On-farm Biodiesel Safety and Quality

Chris Callahan, PE – Callahan Engineering, PLLC
The Vermont Sustainable Jobs Fund (VSJF) was created by the Vermont Legislature in 1995 to identify and fund market driven solutions to our pressing economic, social, and environmental issues.

- Current efforts focus on the intersection between the biofuels / renewable energy, sustainable forestry and agricultural sectors.

The purpose of the Vermont Biofuels Initiative (VBI) is to foster the development of a viable biomass-to-biofuels industry in Vermont that uses local resources to supply a portion of the state’s energy needs. *It is a component of sustainable, diversified agriculture.*
VBI Objectives

• Support the expansion of the supply and demand for locally produced and commodity level biofuels in Vermont;
• Reduce the state’s dependency on petroleum;
• Promote entrepreneurial activity in the emerging biofuels sector through grant funding and technical assistance;
• Stimulate farm-based biofuels production efforts as a means of enhancing farm viability and local fuel and food security; and
• Educate the public about the benefits of sustainably and locally produced biofuels.
Outline

• “Quality” is providing value to a customer
• Most important part of quality is safety
• Safety begins with understanding hazards
• …then assessing failure modes & effects
• …then identifying mitigations
• Standardizing operations
• In order to protect personnel, property environment & product
• Which includes ensuring feedstock and fuel quality
Hazard

“the inherent potential of a material or activity to harm people, property or the environment”

## Hazards Analysis

<table>
<thead>
<tr>
<th>Process Component</th>
<th>Hazard Type</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>People</td>
</tr>
<tr>
<td>Vegetable Oil</td>
<td></td>
</tr>
<tr>
<td>Alcohol</td>
<td>●</td>
</tr>
<tr>
<td>(Methanol or Ethanol)</td>
<td></td>
</tr>
<tr>
<td>Lye</td>
<td>●</td>
</tr>
<tr>
<td>(Sodium Hydroxide or Potassium Hydroxide)</td>
<td></td>
</tr>
<tr>
<td>Alcohol / Lye Mixture</td>
<td>●</td>
</tr>
<tr>
<td>Biodiesel</td>
<td></td>
</tr>
<tr>
<td>(Methyl Ester)</td>
<td></td>
</tr>
<tr>
<td>Glycerol</td>
<td>●</td>
</tr>
<tr>
<td>Wash Water</td>
<td></td>
</tr>
<tr>
<td>Recovered Alcohol</td>
<td>●</td>
</tr>
<tr>
<td>Electrical Components</td>
<td>●</td>
</tr>
</tbody>
</table>
Safety Review

- Codes and Standards
- Schematic Drawing
- Failure Modes and Effects Analysis (FMEA)
- Standard Operating Procedures (SOP’s)
- Dry run
- Wet Run
- First Batch
To avoid unwanted combustion, keep fuels and oxidizers away from each other and ignition sources.

- Hazard: “the inherent potential of a material or activity to harm people, property or the environment.”
- National Electric Code (NEC2008 / NFPA70)[1]
- Recommended Practice for Hazardous Locations (NFPA 497)[2]
- Material Safety Data Sheets (MSDS)
- Best Practices – Penn State[3]
- Unique and Specific Review

FMEA: Failure Modes and Effects Analysis

- Each component is assessed
  - How might it fail?
  - How likely is that failure?
  - What are the effects?
  - How would it be detected?

- Ratings (SOD)
  - Severity
  - Occurrence
  - Detection

- Cumulative Rating
  - Risk Priority Number (RPN)
  - $RPN = S \times O \times D$

SEVERITY
- 10 Hazardous without warning
- 9 Hazardous with warning
- 8 Process inoperative, loss of primary function
- 7 Process operable, reduced level of performance
- 6 Process operable, complete nuisance / discomfort
- 5 Process operable, partial nuisance / discomfort
- 4 Fit / finish, sloppy operation noticeable by lay person
- 3 Fit / finish, sloppy operation not noticeable by lay person
- 2 Fit / finish, sloppy operation noticed by experts
- 1 No effect

OCCURRENCE
- 9-10 Very high occurrence, failure almost inevitable
- 7-8 High occurrence, repeated failures
- 4-6 Moderate occurrence, occasional failures
- 2-3 Low occurrence, relatively few failures
- 0-1 Remote occurrence, failure unlikely

DETECTION
- 10 Absolute uncertainty, no detection method exists
- 9 Very remote chance of detection
- 8 Remote chance
- 7 Very low chance
- 6 Low chance
- 5 Moderate chance
- 4 Moderately high chance
- 3 High chance of detection
- 2 Very high chance of detection
- 1 Almost certain detection
FMEA: Failure Modes and Effects Analysis

FMEA Sheet
(1 of 9 for State Line System)

"...a journey not a destination."

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<tr>
<th>TYPE</th>
<th>#</th>
<th>FUNCTION</th>
<th>POTENTIAL FAILURE MODE</th>
<th>POTENTIAL CAUSES</th>
<th>POTENTIAL EFFECTS</th>
<th>DETECTION METHOD</th>
<th>SEVERITY</th>
<th>OCCURRENCE</th>
<th>DETECTABILITY</th>
<th>RISK</th>
<th>RECOMMENDED ACTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>FV</td>
<td>202</td>
<td>Suction Valve - Guide Tank</td>
<td>Closed when should be Open</td>
<td>Operator error / Misalignment of parts with other parts of process</td>
<td>Low suction, pump not working</td>
<td>Visual inspection</td>
<td>5</td>
<td>3</td>
<td>1</td>
<td>15</td>
<td>1</td>
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<td></td>
<td></td>
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<td>Low suction, pump not working</td>
<td>Visual inspection</td>
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Example

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SOP's: Standard Operating Procedures

- Operations Grouped
- Activities as subgroups
- Each task numbered
- Check list format
- Tested with dry run
- Re-tested with water run
- Avoided several mistakes in first batch
- Revisions, revisions, revisions…
Safety Guidelines

- Penn State Guide
- Small scale
- Somewhat PA specific, but extremely helpful
- Best single source for this sort of info

pubs.cas.psu.edu/FreePubs/pdfs/agrs103.pdf
PPE: Personal Protective Equipment

- Eyes
- Ears
- Mouth & Nose
- Skin
PPE: Personal Protective Equipment

- Combustibility sensors
- Often makes sense to have two
  - One high above process
  - One low, within process
- Safety measure
- Quality measure
- Product shown
  - Industrial Test Equipment
  - HC-922 Multigas sensor
  - [www.gasdetectorsinc.com](http://www.gasdetectorsinc.com)
  - $220
SPCC: Spill Prevention, Containment and Countermeasures

• In that order
• Prevention
  – FMEA
  – Maintenance
  – SOP’s
  – Attention
• Containment
  – Structural
  – Early consideration
• Countermeasures
  – Specific to incident and site

http://www.epa.gov/oilspill/spcc.htm
Outreach & Education

• System Overview Handout
• Open Houses
• Speaking
• Publications
Q&A / Contacts for More Info

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