

# Qualification of Alternative Fuels

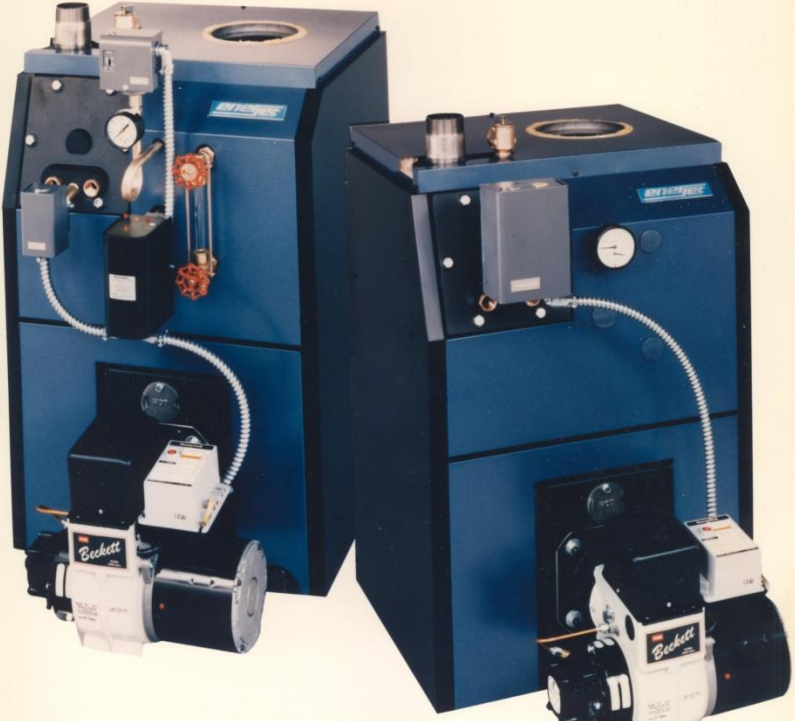
May 8, 2012

## Pyrolysis Oil Workshop

Thomas Butcher  
Sustainable Energy Technologies Department

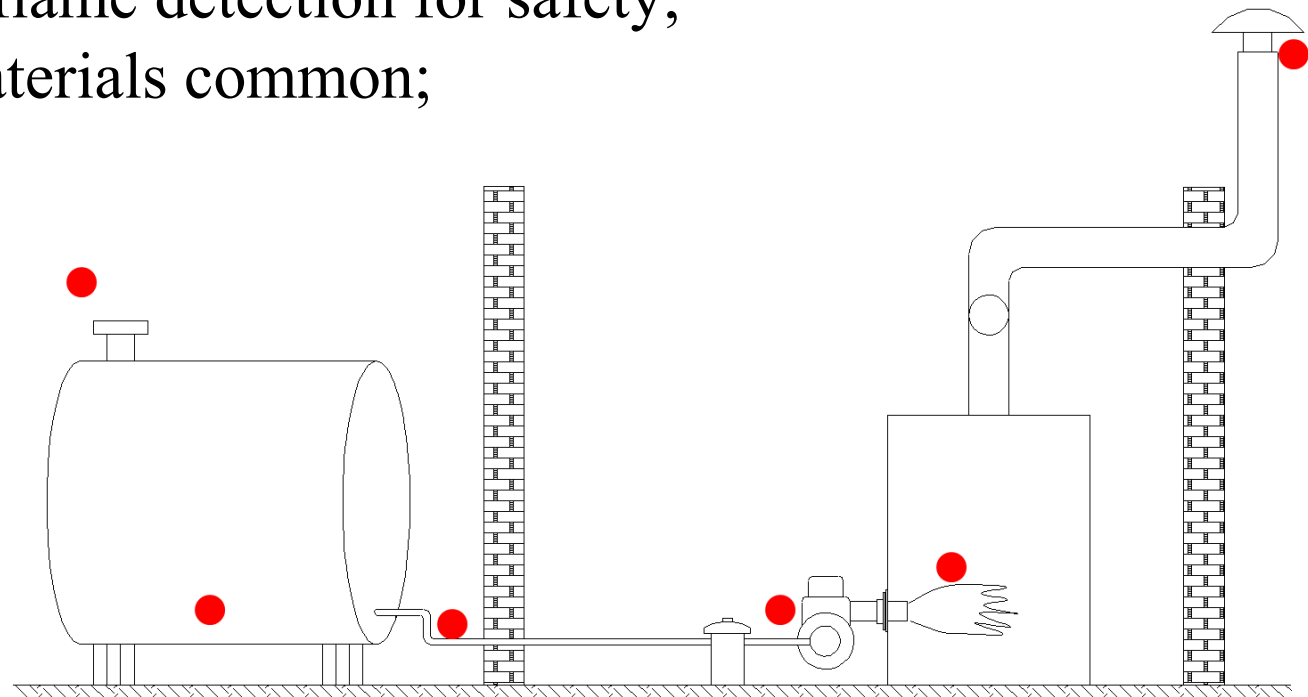


# Applications



# Baseline – Residential and Light Commercial

- Pressure-atomized burners with 100-150 psi fuel pressure, no fuel heating;
- Cyclic operation – to 12,000 cycles per year;
- Fuel filtration to 90 microns or finer;
- Storage for periods of 1 year, possibly longer;
- Storage temperature varied;
- Visible range flame detection for safety;
- Nitrile seal materials common;



# Fuels Considered

- Biodiesel
  - soy
  - palm
  - tallow
  - algae
- SVO – straight vegetable oil
- EL – ethyl levulinate / Biofine
- FFA – 100% free fatty acids
- CTL – Coal-to-liquids
- GTL- Gas-to-liquids
- Pyrolysis oil



# Biodiesel Blends – One Success Story

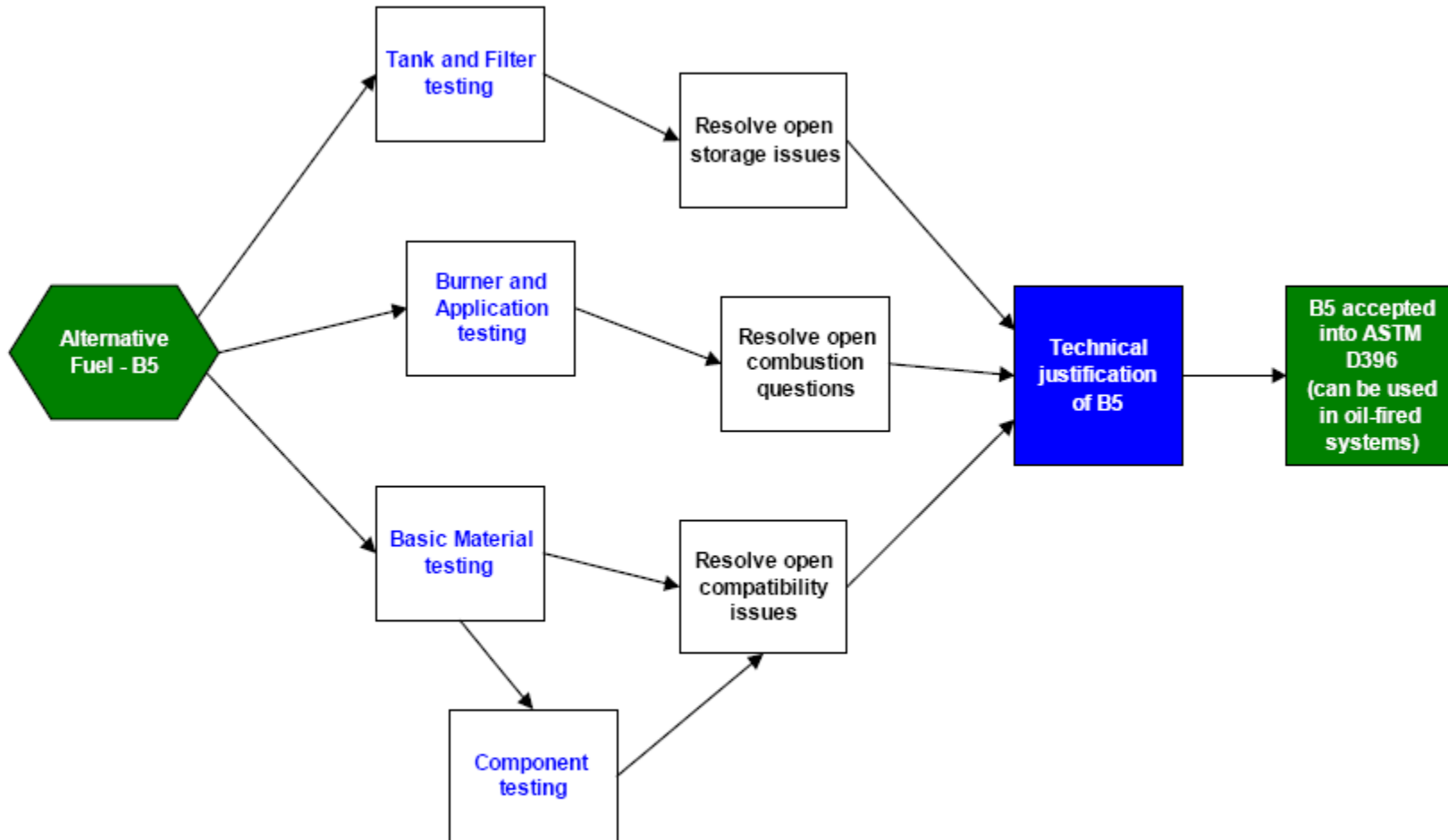
- Beginning in ~ 2001, the industry became strongly interested in using biodiesel in stationary boiler applications;
- Weak standards and poor quality control led to uneven early results;
- Some marketers began to distribute blends to 20% across their customer base;
- Because the equipment was not “listed” for use with these fuels problems came up regarding manufacturer and code official acceptance;
- To address this barrier NORA and NBB began a formal effort to develop the data needed to petition ASTM to redefine heating oil to include up to 5% biodiesel.

# Fuel Property Comparison

Comparison of Typical Fuel Properties, No. 2 Heating Oil and Biodiesel

Property	No. 2 Heating Oil	<u>Biodiesel</u> (B100)
Standard	ASTM D 396	ASTM D 6751
Higher Heating Value (Btu/gal)	139,200	125,000
<u>Kinematic</u> viscosity (@ 40 F)	2.7	4.0 – 6.0
Specific gravity (kg/liter @ 60 F)	0.86	0.88
Density (lb/gal)	7.1	7.25
Water and Sediment ( <u>vol%</u> )	0.001	0.05
Carbon (wt%)	86.6	77.0
Hydrogen (wt%)	13.6	12.0
Oxygen (wt%)	0.1	11.0
Sulfur (wt%)	0.1	0.0 to 0.0024
Flash Point (F)	120 to 210	210 to 350
Cloud Point (F)	-9 to 5	26 to 54
Pour Point (F)	-9 to 16	5 to 50

# Path to Approval



Source: V. Turk, R.W. Beckett Co.

# Components of the B-5 Case for Equivalence at ASTM

Combustion testing – UL296

Seal material compatibility – UL157

“Limit Case” biodiesel – acid number

Combustion chamber materials

Review of lab and field experience

5 % Biodiesel in heating oil really means up to 5% D6751 in D396.





# Interest in biodiesel for heating



235 dealers registered as Bioheat marketers



# Beyond B-5

- With a strong interest in enabling formal acceptance of biodiesel blends beyond B-5, NORA, NBB, and NYSERDA have initiated an effort to provide the technical foundation needed;
- For existing systems focus in on “legacy-safe” blend level
- Beyond legacy-safe, to B-100 focus is on material selection and evaluation of operational issues.

# “Legacy-Safe” Biodiesel Blend Level

- Materials compatibility;
- Pump run tests with manufacturers;
- Burner performance documentation
- Documentation of field experience



# Beyond “Legacy-Safe”

- Materials compatibility;
- Yellow metal compatibility;
- Burner performance documentation
- Tank mixing and “solvency” effect
- Documentation of field experience



B-50 field trial in Seattle





# ASTM Standard



Designation: D7544 – 10

## Standard Specification for Pyrolysis Liquid Biofuel<sup>1</sup>

 D7544 – 10

TABLE 1 Detailed Requirements for Pyrolysis Liquid Biofuels

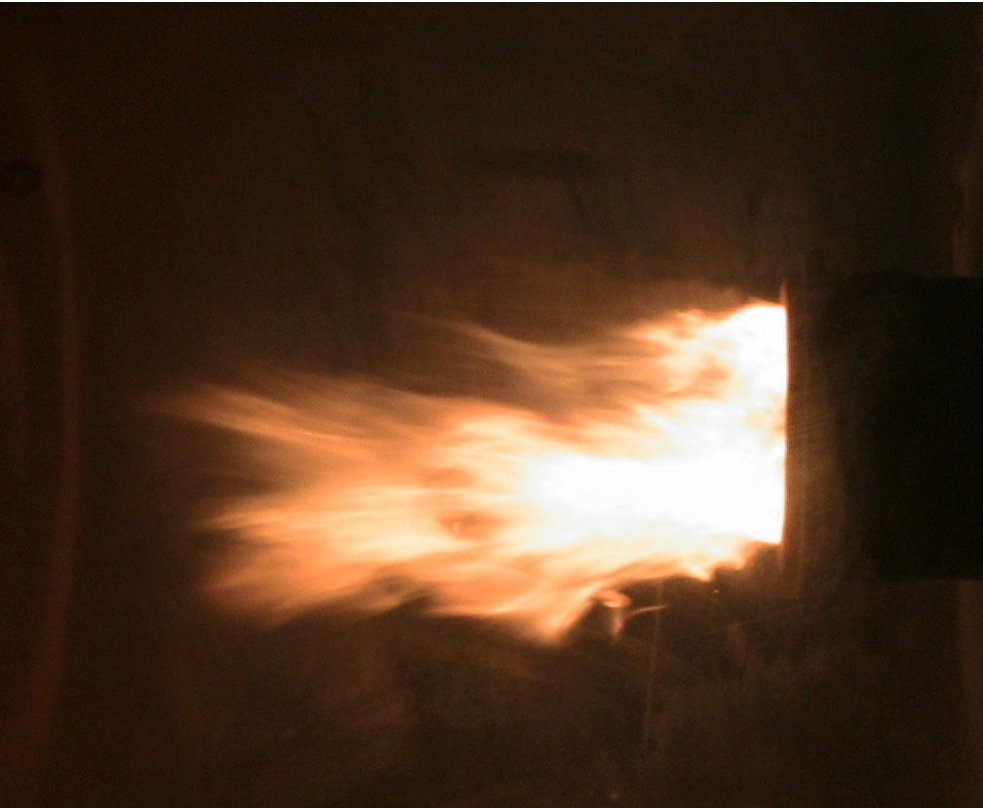
Property	Test Method	Specification	Units
Gross Heat of Combustion	D240	15 min	MJ/kg
Water Content	E203	30 max	mass %
Pyrolysis Solids Content	D7579	2.5 max	mass %
Kinematic Viscosity at 40°C	D445 <sup>A</sup>	125 max	mm <sup>2</sup> /s
Density at 20°C	D4052	1.1–1.3	kg/dm <sup>3</sup>
Sulfur Content	D4294	0.05 max	mass %
Ash Content	D482	0.25 max	mass %
pH	E70	Report	...
Flash Point	D93, Procedure B	45 min	°C
Pour Point	D97	–9 max	°C

<sup>A</sup> Without filtering.

## 1. Scope\*

1.1 This specification covers a pyrolysis liquid biofuel produced from biomass intended for use in industrial burners equipped to handle these types of fuels. This type of biofuel is not intended for use in residential heaters, small commercial boilers, engines, or marine applications.

# Residential Oil Burner – Flame Comparison



No. 2 Heating Oil



Pyrolysis Oil

Quartz Combustion Chamber, Fuel at 300 psi, 240 F - Econox Nozzle Heating System, Burner from Carlin Combustion Technologies , Fuel From Avello Bioenergy, Tests at BNL 5/4/12.

# Avello™ Biofuel Oil™



- Avello is developing light and heavy Biofuel Oil blends for industrial and home-heating applications
- Sulfur content of Avello Biofuel Oil is below detection limit (<10 PPM)

Property	Biofuel Oil <sup>1</sup>	Conventional Pyrolysis Oil <sup>2</sup>	No. 2 Fuel Oil <sup>2</sup>
Moisture content (wt%)	7	20 - 25	< 1.0
HHV (BTU/gal)	96,000	72,000 – 80,000	138,500

1. From Red Oak feedstock. Properties shown for specific sample tested by Brookhaven National Laboratory in combustion application (May 2012).

2. Easterly, James L. "Assessment of Bio-Oil as a Replacement for Heating Oil." 1 Nov. 2002. Web: <<http://www.nrbp.org/pdfs/pub34.pdf>>.

# Summary of Steps

- What target markets and in what order?
- What is the fuel planned for each market?
- Blends or total displacement?
- Legacy or new equipment?
- Technical foundation to support safe and reliable use;
- Development of Standards