

A Review of Lab Experience with Biodiesel Blends

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Researchers: R.W. Beckett Corp. / Ag Environmental Products

Date: 1993

Scope: B-100, soy,3-section, wet-base, Dunkirk boiler, AFII burner

References : Beckett report unpublished;

Tyson, Shain K., Biodiesel as a heating oil blend stock, in Proceedings of the 2001 National Oilheat Research Alliance Technology Conference, April 30-May 1, 2001, R. McDonald ed. BNL-52625.

Turk, Victor J.; Laisy, John M.; and Mastrangelo, William, R., Alternative fuel oils and the effect of selected properties on combustion, in Proceedings of the 2001 National Oilheat Research Alliance Technology Conference, April 30-May 1, 2001, R. McDonald ed. BNL-52625.

Key Findings:

- Lower sulfur and smoke emissions, slightly lower Nox emissions
- Difficulty with cold starts on B-100
- Problems with cad cell at high excess air settings
- Expressed material compatibility concerns with some gaskets and labels.

Key Findings:

- “Brightness of the biodiesel flame (as measured by the cad cell flame detector resistance) was slightly less than with the petroleum fuel oil. At a typical operating level, the cad cell resistance measured about 50 higher with the biodiesel than with the petroleum fuel oil. This difference would not be expected to cause problems with primary safety control functions with properly tuned burners.”
- “Gaskets and labels on burners were adversely affected by saturation with biodiesel, and the biofuel is expected to compromise fuel pump seals over time. This is due to the chemical differences between plain hydrocarbons (for which the gaskets, labels and seals are designed) and esters.”

Researchers: Brookhaven National Lab

Date: 2001

Scope: Wet-base boiler, blends to B-30 with some exploratory B-100 tests, 50% blends in kerosene

References :

Krishna, C.R.; Celebi, Y.; Wei, G.; McDonald, R., Lab tests of biodiesel blends in residential heating equipment, in Proceedings of the 2001 National Oilheat Research Alliance Technology Conference, April 30-May 1, 2001, R. McDonald ed. BNL-52625.

Key Findings:

- For the blends steady state and transient operation like #2 oil
- With B-100 cold start only achieved at low excess air
- At very high excess air levels cad cell problems were found with “neat” biodiesel

Researchers: Carlin Combustion Technologies

Date: 2002

Scope: Combustion tests with biodiesel blends to evaluation Nox reduction potential. Explored B-10, B-20, B-30, and B-45 blends

References : Feldman, Charles; Engley, David; Shayda, Michael; and Stadlander, Kennety, Low cost / No cost techniques to reduce NOx in residential oil burners, in Proceedings of the 2002 National Oilheat Research Alliance Technology Symposium, Providence August 20-21, 2002, BNL Report 52670.

Key Findings:

- Drum of B-100 became solid at 60 F
- B-45 blends did not give good combustion performance
- B-10, B-20, B-30 performed like #2 oil
- No NOx reduction measured.

Researchers: John E. Batey, Energy Research Center

Date: 2003

Scope: 20% soy-based biodiesel, 80% 500 ppm S highway diesel. Range of boilers and furnaces.

References : John E. Batey, Combustion Testing of a Bio-diesel Fuel Oil Blend in Residential Oil Burning Equipment, report prepared for Massachusetts Oilheat Council and National Oilheat Research Alliance, July 2003.

Key Findings:

- NOx emissions frequently reduced by about 20%;
- Combustion stability very good as indicated by CO levels;
- Sulfur oxide emissions reduced by 83%;
- Smoke numbers are lower with biodiesel blends.

Recommended Future Work:

- Testing a range of blends;
- Cold-flow characteristics;
- Testing with ULS;
- Long-term boiler fouling rates;
- Field tests and demonstrations.

Researchers: S. Win Lee et al., CANMET Energy Technology Centre, Ottawa

Date: 2004

Scope: B-20, soy, cast iron residential boiler, detailed dilution-based particulate measurements, steady state and cyclic performance, cold start performance over the range 32 F to 68 F.

References : Lee, S. Win; Herage, T.; Young, B., Emission reduction potential from the combustion of soy methyl ester fuel blended with petroleum distillate fuel, Fuel 83 (2004) 1607-1613.

Key Findings:

No burner adjustments, good combustion performance with B-20

19.7% reduction in SO₂

No change in NO_x emissions;

Under cold start (32 F) conditions, higher startup CO transient with B-20;

Particulates (dilution sampler) reduced by 15% with B-20

Researchers: Vermont Biofuels Association

Date: 2006

Scope: Testing two boilers and two furnaces at two different locations. B-20.

References : Vermont Biodiesel Project and Vermont Biofuels Association, Laboratory and Field Testing of Biodiesel in Residential Space Heating Equipment, August 2006.

Key Findings:

- Without adjustment, cad cell resistance was observed to increase up to 40% with B-20;
- A decrease in efficiency of 0.5%, on average, was observed with B-20 (considered negligible by authors);
- B-20 performs as well, or nearly as well, as No. 2 oil

Researchers: Esso / Imperial Oil

Date: 2009

Scope:

- 3 Kerr Furnaces
- 3 Tests for each furnace – each test with 3X40 day cycles to simulate spring/fall, moderate severity, and winter cold snap conditions;
- Canola, Soy, and Tallow
- B5, B10, B20
- Weekly inspections and measurements

References : Imperial Oil, Final Report Bio-Furnace Fuel Test, September 2009.

Key Findings:

- Cad cell resistance increased with biodiesel content but still within acceptable range;
- Lower smoke and also lower excess air with biodiesel;
- Two of three pumps starting to leak after three tests leading to recommendation that biodiesel levels over B-10 should not be used;

Researchers: Penn State University.

Date: 2010-2013

Scope:

Long term pump run tests;

Focus on seal leaks with lip-type seals;

Two base fuels S1500 and S15;

Target 10,000 hour durability with 5 min on/1 min off;

Regular inspections of pumps and fuels;

Two test rounds;

First round not successful – protocol not well followed;

Second round B0, B12, and B20 – improved monitoring, scoring of leaks, analysis;

Leak score metric of pump manufacturer followed.



References :

Project report not completed. Results presented at NBB Biodiesel Technical Workshop

Researchers: Penn State University

Key Findings:

- Fuels with Biodiesel scored better than neat fuels;
- Post test examination of lip seals showed much greater stress than that in pumps removed from the field after longer service (test is a good stress);
- Two pumps bound-up in the 4600-5000 hour time period, both base fuels involved; both at B-12, one resumed function (S15) one did not (S1500)

Researchers: Brookhaven National Laboratory and Stony Brook University

Date: 2012-2013

Scope:

- Basic Materials Testing with Elastomers;
- Focus on specific nitrile material used in common oil burner pump shaft seals;
- Immersion for 670 hours at 125 F;
- Tensile strength, hardness, compression set, volume swell;
- B0, B20, B50, B100
- Explored addition of high levels of organic acids.

References : Not published, results presented at NBB Biodiesel Technical Workshop

Key Findings:

- Across the entire blend level studied, no difference in measured properties;
- When high levels of organic acid added seal properties degraded.



Researchers: Brookhaven National Laboratory

Date: 2015

Scope: Explore impact of changing biodiesel blend level, B0 to B100 on excess air, CO, smoke, and cad cell resistance.

One retention head burner selected;

Without changing excess air setting, change blend level and study impacts in detail;

Some exploration of excess air setting adjustments after fixed air setting tests.

References : Not published

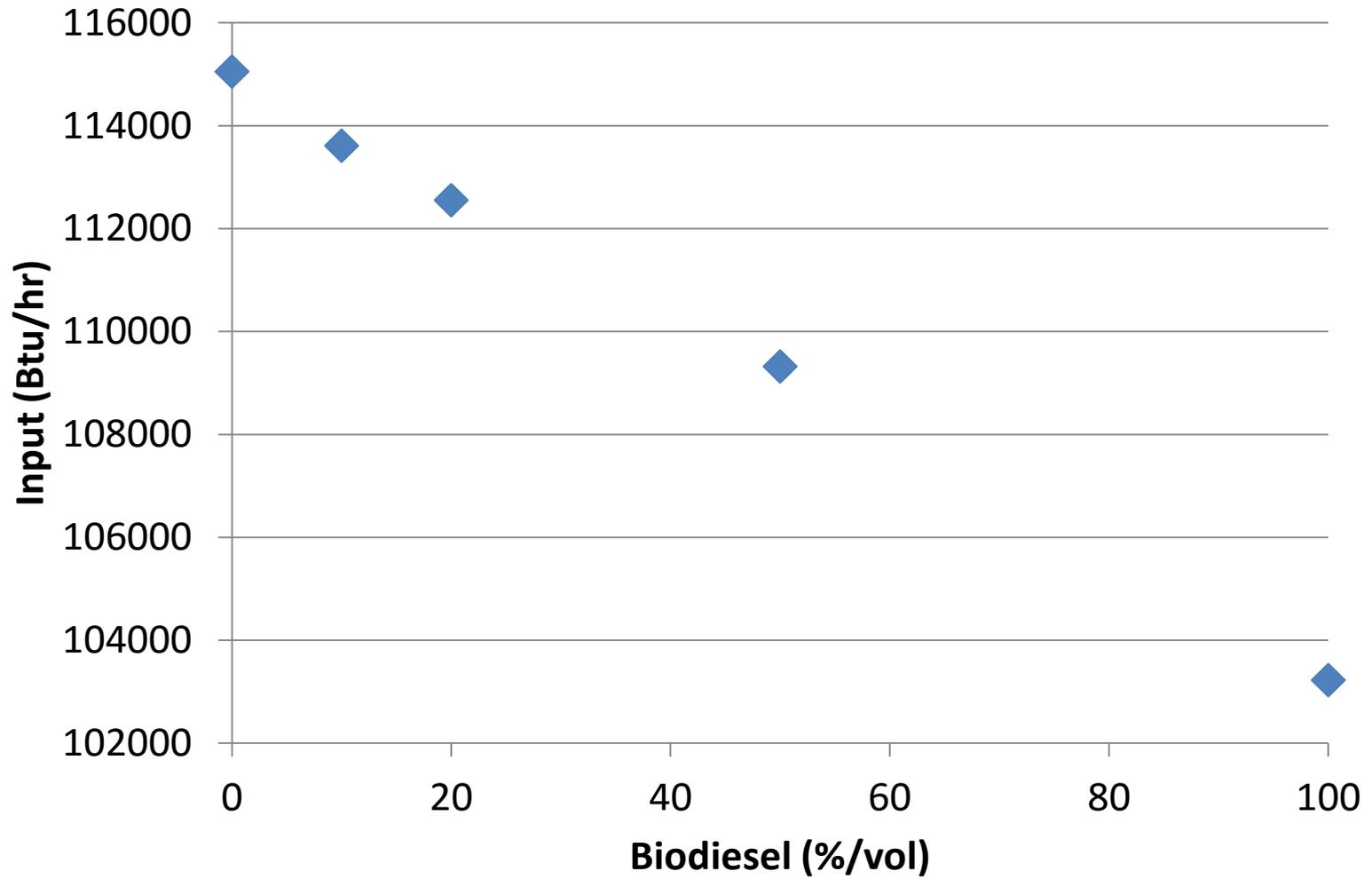
Key Findings:

Increasing blend level:

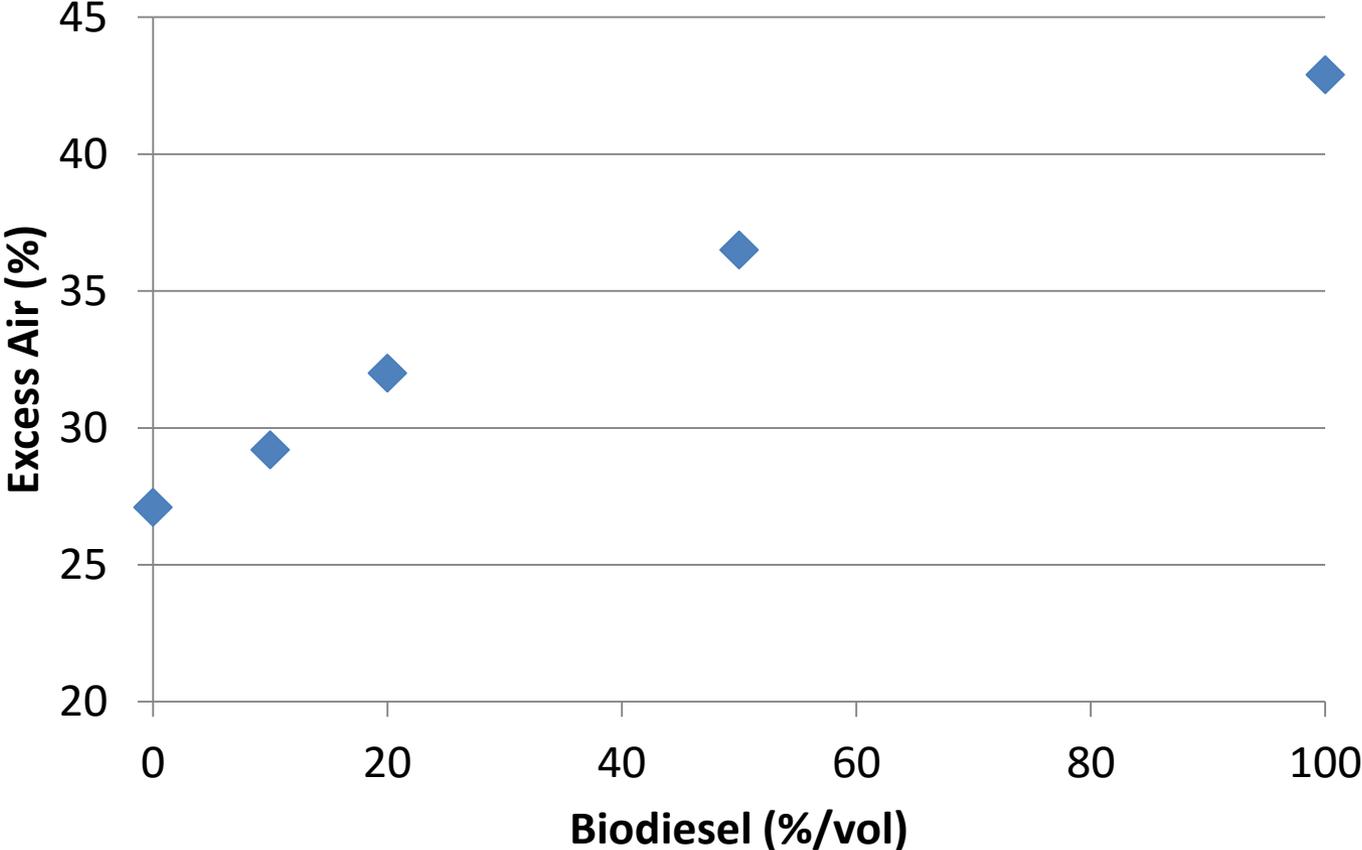
- increases excess air;
- increases cad cell resistance;
- lowers heat input rate;
- small effect on gph.

Starting with a well tuned burner at B-100 and switching to B-0 would lead to a strong reduction in excess air and, potentially, elevated CO and smoke.

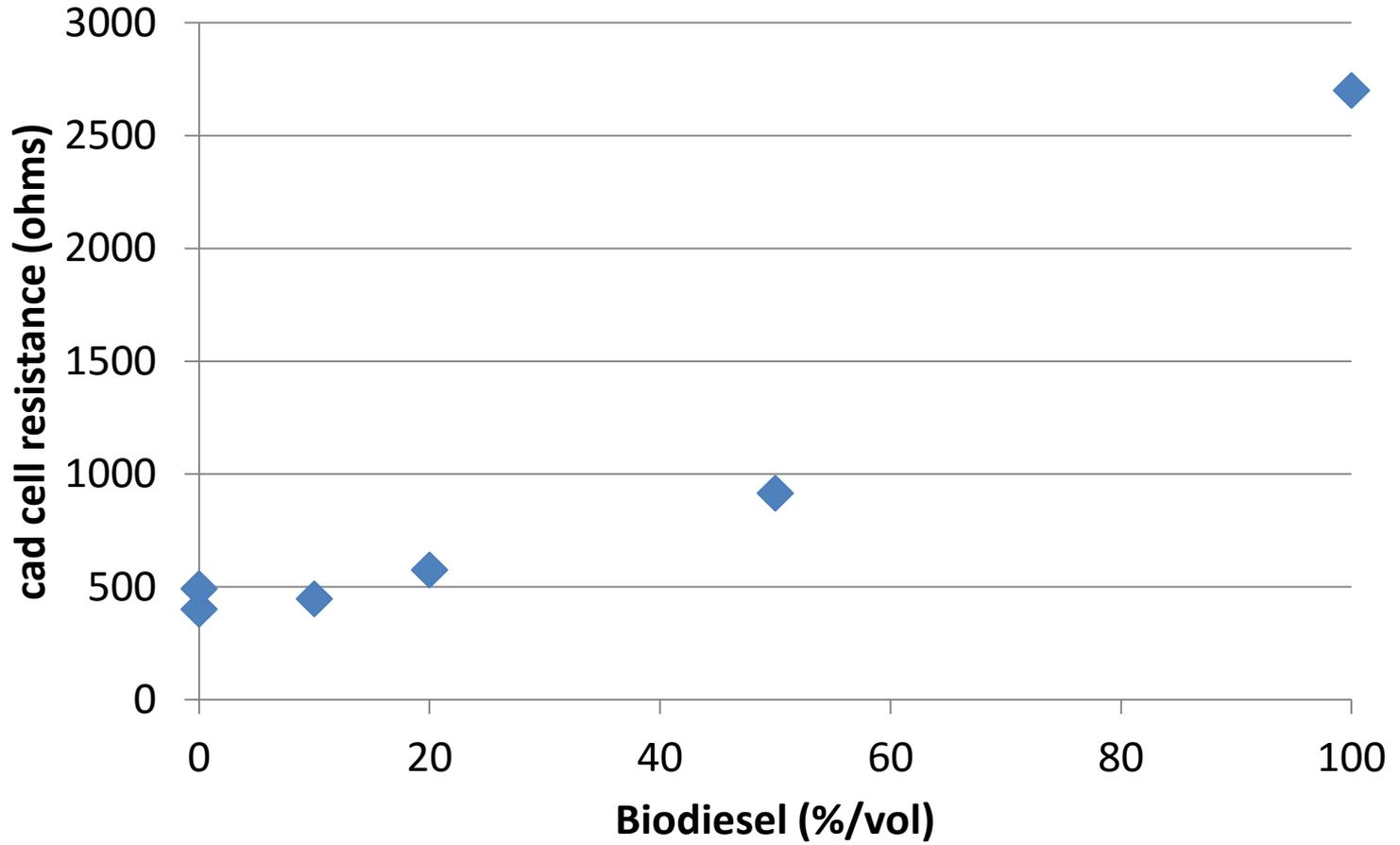
Heat Input Rate



Excess Air



Cad Cell



Conclusions

A great deal of laboratory work has been done with biodiesel in heating systems;

Results can vary depending on type of equipment and type of test;

Cad cell signal is weaker with increasing biodiesel blend levels and may or may not cause a problem at high blend levels;

Retuning of the excess air if there are strong swings in blend level is required.