Tank also) the Heat Exchanger must be blocked off (connect the two coolant hoses on the Heat Exchanger).
  - If the fuel level indicator shows that the Diesel Level in the Diesel Tank is going down although the system is operating in SVO-Mode (yellow LED off, red LED off) and the Level of SVO in the Main Tank (normally SVO Tank) is not decreasing, this points to a malfunctioning of the ELSBETT SVO-System. In this case please contact your ELSBETT Service Partner immediately.
  - Do not use a steam cleaner to clean the components.

8) Servicing of Components

Service Intervals and checks:

1) Check fuel pipes                      every Service
2) Check for leaks                       every Service
3) Check for rubbing of pipes           every Service
4) Check function of components        yearly / 600 h
   - Check SVO-Pump
   - Check temperature switches
   - Check electrical components
5) Clean/replace Diesel Pre-Filter     yearly / 600 h
   Clean/replace SVO Pre-Filter          every 6 months / 300 h
6) Change SVO Filter                    change at same interval as engine oil or if blocked
7) Change Diesel Filter                 yearly / 600h
8) Engine Oil Change                    Please refer to "Change of Engine Oil" (Chapter 4)
9) Engine Oil Filter Change             Please refer to "Change of Engine Oil" (Chapter 4)

Please document all Service work in the service booklet; this is necessary for your ELSBETT warranty.
9) Diesel tank empty

- If the engine stopped because of an empty Diesel Tank, you can bleed the system by using the manual pump on the Diesel Pre- Filter.
- If the engine is cold and not start again, you can also bleed the system as an exception by using the switch for the SVO- Pump (see chapter 10).

1) Fill up the Diesel Tank.
2) Turn ignition on.
3) Press switch for SVO- Pump on the ELSBETT- Control Unit for 2 minutes.
4) Start the engine while still pressing the switch.
5) When engine is running release switch, repeat procedure until fuel system is bled.

10) SVO Tank empty

- The manual pump on the SVO pre Filter has no function. You cannot bleed the System using this pump.
- For bleeding the SVO-System, turn on the ignition and press the switch next to the fuses on the ELSBETT- Control Unit for about 2 minutes. Using a pen similar. This activates the SVO-Pump and bleeds the Elsbett 2-tank System.

Important: This function is not for operating the vehicle when the engine is cold!

- Bleed the SVO- Fuel System in this manner especially after changing the SVO- Filter.

11) Possible Problems

- Difficulty starting the engine when cold
- Insufficient flushing with Diesel Fuel before engine switch-off (minimum journey 10 km)
- Diesel tank empty or wrong fuel filled (no Winter Diesel in cold conditions, Bio Diesel, ...)
- Diesel Filter blocked
- Diesel Pre- Filter blocked
- Air lock in the fuel system especially in Diesel mode

- Power loss
- Original Fine Filter, Diesel or SVO Filter blocked (dirt, water, ...)
- Pre- Filters blocked
- Electronic problems: read out ECU
- Fuel system worn frequent non-flushing, using bad-quality fuel or Diesel with Bio Diesel, ...

- Increased Diesel consumption
- Switch sometime not turned to "SVO"
- SVO- Filter blocked
- SVO- Pump not working
- SVO- Pump Pressure not sufficient (adjust at pump 2-2.5 bar)
- Pressure valve malfunctioning
# ELSBETT- Control Unit

(For ELSBETT- cable unit with colour coded cable)

## PIN

<table>
<thead>
<tr>
<th>PIN</th>
<th>Description</th>
<th>Colour Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>battery + ignition</td>
<td>grey</td>
</tr>
<tr>
<td>2</td>
<td>battery + ignition (connecting with PIN 10)</td>
<td>red/black</td>
</tr>
<tr>
<td>3</td>
<td>temperature switch (ground)</td>
<td>brown/white</td>
</tr>
<tr>
<td>4</td>
<td>Diesel pump (+12V/24V)</td>
<td>yellow</td>
</tr>
<tr>
<td>5</td>
<td>battery + direct (+12V/24V)</td>
<td>red</td>
</tr>
<tr>
<td>6</td>
<td>SVO pump (ground)</td>
<td>brown/green</td>
</tr>
<tr>
<td>7</td>
<td>SVO pressure switch (ground)</td>
<td>red/purple</td>
</tr>
<tr>
<td>8</td>
<td>tank sensor sign (+)</td>
<td>black/grey</td>
</tr>
<tr>
<td>9</td>
<td>magnetic valve (ground)</td>
<td>red/brown</td>
</tr>
<tr>
<td>10</td>
<td>SVO pressure switch (+12V/24V)</td>
<td>white &amp; white/black</td>
</tr>
<tr>
<td>11</td>
<td>temperature switch (+12/24V)</td>
<td>black/blue</td>
</tr>
<tr>
<td>12</td>
<td>Diesel pump (ground)</td>
<td>brown/black</td>
</tr>
<tr>
<td>13</td>
<td>SVO pump (+12/24V)</td>
<td>green</td>
</tr>
<tr>
<td>14</td>
<td>loading sign (ground)</td>
<td>brown</td>
</tr>
<tr>
<td>15</td>
<td>tank sensor (ground)</td>
<td>brown &amp; brown (loading sign)</td>
</tr>
<tr>
<td>16</td>
<td>magnetic valve (+12/24V)</td>
<td>blue</td>
</tr>
<tr>
<td>17</td>
<td>D+ (sign engine run)</td>
<td>purple</td>
</tr>
<tr>
<td>18</td>
<td>main ground</td>
<td>brown</td>
</tr>
</tbody>
</table>

## Fuses

<table>
<thead>
<tr>
<th>F1</th>
<th>10 A always</th>
</tr>
</thead>
</table>

either

<table>
<thead>
<tr>
<th>F2</th>
<th>10 A all engines without common- rail- injection system (UIP, ...)</th>
</tr>
</thead>
<tbody>
<tr>
<td>F3</td>
<td>10 A all engines with common- rail- injection system (CR)</td>
</tr>
</tbody>
</table>
ELSBETT Cable Unit Schematic

- Exhaust temperature sensor
- Battery + ignition ground
- Exhaust temperature control
- Sign OUT
- Switch/Indicator Unit
- Control Unit
- Data Logger
- Cable Unit
- Battery + direct
- Ground
- Battery + ignition
- D+
- Straight plug Diesel-pump (power compensation possible)
- Straight plug Magnetic valve
- Fuel pressure switch
- Coolant temperature switch
- SVO pump
- Diesel fuel sensor
- Cable handbrake connecting in the cable unit
  - PIN 2 R/B and PIN 10 BW

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Fuel Schematic for New Holland T7000 series

- SVO Tank
- Diesel Tank
- Pre-Filter
- SVO Pump
- Cabin heater
- ELSBETT Temperature switch
- Engine Cooling system
- Pressure valve
- T-Bar
- Original Injection system (including feed pump)

SVO → Diesel → SVO or Diesel → Coolant

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Some parts of the ELSBETT-System

- SVO Filter
- Diesel Filter
- Diesel Tank
- Diesel Pre-Filter
- Original Pre-Filter (never used)
- Original Fuel Filter
- SVO Pre-Filter
- SVO Pump
- ELSBETT Control Unit
- Switch for running SVO Pump
- Exhaust temperature control
- Addition relay for ignition
SVO control inside the cab
Exhaust temperature sensor/relay
Compensation for reduced energy in SVO
Our challenges with the SVO systems

NH T7060
• SVO too hot from heat exchanger – engine derating
• SVO filter clogging (?)
• Low temperatures – mix with petroleum diesel

Case 621E
• Engine coolant not reaching operating temperature
• SVO filter clogging (?)
• Low temperatures – mix with petroleum diesel
• Power supply – 12V vs. 24V
• Fuse location in control box
Types of oils (per Elsbett)

Canola or rapeseed..... Ok

Sunflower..... Ok if degummed

Soybean..... Not ok in direct injection engines
### Rapeseed Oil Quality Standard - Germany

<table>
<thead>
<tr>
<th>Properties / Contents</th>
<th>Unit</th>
<th>Limiting Value (min.</th>
<th>max.</th>
<th>Testing Method</th>
</tr>
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<tbody>
<tr>
<td><strong>Characteristic Properties</strong></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Density (15 °C)</td>
<td>kg/m³</td>
<td>900</td>
<td>930</td>
<td>DIN EN ISO 3675, DIN EN ISO 12185</td>
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<tr>
<td>Flash Point by P.-M.</td>
<td>°C</td>
<td>220</td>
<td></td>
<td>DIN EN 22719</td>
</tr>
<tr>
<td>Calorific Value</td>
<td>kJ/kg</td>
<td>35000</td>
<td></td>
<td>DIN 51900-3</td>
</tr>
<tr>
<td>Kinematic Viscosity (40 °C)</td>
<td>mm²/s</td>
<td>38</td>
<td></td>
<td>DIN EN ISO 3104</td>
</tr>
<tr>
<td>Low Temperature Behaviour</td>
<td></td>
<td></td>
<td></td>
<td>Rotational Viscosimeter (testing conditions will be developed)</td>
</tr>
<tr>
<td>Cetane Number</td>
<td></td>
<td></td>
<td></td>
<td>Testing method will be reviewed</td>
</tr>
<tr>
<td>Carbon Residue</td>
<td>Mass-%</td>
<td>0.40</td>
<td></td>
<td>DIN EN ISO 10370</td>
</tr>
<tr>
<td>Iodine Number</td>
<td>g/100 g</td>
<td>100</td>
<td>120</td>
<td>DIN 53241-1</td>
</tr>
<tr>
<td>Sulphur Content</td>
<td>mg/kg</td>
<td>20</td>
<td></td>
<td>ASTM D5453-93</td>
</tr>
<tr>
<td><strong>Variable Properties</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Contamination</td>
<td>mg/kg</td>
<td>25</td>
<td></td>
<td>DIN EN 12682</td>
</tr>
<tr>
<td>Acid Value</td>
<td>mg KOH/g</td>
<td>2.0</td>
<td></td>
<td>DIN EN ISO 660</td>
</tr>
<tr>
<td>Oxidation Stability (110 °C)</td>
<td>h</td>
<td>5.0</td>
<td></td>
<td>ISO 6886</td>
</tr>
<tr>
<td>Phosphorus Content</td>
<td>mg/kg</td>
<td>15</td>
<td></td>
<td>ASTM D3231-69</td>
</tr>
<tr>
<td>Ash Content</td>
<td>Mass-%</td>
<td>0.01</td>
<td></td>
<td>DIN EN ISO 6245</td>
</tr>
<tr>
<td>Water Content</td>
<td>Mass-%</td>
<td>0.075</td>
<td>pr EN ISO 12937</td>
<td></td>
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</tbody>
</table>
SVO Usage by Month
Mar 2009 - Jan 2010

SVO (gallons)

Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan Feb

7060
621E
**Overall SVO vs. Petro-diesel usage**

<table>
<thead>
<tr>
<th></th>
<th>NH T7060 (966 hours)</th>
<th>Case 621E (843 hours)</th>
</tr>
</thead>
<tbody>
<tr>
<td>% SVO used of total fuel use</td>
<td>81%</td>
<td>44%</td>
</tr>
<tr>
<td>Total SVO used</td>
<td>1666 gallons</td>
<td>418 gallons</td>
</tr>
<tr>
<td>Total diesel used</td>
<td>392 gallons</td>
<td>528 gallons</td>
</tr>
</tbody>
</table>
Summary

- Converted agricultural and other machinery to bio-based hydraulic oil
- Used B100 successfully in New Holland equipment
- Press and use canola oil in two pieces of equipment
QUESTIONS?