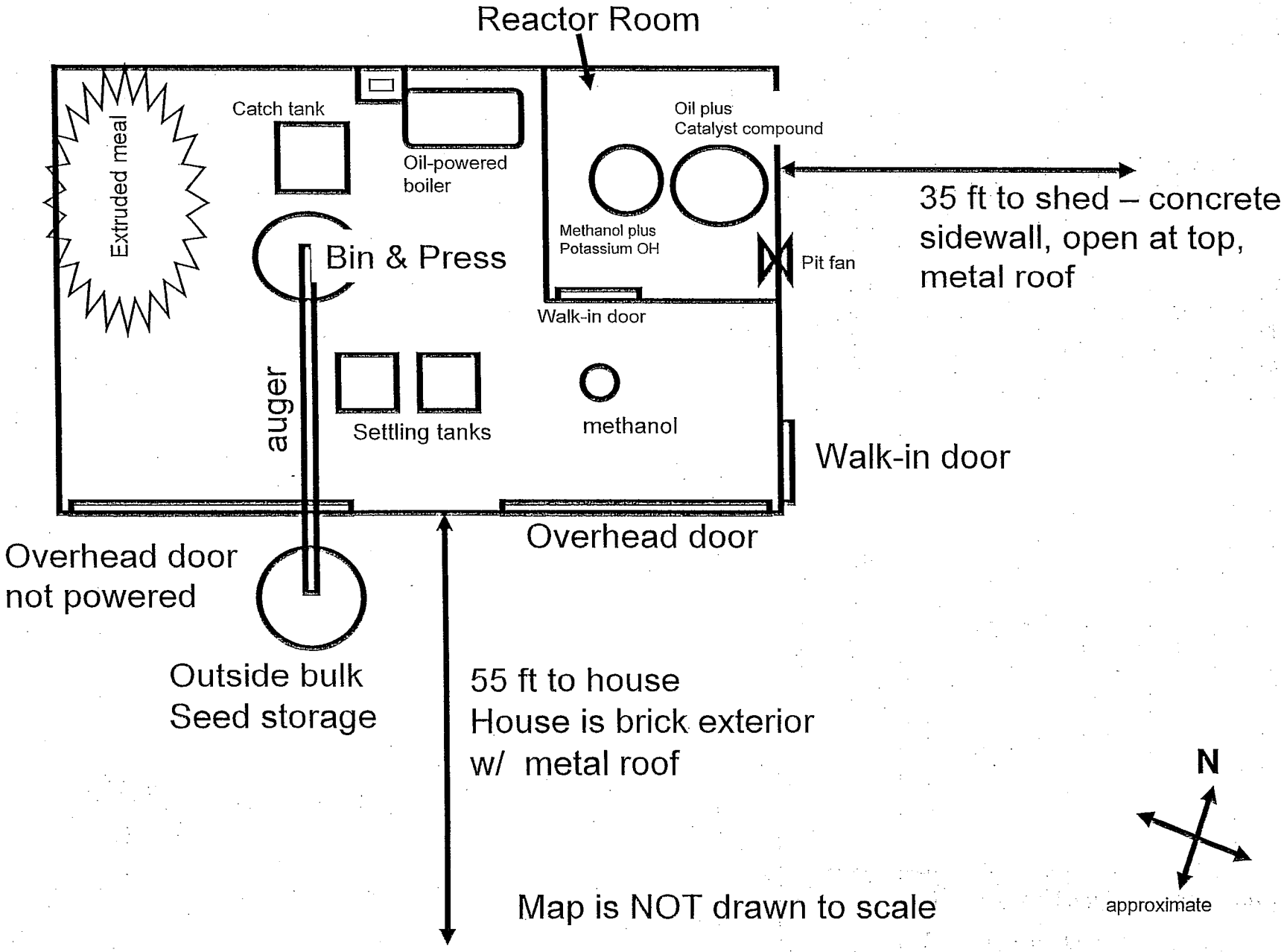
Reactor Room
Extruded meal
Catch tank
Oil-powered boiler
Oil plus Catalyst compound
Methanol plus Potassium OH
Pit fan
35 ft to shed – concrete sidewall, open at top, metal roof
Bin & Press
Walk-in door
auger
Settling tanks
methanol
Walk-in door
Overhead door
Overhead door not powered
Outside bulk Seed storage
55 ft to house
House is brick exterior w/ metal roof
Map is NOT drawn to scale
N
approximate

This is a document containing observations and ideas to improve safety and reduce risk within the small biodiesel pilot facility run by Chris and Dustin Willis in Independence, Wisconsin. I visited their facility on March 6, 2009 to learn about the collaborative work with Cooperative Extension Agents Jon Zander and Carl Duley, and was also asked to think about some of the safety implications of the facility and processes. This is NOT intended to be a comprehensive review of ALL risks and hazards associated with the facility. There will always be some type of danger associated with any type of process like this – especially when you are performing energy conversion processes.

I did not try to do a chemical engineering-type analysis of the reactions occurring within the stainless steel tanks during the actual conversion process (though I do identify means to consider the risk associated with the input and output products). As is the case with safety and human health implications with any process like this, other local experts need to be consulted. This would include the facility insurance company; local fire department; local electrician; and regulators (where appropriate). In addition, the material safety data sheets which are included with this set of observations contain much additional information. These are only highlighted in this document, but should be considered to be PART of my overall observations. If any of you (including Chris and Dustin) have questions, feel free to give me a call (evening as are okay) ay 608-234-0181 or email me at shutske@wisc.edu

Product Flow and Hazards

Seed in storage (soybeans, canola, sunflowers)

- Minimal suffocation hazard, stay out of bin – shut off auger if entry ever required.
- Biggest risk is falling off ladder – minimize need to climb ladder, wear decent shoes, maintain three points of contact when going up and down.

Auger takes seed to top of smaller bin inside shed atop press

- Keep auger shielded including drive unit.
- Ground the electrical system powering auger in case wiring or motor is damaged.
- Keep auger flighting shielded as appropriate at both ends.
- Noise (likely minimal).

Press and Motor

- Electrical hazards – make sure system is grounded, properly installed, wiring inspected from time to time, watch for rodent damage, etc.
- Overheat, fire – Keep clearance around the motor, keep it cleaned off, well-cooled, etc.

- Pressure/part failure, mechanical – Inspect periodically, keep head bolt appropriately torqued, inspect if any unusual operation by noise, unusual odors, overheating, etc. and correct issue.

Oil

- Provisions to catch all oil must be in place to prevent slippery surfaces, accidental release, etc. Inspect containers periodically looking for soft spots or any type of damage.
- Overflow potential – determine risk if you do have an overflow consition and plan accordingly.
- Slippery surfaces, falls – Keep oil of floor, use oil dry when needed, wear good slip resistant shoes.

Boiler/Water Heater

- Biggest hazards are fire, carbon monoxide, over-run condition
- Insure properly installed, connected (water lines, electrical).
- Vented properly (carbon monoxide risk) – Consider having heater inspected.
- Make sure all pressure relief connections fully functional.
- Protect from freezing if power out.

Oil Settling Tanks

- Large quantities of oil
- Mess, spill, runoff
- Slippery
- Fire (would fuel a fire, but not likely cause – oil, while difficult to ignite has a huge "heat of combustion." One ignited, there's a lot of energy in a tank of oil which is hard to control with the fuel being fluid.)
- See other comments above on oil catching tank hazards.

Overall Garage Area

- Noise (probably not problematic)
- Air quality (probably not an issue during pressing, seed movement enclosed, minimal dust). Biggest air quality issues are carbon monoxide potential from boiler and the chemicals/gases used and created in the process of conversion.
- Fire – Attention to housekeeping (keeping stuff picked up, oil cleaned up etc.); boiler in good condition and inspected with failsafe devices (for overpressure, power failure, etc); plan if fire occurs (exits, fire extinguishers, notification, pre-planning with fire department because of high load facility with lots of fuel!); monitor temperatures and overheat condition on press. Note that in an older bulding like this, wiring is often a fire cause – have building inspected or review when your insurer comes out.

- Meal pile (extruded seed material) – Monitor for overheating condition and possible spontaneous combustion issues; monitor for rodents/critters; keep kids off/out of it.
- Housekeeping for visitors (generally keeping stuff picked up, oil off the floor, proper storage of tools, equipment, chemicals, overhead head-bump hazards, running into projected parts, etc.)
- Methanol stored in garage – likely a problem with product being so extremely flammable and toxic. Consider a safety cabinet or even secured outside storage.
- Exits – For fire and other issues, maintain at least two easily vacated exits that are unobstructed, presumably the walk-in door and the overhead door on the west (??) side. Look at pathways and have a plan during high risk times including working in reactor room.
- Fire extinguishers – Consider at least three large fire extinguishers (ABC dry chemical) at least 10 pounds with possibly one 20-pounder for a bigger fire. Locate at least one near main exit door. Check extinguishers regularly (pressure). Realize extinguisher may not be able to handle all fires (especially if large amounts of oil involved), and also do not risk using extinguisher if toxic gases are present in a fire. Buy from reputable source and assure U.L. approved (about $150 for a 20-pounder and $80-$95 for a 10 pounder). Travel distance should be maximum of 50 ft. from an extinguisher. Get decent mounting brackets and make sure extinguisher equipped with flexible hose.
- Fire detection – Consider a fire/smoke detector a smoke detector rated for this type of facility may be acceptable. A heat detection unit will probably not respond until a fire is advanced. Sensitivity though can be an issue (false alarms especially) Contact distributor for advice such as http://alpinealarms.com/sitemap/SmokeDetectors.html Idea is to send wireless signal and to provide immediate audible or visual signal to building occupants. Recommend signal to house as well to aid in evacuation in area (especially if fire occurs at night).
- Overall – Do not be surprised if there are significant insurability issues with this building. If it were to catch on fire, and you're not there, there's a HUGE load of fuel in this building and it's not likely you'll save it. If the building does catch fire for any reason, it's absolutely critical that occupants in the house be notified in some way and have a plan to get away from the area. This would include detection in the shed and detection in the home. Ideally, the shed detectors should send a signal to the house to awaken and alert occupants. Home occupants need a specific plan for where they will go and what they will do.

Reactor Room

The reactor room is complex, and presents some real concerns to human safety and health. These are divided into areas of hazardous substances/chemicals; fire/explosion; and "other" including safety issues with the resulting fuel and glycerin.

Hazardous Substances/Chemicals:

Methanol – The material safety data sheet is provided for methanol.

In summary, the MSDS contains the following information:

Poison! May be fatal or cause blindness if swallowed. Vapor harmful. Flammable liquid and vapor. Harmful if swallowed, inhaled, or absorbed through the skin. Causes eye, skin, and respiratory tract irritation. May cause central nervous system depression. Cannot be made non-poisonous. Target Organs: Eyes, nervous system, optic nerve.

The risk from "Swallowing" methanol is probably not significant if the material is always stored in the original container and children are kept away. The risk for respiratory exposure is significant, and it is important to get a handle on the levels present during key parts of the procedures when exposure is most likely to occur. The critical levels to be aware of are 200 parts per million for an "8-hour Time Weighted Average" or TWA. During routine exposures, it is critical that levels be kept BELOW 200 ppm. Another MSDS found at: http://www.jtbaker.com/msds/englishhtml/M2015.htm

Says, "wear a supplied air, full-facepiece respirator, airlined hood, or full-facepiece self-contained breathing apparatus. Breathing air quality must meet the requirements of the OSHA respiratory protection standard (29CFR1910.134). This substance has poor warning properties."

The cartridge style "air purifying" respirator that we discussed when I visited will not provide adequate protection against toxic levels. The full-facepiece or self-contained style respirator is probably not practical or affordable for this application. Thus, it is crtical that levels of free methanol in the work airspace be kept to levels well below 200 ppm. Also, in the MSDS, note that the NIOSH "IDLH" (Immediately Dangerous to Life and Health) level is 6,000 ppm. It is best to NEVER approach this level by handling the methanol in a "Closed circuit" to the extent possible and by using adequate ventilation. The manure pit fan is good. Make sure to have plenty of make up air available. To get a handle on the concentration of methanol in the air, there are two options. Page 54 of the Raeco catalog (see the PDF as part of this document) has a product that will provide a "direct read" air concentration of methanol and has a range of 27 to 3,200 ppm. This will help get a general sense of levels present during processing. Another option is to check with a local fire department to see if a flammable vapor monitor is available that can be borrowed. These monitors typically read a continuous reading and will provide a digital readout and alarm. It is important to know how concentrations vary over time and during different production conditions (temperature especially).

The other significant risk for methanol is fire/explosion. The lower explosive limit of methanol in the air is 6% by volume which is 60,000 ppm. Obviously, this is a high level compared to the IDLH level. If you monitor during "normal" processes for worker health/safety, you will be at a level well below the explosive limit. The biggest issue for explosions/fires is likely to occur during some type of system failure such as a spill, leak,

overflow, or failure in your ventilation system. This possibility needs to be planned for and backup measures put in place.

WITHIN the areas where methanol is handled, eliminate ALL ignition sources. The explosion-proof ventilation fan is a good example. The light in the process room should be replaced with an approved box/fixture and a metal cage surrounding the bulb (check with your insurer and/or a master electrician for this and OTHER needs within your electrical system).

Potassium Hydroxide – The material safety data sheet is provided for potassium hydroxide AS WELL as sodium hydroxide (in case its ever used in the process). For potassium hydroxide, the following hazards are noted:

Potential Health Effects

Inhalation:
Severe irritant. Effects from inhalation of dust or mist vary from mild irritation to serious damage of the upper respiratory tract, depending on the severity of exposure. Symptoms may include coughing, sneezing, damage to the nasal or respiratory tract. High concentrations can cause lung damage.
Ingestion:
Toxic! Swallowing may cause severe burns of mouth, throat and stomach. Other symptoms may include vomiting, diarrhea. Severe scarring of tissue and death may result. Estimated lethal dose: 5 grams.
Skin Contact:
Corrosive! Contact with skin can cause irritation or severe burns and scarring with greater exposures.
Eye Contact:
Highly Corrosive! Causes irritation of eyes with tearing, redness, swelling. Greater exposures cause severe burns with possible blindness resulting.
Chronic Exposure:
Prolonged contact with dilute solutions or dust of potassium hydroxide has a destructive effect on tissue.
Aggravation of Pre-existing Conditions:
Persons with pre-existing skin disorders or eye problems or impaired respiratory function may be more susceptible to the effects of the substance.

Personal Protective equipment recommendations include:

- Eyes: Wear safety glasses and chemical goggles or face shield if handling liquids (editorial note from John S. – This would also be a good idea when handling the flaked dry form).
- Skin: Wear appropriate gloves to prevent skin exposure.

- Clothing: Wear appropriate protective clothing to prevent skin exposure.
- Respirators: Follow the OSHA respirator regulations found in 29CFR 1910.134 or European Standard EN 149. Always use a NIOSH or European Standard EN 149 approved respirator when necessary. (Note, if there is no/very low levels of dust with this, a simple, tight-fitting N-95 respirator is probably adequate for this task. You should also check the information provided from your source, since I do not have detailed information on the particular form of this product)

Glycerine – MSDS is attached and should be reviewed.

Vegetable Oil – MSDS sheets for both soybean and sunflower oil are attached and should be reviewed. These do not appear to present a significant human health hazard in normal conditions. Flash points are high indicating their relative safety. The real risk is the potwntial for the oil to further "fuel" a fire that breaks down. Ounce for ounce, vegetable oil has SIGNIFICANTLY more energy in it (once ignited) as compared to wood paper, cotton rags, etc. and insurers and fire departments get very concerned about the "fire load" presented with these kinds of substances.

Airborne Products of Reaction Process -- As part of this informal set of observations, I did not have a chance to investigate the gases and vapors that get created during the actual process of converting oil to biodiesel, nor did I investigate the reaction that occurs when the KOH is combined with methanol. My understanding is that you are creating potassium methoxide. I have included an MSDS for this product. Note that this chemical has MANY different hazards associated with it. From my quick look at the reactor room, I do not have information to assure that the potassium methoxide that results from the mixing of methanol and potassium hydroxide is FULLY CONTAINED. It must be. Note that if a fire occurs with potassium methoxide that water IS NOT used to control the fire. Water on this chemical will cause a violent reaction. This part of your process really needs to be reviewed in cooperation with your local fire department. Note that there are also warnings on the MSDS about not allowing this chemical to be released into the environment without oversight.

OTHER:

Here are a few other considerations to think about. I have not tried to do a lot of investigation on any of these, but think they should be at least considered....

1. Disposal/use of glycerine – check with your nutritionist of vet if you plan to feed this. What about the potassium in the process? Where does it go? Disposal needs more investigation.

2. Resulting biodiesel – As part of this analysis, I did not try to consider safety of equipment resulting from lubricity of the fuel in your engines that you're using it in. A

bit more homework might be in order here. I also do not know if burning your own biodiesel in your engines might impact warranties from the manufacturer.

3. Environmental releases, spills, etc. – The MSDS for each product contains environmental risk information. It's best to plan for containment if a leak or accidental release were to occur. Your total amounts on site are relatively small. Again, a quick check with your local fire department would be helpful. Again, I am not certain if your actual process is "enclosed" or partially vented into the surrounding air (including outside the building). You definitely do not want to vent back into the enclosed room, but some of the products (potassium methoxide) is also not supposed to be released into the outside air.

Generally –

- Venting out or keeping products from being released into the air is GREATLY preferred as compared to trying to use a respirator to control personal health risks.
- The most common "accidents" are the mundane things – slips, trips, falls, bumps, bruises, lifting injuries, etc. This is especially important to consider when you have visitors or guests into the facility.
- The brief set of observations is NOT a replacement for a more formal overview by those who have a DIRECT set of interests in the facility. This would include your insurance company; local fire department; local electrician; and regulators (where appropriate).
- Controlling fire risk is relatively simple. You need to avoid a.) Fuel b.) Ignition sources c.) Oxygen from coming together at the same place and same time. Carefully consider and eliminate ALL possible sources of ignition. Consider also moving products apart to minimize risk (for example, move your methanol outside the main storage area/garage and into a steel cabinet away from the main building as a way to reduce fire/explosion risk and health hazards).
- Think through and have a plan for any type of likely contingency or emergency.
- As you change/add to your system, consider each component, part, product, or connection in the production "circuit." Think about where that component could "fail," and if it fails, how would safety be affected. It's impossible to eliminate all risk. Focus on parts of your system which represent "high probability of occurrence" and "high severity" if something bad happens. Change the most risk-filled part of the process if possible to eliminate the risk. Use changes in the design/physical layout of the system and processes and don't be dependent on simply "working safe" to eliminate risk – people do make mistakes.